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(REVISION — 2015) Signature ....

DIPLOMA EXAMINATION IN ENGINEERING/TECHNOLOGY/ MANAGEMENT/COMMERCIAL PRACTICE — APRIL, 2019

ELECTRIC POWER GENERATION, TRANSMISSION AND DISTRIBUTION

[*Time* : 3 hours

(Maximum marks : 100)

PART — A

(Maximum marks : 10)

Marks

I Answer *all* questions in one or two sentences. Each question carries 2 marks.

1. State the function of economiser in steam power station.
2. Define the term connected load.
3. Illustrate the skin effect experienced in conductors.
4. Define Ferranti effect.
5. Define the term voltage regulation. (5×2 = 10)

PART — B

(Maximum marks : 30)

II Answer any *five* of the following questions. Each question carries 6 marks.

1. Draw the layout of Hydro electric power station.
2. Explain the objectives of tariffs in electrical power system.
3. Define the terms : (a) capacity factor (b) Average load (c) Max. Demand.
4. Explain the methods of improving string efficiency with necessary reasons.
5. Explain different transmission line parameters.
6. Explain various methods of underground cable laying.
7. Give the advantages of high voltage AC system for transmission. (5×6 = 30)

Marks

PART — C

(Maximum marks : 60)

(Answer *one* full question from each unit. Each full question carries 15 marks.)

Unit — I

III (a) Draw the layout of a nuclear power plant. 8

(b) A hydroelectric generating station is supplied from a reservoir of capacity 5×10^6 m^3 at a head of 200m. Find the total energy available in kWh, if the overall efficiency is 75%. 7

Or

IV (a) Draw the layout of thermal power station and describe its working. 8

(b) Mention the factors to be considered for the selection of nuclear power plant. 7

Unit — II

V (a) State and explain load curve and load duration curve. 8

(b) Explain different types of tariff used in electric system. 7

Or

VI (a) A generation station has a maximum demand of 20 MW, a load factor of 60%, plant capacity factor of 48% and plant use factor of 80%. Find :

(i) The daily energy produced

(ii) The reserve capacity

(iii) The number of operating hours per daily

(iv) The maximum energy that could be produced daily if the generation station was running all the time. 8

(b) Specify the load factor and its importance. 7

Unit — III

VII (a) Draw the single line diagram of a typical supply scheme. 8

(b) Describe the transposition of conductors. 7

Or

VIII (a) Compare AC and DC transmission system. 8

(b) Define corona and the methods to reduce the effect of corona. 7

Unit — IV

IX (a) Explain about the different insulators used in overhead line. 8

(b) Explain different causes of failures occur in insulators. 7

Or

X (a) With neat figure explain Distribution system. 8

(b) Describe the advantages of HVDC over AC transmission. 7

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ELECTRICAL POWER GENERATION, TRANSMISSION AND DISTRIBUTION

MAX MARKS: 100 **ANSWER KEY** **TIME: 3 Hours**

PART-A
(Maximum marks: 10)

I. Answer all questions. Each question carries 2 marks.

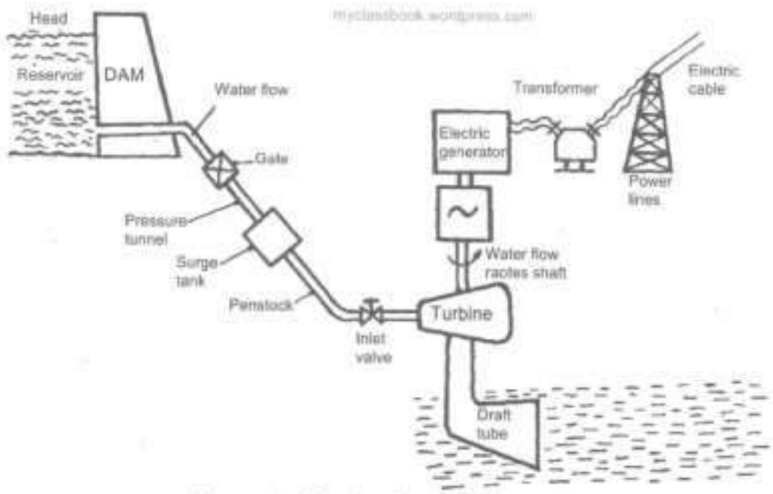
1	A common application of economizers in steam power plants is to capture the waste heat from boiler stack gases (flue gas) and transfer it to the boiler feed water. This raises the temperature of the boiler feed water, lowering the needed energy input, in turn reducing the firing rates needed for the rated boiler output
2	The total electric power-consuming rating of all devices (as lamps o motors) connected to a distribution system
3	Skin effect is the tendency of an alternating electric current (AC) to become distributed within a conductor such that the current density is largest near the surface.
4	The Ferranti effect is an increase in voltage occurring at the receiving end of a long transmission line, above the voltage at the sending end. This occurs when the line is energized with a very light load or the load is disconnected.
5	Voltage regulation. is a measure of change in the voltage magnitude between the sending and receiving end of a component, such as a transmission or distribution line.

(5x2=10)

PART-B
(Maximum marks:30)

II Answer any *five* questions. Each question carries 6 marks.

1



Layout of hydro electric power plant

2 : Objectives of tariffs:

Equal distribution of cost

- The most important objectives of the tariff are the fairly equal distribution of the cost of energy supply to different classes of users.
- Charges to be applied for consumption should be justification for each category of use.

Recovery of capital investment:

- Utility invests hugs amounts money in the system right from the generation to serve the energy in the consumer premises.
- Recovery of the cost incurred in all elements of power system i.e. Generation, Transmission and Distribution of Energy.

Recovery of running cost:

- Apart from the initial cost, it demands some costs to keep the system healthy in running condition.
- Recovery of the cost incurred in operation and maintenance and supply of equipment.

Recovery of miscellaneous cost:

- Distribution of energy to be the consumer involves many associated services in addition to only supply.
- Recovery of cost invested in miscellaneous services such as,

    1. Cost of metering equipment
    2. Billing
    3. Cost of the collection

3 a)The net capacity factor of a power plant is the ratio of its actual output over a period of time, to its potential output if it were possible for it to operate at full name plate capacity continuously over the same period of time.

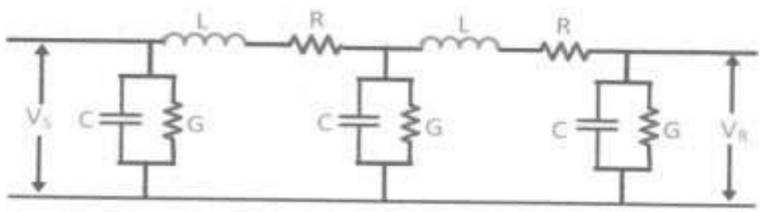
b)The load average represents the average system load over a period of time. It conventionally appears in the form of three numbers which represent the system load during the last one-, five-, and fifteen-minute periods.

c) Maximum demand is the highest level of electrical demand monitored in a particular period usually for a month period

4 The various methods for this purpose are :

1. By using longer cross-arms. The value of string efficiency depends upon the value of K i.e., ratio of shunt capacitance to mutual capacitance. The lesser the value of K, the greater is the string efficiency and more uniform is the voltage distribution. The value of K can be decreased by reducing the shunt capacitance. In order to reduce shunt capacitance, the distance of conductor from tower must be increased i.e., longer cross-arms should be used. However, limitations of cost and strength of tower do not allow the use of very long cross-arms. In practice, $K = 0{\cdot}1$ is the limit that can be achieved by this method.
2. By grading the insulators. In this method, insulators of different dimensions are so chosen that each has a different capacitance. The insulators are capacitance graded i.e. they are assembled in the string in such a way that the top unit has the minimum capacitance, increasing progressively as the bottom unit (i.e., nearest to conductor) is reached. Since voltage is inversely proportional to capacitance, this method tends to equalise the potential distribution across the units in the string. This method has the disadvantage that a large number of different-sized insulators are required. However, good results can be obtained by using standard insulators for most of the string and larger units for that near to the line conductor.
3. By using a guard ring. The potential across each unit in a string can be equalised by using a guard ring which is a metal ring electrically connected to the conductor and surrounding the bottom insulator. The guard ring introduces capacitance between metal fittings and the line conductor. The guard ring is contoured in such a way that shunt capacitance currents i_1, i_2 etc. are equal to metal fitting line capacitance currents i'_1, i'_2 etc. The result is that same charging current I flows through each unit of string. Consequently, there will be uniform potential distribution across the units.

5 The performance of transmission line depends on the parameters of the line. The transmission line has mainly four parameters, resistance, inductance, capacitance and shunt conductance. These parameters are uniformly distributed along the line. Hence, it is also called the distributed parameter of the transmission line.

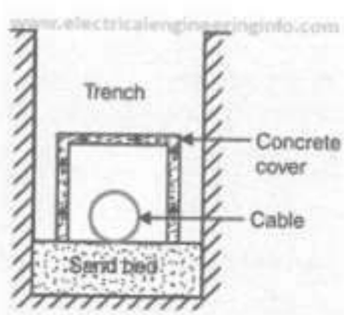


Tranmission Line Model
$Z = R + jwL, Y = G + jwC$

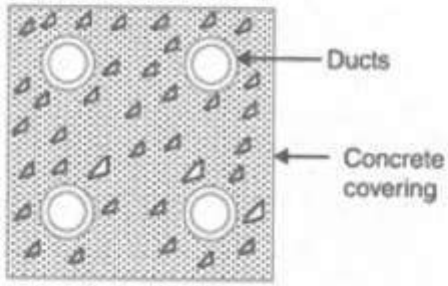
The inductance and resistance form series impedance whereas the capacitance and conductance form the shunt admittance.

6 There are three main methods of laying underground cables, which are - (i) direct laying, (ii) draw-in system and (iii) solid system.

a) Direct laying: This method of laying underground cables is simple and cheap and is much favoured in modern practice.In this method of laying underground cables, a trench of about 1·5 metres deep and 45 cm wide is dug.The trench is covered with a layer of fine sand (of about 10 cm thickness) and the cable is laid over this sand bed.The sand prevents the entry of moisture from the ground and thus protects the cable from decay.After the cable has been laid in the trench, it is covered with another layer of sand of about 10 cm thickness.



b) draw-in system: In this method of laying underground cables, conduit or duct of glazed stone or cast iron or concrete are laid in the ground with manholes at suitable positions along the cable route.The cables are then pulled into position from manholes. Fig. below shows a section through four-way underground duct line.Three of the ducts carry transmission cables and the fourth duct carries relay protection connection, pilot wir



c) solid system

In this method of laying underground cables, the cable is laid in open pipes or troughs dug out in the earth along the cable route.The troughing is of cast iron, stoneware, asphalt or treated wood.After the cable is laid in position, the troughing is filled with a bituminous or asphaltic compound and covered over.Cables laid in this manner are usually plain lead covered because troughing affords good mechanical protection.

7 The advantage of transmitting electricity at high voltage is that is minimizes the power loss due to resistance in conductors. Power is dissipated as heat. The relationship between power, current and resistance is $P=I^2R$. Increasing the voltage decreases the current, which decreases the power loss.

NB:Any Five questions only to be answered

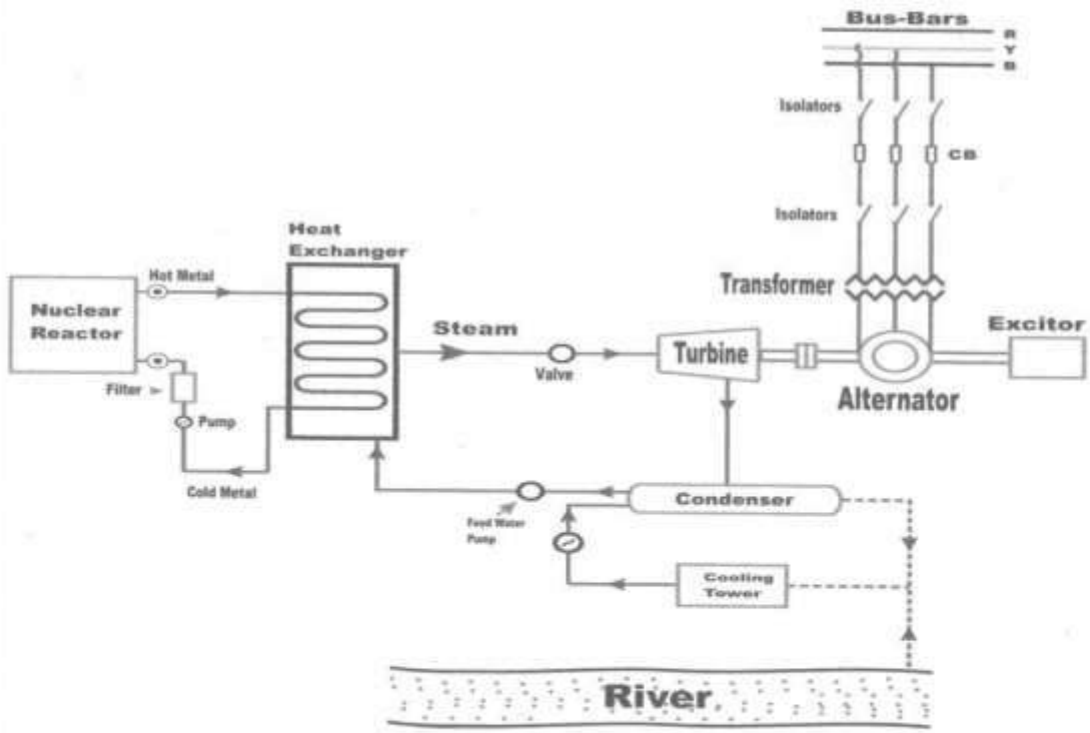
(5x6=30)

PART-C

(Maximum marks: 60)

III. Answer any one full question from each unit. Each question carries 15 marks.

III a)



III b) Weight of water available is W = Volume of water × density

$= (5 \times 10^6) \times (1000)$ (since mass of $1 m^3$ of water is 1000 kg)

$= 5 \times 10^9$ kg $= 5 \times 10^9 \times 9{\cdot}81$ N

Electrical energy available = W × H × η overall

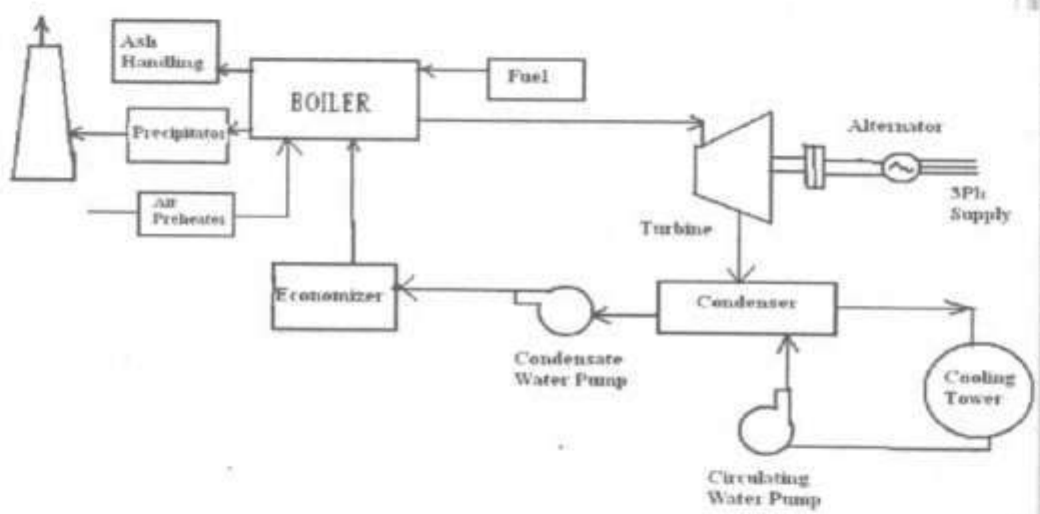
$= (5 \times 10^9 \times 9{\cdot}81) \times (200) \times (0{\cdot}75)$ watt sec

$= (5 X 10^9 X 9.81 X 200 X 0.75) / (3600 X 1000)$ kWh

$= 2.044 \times 10^6$ kWh

IV a)

GENERAL LAYOUT OF THERMAL POWER STATION



IV b) power programme and can be significantly affected by costs and public acceptance. While site selection of a nuclear power plant, the aim is to protect the plant against external threats as well as to minimize any environmental detriments and threats that might arise from it.

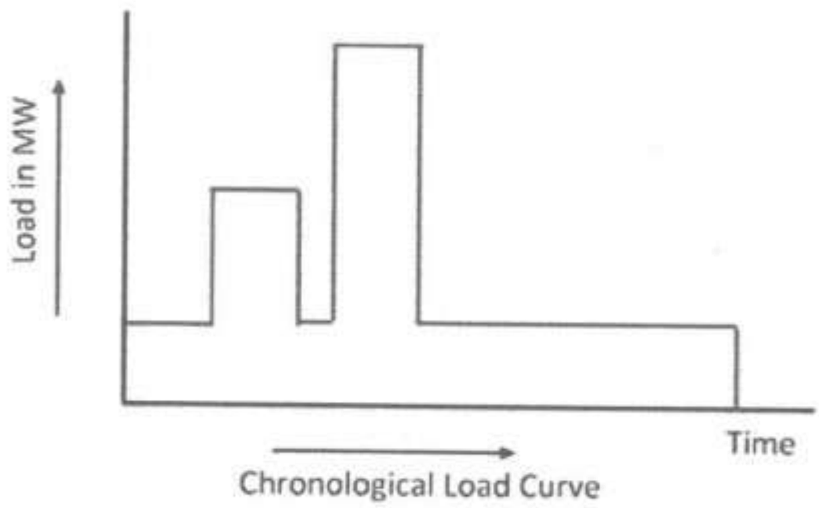
Some important factors while site selection:

1.Use of land and water area: Construction is not allowed on shore zones belonging to the coastal area of a sea or of a water system which would otherwise affect ecology.

2.Availability of nuclear fuel, cooling water: The site should be such that the fuel required for nuclear power generation such as uranium and others should be available near the site or transporting such fuel should not be difficult and time consuming. Also PWR, BWR mostly use light water as their coolant as well as moderator so water facility should be available near to the site and in plenty.

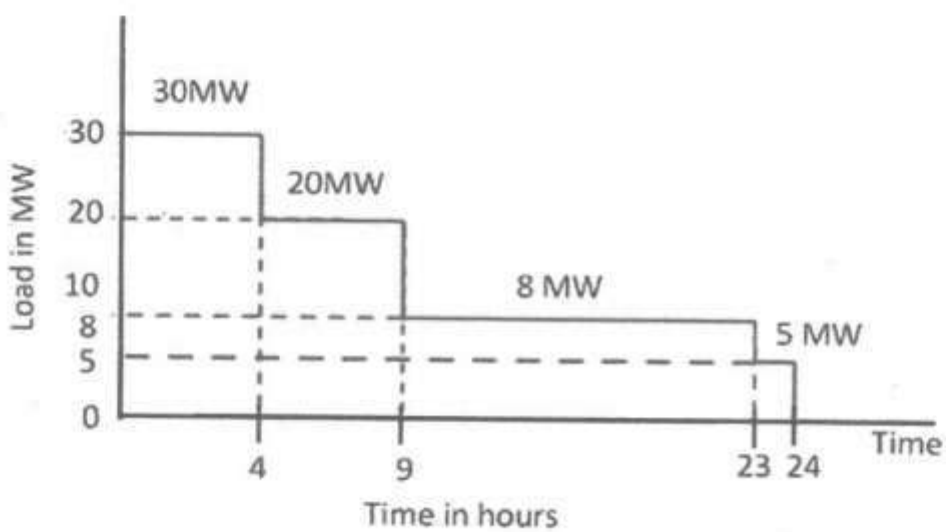
3.Population and sources of livelihood in the region: A nuclear power plant site extends to about a kilometers' distance from the facility. It is defined as an area where only power plant related activities are allowed as a rule. Permanent settlement is prohibited and only very limited employee accommodation or recreational settlement is allowed.
4.Human activities and human facilities: In the plant's vicinity there may not be facilities or population centres where the necessary protective measures, such as sheltering indoors or evacuation, would be difficult to implement. In the plant's vicinity, no activities may be carried out that could pose an external threat to the plant. The general principle in the siting of nuclear power plants is to have the facilities in a sparsely populated area and far away from large population centres. What justifies placement in a sparsely populated area is that emergency planning will then be directed at a smaller population group and will thus be easier to implement. The licensee responsible for the operation of the nuclear power plant shall have authority of decision over all activities in the area and shall be able to remove un authorised individuals from the site, if necessary, or prevent such individuals from entering it.The plant site may contain other non- facility related activities provided that they do not pose a threat to plant safety
5.External threats and environmental threats: Examples of exceptional natural phenomena include• Freezing or other clogging of the cooling water intake,Storms,Flood
6.Seismic area evaluation: Earthquake is a biggest threat to nuclear power plant and hazardous accidents might take place if the earthquake strikes the site.
7.Transport arrangements and Traffic arrangements: Transport system to the plant should be smooth and should not affect the working of plant due to delays in transporting necessary material, men etc to the plant.

V a) Load cuve :The curve showing the variation of load on the power station (power plant) with reference to time is known as load curve.



Ideal Load Curve

Load Duration Curve : In this curve, the load elements of a load curve are arranged in order of descending magnitudes. So, the area under the load duration curve and the area under the load curve are equal. The following figure shows an example of the load curve and the load duration curve.



Load Duration Curve

V b) Various types of electricity tariff

Simple tariff. In this type of tariff, a fixed rate is applied for each unit of the energy consumed.
Flat rate tariff
Block rate tariff.
Two part tariff. ...

Maximum demand tariff. ...
Power factor tariff. ...
Three part tariff.

1. Simple Tariff

In this type of tariff, a fixed rate is applied for each unit of the energy consumed. It is also known as a uniform tariff. The rate per unit of energy does not depend upon the quantity of energy used by a consumer. The price per unit (1 kWh) of energy is constant. This energy consumed by the consumer is recorded by the energy meters.

2. Flat Rate Tariff

In this tariff, different types of consumers are charged at different rates of cost per unit (1kWh) of electrical energy consumed. Different consumers are grouped under different categories. Then, each category is charged money at a fixed rate similar to Simple Tariff. The different rates are decided according to the consumers, their loads and load factors.

3. Block Rate Tariff

In this tariff, the first block of the energy consumed (consisting of a fixed number of units) is charged at a given rate and the succeeding blocks of energy (each with a predetermined number of units) are charged at progressively reduced rates. The rate per unit in each block is fixed.

4. Two Part Tariff

In this tariff scheme, the total costs charged to the consumers consist of two components: fixed charges and running charges. It can be expressed as:

Total cost = [A (kW) + B (kWh)] Rs.
Where, A = charge per kW of max demand (i.e. A is a constant which when multiplied with max demand (kW) gives the total fixed costs.)
B = charge per kWh of energy consumed (i.e. B is a constant which when multiplied with units consumed (kWh), gives total running charges.)

5. Maximum Demand Tariff

In this tariff, the energy consumed is charged on the basis of maximum demand. The units (energy) consumed by him is called maximum demand. The max demand is calculated by a maximum demand meter. This removes any conflict between the supplier and the consumer as it were the two part tariff. It is similar to two-part tariff.

6. Power Factor Tariff

In this tariff scheme, the power factor of the consumer's load is also considered. We know that power factor is an important parameter in power system. For optimal operation, the pf must be high. Low pf will cause more losses and imbalance on the system. Hence the consumers which have low pf loads will be charged more.

7. Three Part Tariff

In this scheme, the total costs are divided into 3 sections: Fixed costs, semi-fixed costs and running costs.
Total Charges = [A + B (kW) + C (kWh)]
Where, A = fixed charges,
B = charge per kW of max demand (i.e. B is a constant which when multiplied with max demand (kW) gives the total fixed costs.)
C = charge per kWh of energy consumed (i.e. C is a constant which when multiplied with units consumed (kWh), gives total running charges.)

VI a)

1) Find the daily energy produced

$$\text{Load Factor} = \frac{\text{Average Load}}{\text{Max. Load}}$$

$$0.6 = \frac{\text{Average Load}}{20\ \text{MW}} \quad \textit{and then} \quad \text{Average Load} = 0.6 \times 20\ \text{MW} = 12\ \text{MW}$$

$$\text{Average Load} = \frac{\text{Area under the load curve (kWh)}}{\text{no. of hours (h)}}$$

The time for daily energy produced is 24 h

Area under the load curve = energy produced = $12 \times 24 = 288$ MWh

2) Find the reserve capacity

$$\text{Plant Capacity Factor} = \frac{\text{Average Demand}}{\text{Installed Capacity}}$$

$$\text{Installed Capacity} = \frac{\text{Average Demand}}{\text{Plant Capacity Factor}} = \frac{12}{0.48} = 25\ \text{MW}$$

$$\text{Reserve Capacity} = \text{Installed Capacity} - \text{Max. Demand}$$

$$\text{Reserve Capacity} = 25 - 20 = 5\ \text{MW}$$

3) Find the number of operating hours per daily

$$\text{Plant Use Factor} = \frac{\text{Average Demand} \times T}{\text{Installed Capacity} \times \text{no. of operating hours}}$$

$$0.8 = \frac{12 \times 24}{25 \times \text{no. of operating hours}}$$

$$\text{no. of operating hours} = \frac{12 \times 24}{25 \times 0.8} = 14.4 \text{ h}$$

4) Find the maximum energy that could be produced daily if the generation station was running all the time.

The maximum energy that could be produced daily $= \text{Installed Capacity} \times 24$

$= 25 \times 24 = 600$ MWh

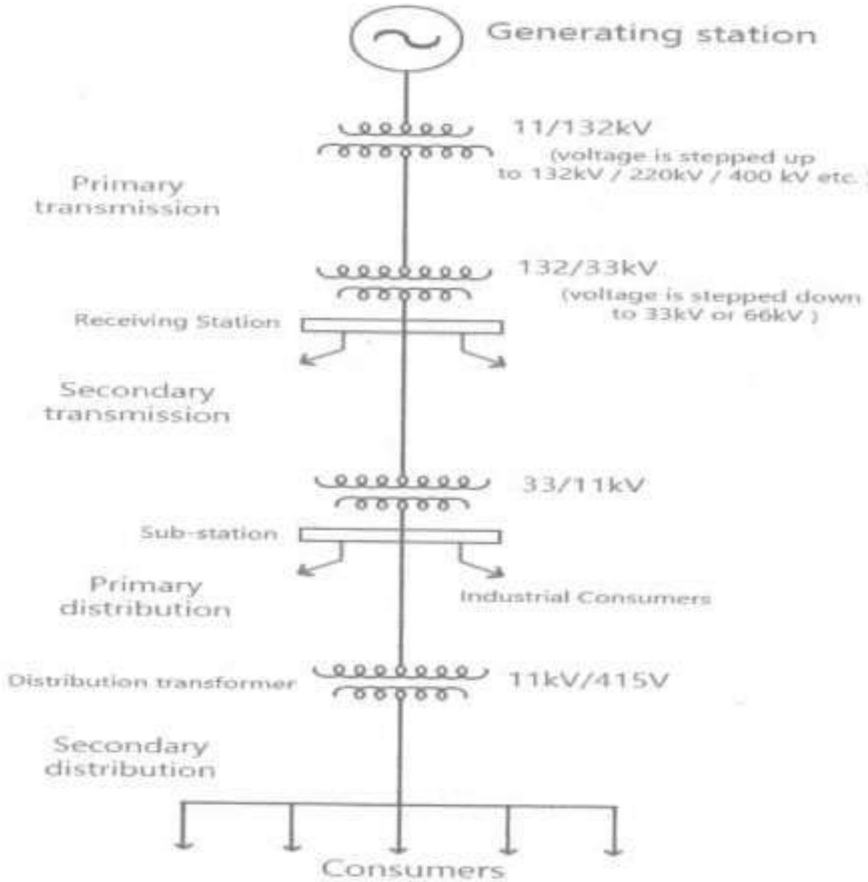
$= 25 \times 24 = 600\,000$ kWh

VI b) In electrical engineering the **load factor** is defined as the average load divided by the peak load in a specified time period. It is a measure of the utilization rate, or efficiency of electrical energy usage; a low load factor indicates that load is not putting a strain on the electric system, whereas consumers or generators with that put more of a strain on the electric distribution will have a high load factor.

It can be derived from the load profile of the specific device or system of devices. Its value is always less than one because maximum demand is never lower than average demand, since facilities likely never operate at full capacity for the duration of an entire 24-hour day. A high load factor means power usage is relatively constant. Low load factor shows that occasionally a high demand is set. To service that peak, capacity is sitting idle for long periods, thereby imposing higher costs on the system. Electrical rates are designed so that customers with high load factor are charged less overall per kWh. This process along with others is called load balancing or peak shaving.

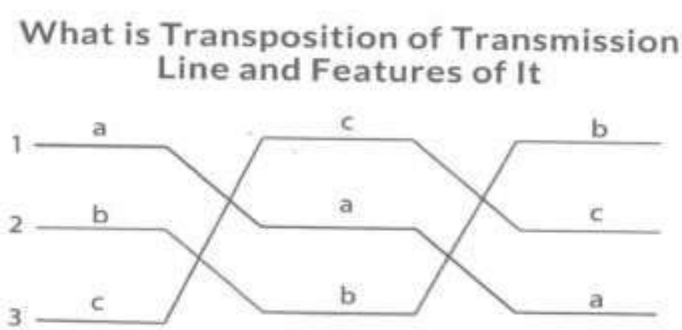
The load factor is closely related to and often confused with the demand factor.

VII a



VII b

Transposition is the periodic swapping of positions of the conductors of a transmission line, in order to reduce crosstalk and otherwise improve transmission. In telecommunications this applies to balanced pairs whilst in power transmission lines three conductors are periodically transposed.



VIII a

Comparison Chart

Basis for Comparison	AC Transmission Line	DC Transmission Line
Definition	The ac transmission line transmit the alternating current.	The dc transmission line is used for transmitting the direct current.
Number of Conductors	Three	Two
Inductance & surges	Have	Don't Have
Voltage drop	High	Low
Skin Effect	Occurs	Absent
Need of Insulation	More	Less
Interference	Have	Don't Have
Corona Loss	Occur	Don't occur
Dielectric Loss	Have	Don't have
Synchronizing and Stability Problem	No difficulties	Difficulties

VIII b The phenomenon of electrical discharge occurring in transmission line for high values of voltage is known as the **corona effect in power system.** Corona loss can be minimized by controlling the following factors:

1). Frequency of supply:Corona loss increases as the supply frequency increases.

2). Radius of the conductors: Generally corona loss increases on decreasing the radius of the conductor.

In order to prevent this ,bundled or hollow large diameter conductors must be used.

3). Distance between the two conductors: To prevent corona spacing between the conductors must be increased.

4). Air Pressure:In hilly areas the corona effect is more dominant due to reduced pressure.

5). Weather is also an important factor that must be considered.

IX a

For the successful operation of power lines, proper selection of insulators is very essential. There are several types of overhead line insulators. Most commonly used types are

- Pin type insulators
- Suspension type insulators
- Strain insulators
- Shackle insulators

IX b

The causes of the failure of insulator are :-

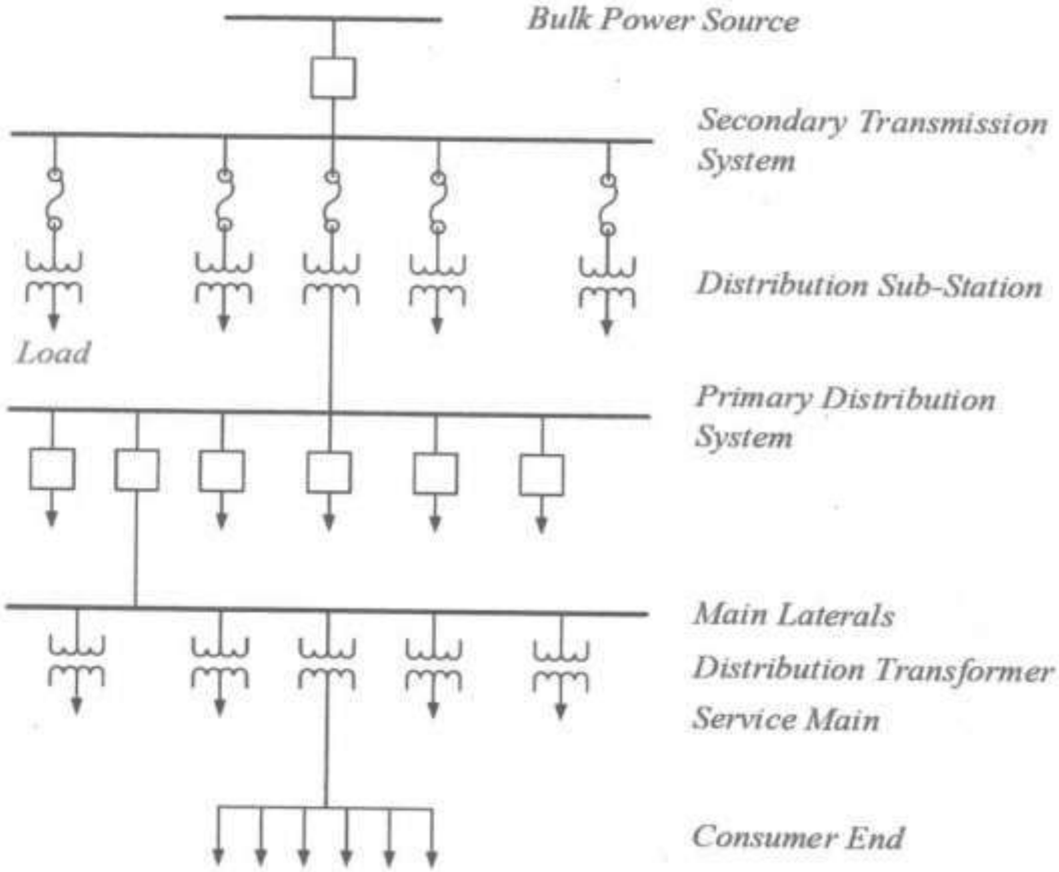
Cracking of insulator: The main cause of cracking is due the stress produced in the porcelain due to unequal expansion and construction produced in cement, steel and porcelain caused by seasonal heat cold, dryness, and dampness or by heating of the insulator. To avoid such cracking, many improvements in the designs have been made, sometimes cushions are placed in between shells and steel pins in order to allow for its expansion.

1. Defective of materials: If the material is defective anywhere, it will puncture from these and thus becomes unfit for further use.
2. Porosity of the materials: If the porcelain is manufactured at lower temperatures, it will make it porous, and due to this reason it will absorb moisture from air or from cement and thus becomes unfit for further use.
3. Improper glaze: If material is not properly glazed, the water will stick to it which will result into deposition of dust etc. over it which is partially and reduces the flashover distance. Causes the insulators may be damaged.
4. Flash over: If there is a flash from one metal part to other, it will cause over-heating and will result into shattering of it.
5. Mechanical Stress: The pulling of the insulator may also sometimes cause mechanical stress in it (if its material is defective) due to which it may break.
6. Short circuit: The large birds may also sometimes cause arc and thus may result in failure of the insulators (it is possible only if the spacing between the conductors is less).

X a

A typical power distribution system consists of -

- Distribution substation
- Feeders
- Distribution Transformers
- Distributor conductors
- Service mains conductors



X b The reasons for selecting HVDC instead of AC for a specific project are often numerous and complex. The most common arguments in its favour are:

1. Lower investment cost

2. Long distance water crossing

3. Lower losses

4. Asynchronous interconnections

5. Controllability

6. Limited short-circuit currents

7. Environment.