GOVT CO-ED POLYTECHNIC

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LAB MANUAL

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2000464(024)–Electrical Power Generation Transmission & Distribution (Lab)

CONTENTS

Experiment No: 1

AIM: To study hydroelectric power plant and its schematic diagram.

Theory:

There hydroelectric plants are located in geographic areas where they will make economic use of hydraulic energy sources. Hydraulic energy is available wherever there is a flow of liquid and accumulated head. Head represents potential energy and is the vertical distance through which the fluid falls in the energy conversion process.

There are three main types of hydroelectric plant arrangements, classified according to the method of controlling the hydraulic flow at the site:

1. Run-of-the-river plants, having small amounts of water storage and thus little control of the flow through the plant.
2. Storage plants, having the ability to store water and thus control the flow through the plant on a daily or seasonal basis.
3. Pumped storage plants, in which the direction of rotation of the turbines is reversed during off-peak hours, pumping water from a lower reservoir to an upper reservoir, thus ''storing energy'' for later production of electricity during peak hours.

Schematic Diagram:

The dam is constructed across a river or lake and water from the catchment area collects at the back of the dam to form a reservoir. A pressure tunnel is taken off from the reservoir and water brought to the valve house at the start of the penstock.

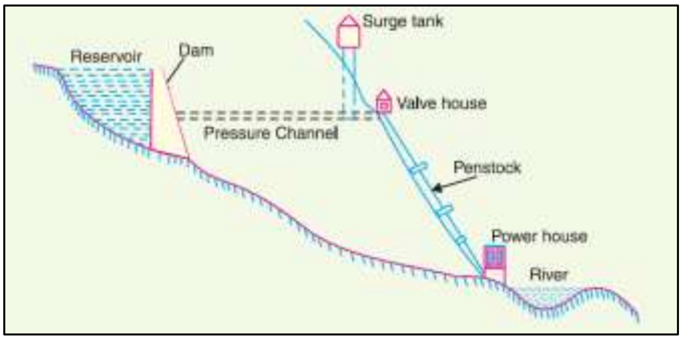


Fig. 1.1: Schematic Diagram of Hydro-Electric Power Plant

The valve house contains main sluice valves and automatic isolating valves. The former controls the water flow to the power house and the latter cuts off supply of water when the penstock bursts. From the valve house, water is taken to water turbine through a huge steel pipe known as penstock. The water turbine converts hydraulic energy into mechanical energy. The turbine drives the alternator which converts mechanical energy into electrical energy. The schematic arrangement of a modern hydro-electric plant is shown in Fig. 1.1.

Result:

Thus, the hydro-electric power plant and its schematic diagram has been studied successfully.

Experiment No: 2

AIM: To study thermal power station and its schematic diagram.

Theory:

A steam/thermal power station basically works on the Rankine cycle. Steam is produced in the boiler by utilizing the heat of coal combustion. The steam is then expanded in the prime mover (*i.e.*, steam turbine) and is condensed in a condenser to be fed into the boiler again. The steam turbine drives the alternator which converts mechanical energy of the turbine into electrical energy. This type of power station is suitable where coal and water are available in abundance and a large amount of electric power is to be generated.

Although steam power station simply involves the conversion of heat of coal combustion into electrical energy, yet it embraces many arrangements for proper working and efficiency. The schematic arrangement of a modern steam power station is shown in Fig. 2.1. The whole arrangement can be divided into the following stages for the sake of simplicity:

1. Coal and ash handling arrangement 2. Steam generating plant
3. Steam turbine 4. Alternator
5. Feed water 6. Cooling arrangement

Schematic Diagram:

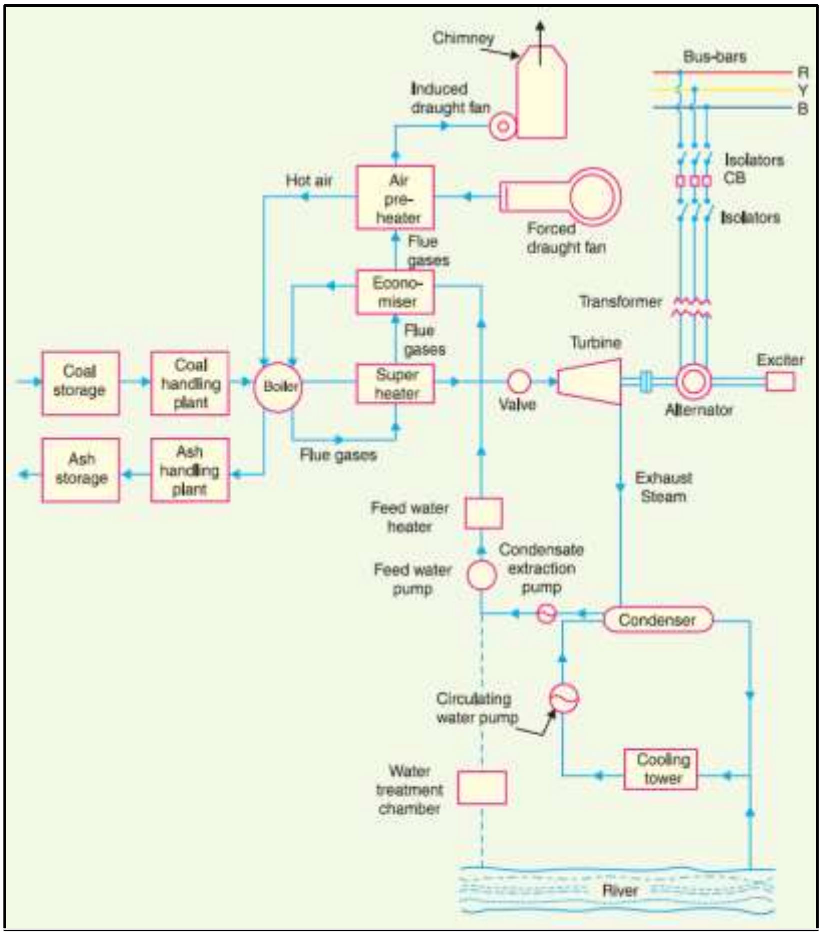


Fig. 2.1: Schematic Diagram of Thermal Power Plant

1. **Coal and ash handling plant:-** The coal is transported to the power station by road or rail and is stored in the coal storage plant. From the coal storage plant, coal is delivered to the coal handling plant where it is pulverised (*i.e.*, crushed into small pieces). The pulverised coal is fed to the boiler by belt conveyors. The coal is burnt in the boiler and the ash produced after the complete combustion of coal is removed to the ash handling plant and then delivered to the ash storage plant for disposal.
2. **Steam generating plant:-** The steam generating plant consists of a boiler for the production of steam and other auxiliary equipment like super heater, economiser, pre-heater etc. for the utilisation of flue gases.
3. **Steam turbine :-** The dry and superheated steam from the superheater is fed to the steam turbine through main valve. The heat energy of steam when passing over the blades of turbine is converted into mechanical energy. After giving heat energy to the turbine, the steam is exhausted to the condenser which condenses the exhausted steam by means of cold water circulation.
4. **Alternator :-** The steam turbine is coupled to an alternator. The alternator converts mechanical energy of turbine into electrical energy. The electrical output from the alternator is delivered to the bus bars through transformer, circuit breakers and isolators.
5. **Feed water :-** The condensate from the condenser is used as feed water to the boiler. Some water may be lost in the cycle which is suitably made up from external source. The feed water on its way to the boiler is heated by water heaters and economiser. This helps in raising the overall efficiency of the plant.
6. **Cooling arrangement :-** In order to improve the efficiency of the plant, the steam exhausted from the turbine is condensed* by means of a condenser. Water is drawn from a natural source of supply such as a river, canal or lake and is circulated through the condenser. The circulating water takes up the heat of the exhausted steam and itself becomes hot. This hot water coming out from the condenser is discharged at a suitable location down the river.

Result:

Thus, the thermal power plant and its schematic diagram has been studied successfully.

Experiment No: 3

AIM: To study nuclear power station and its schematic diagram.

Theory:

In nuclear power station, heavy elements such as Uranium (U^{235}) or Thorium (Th^{232}) are subjected to nuclear fission in a special apparatus known as a *reactor*. The heat energy thus released is utilised in raising steam at high temperature and pressure. The steam runs the steam turbine which converts steam energy into mechanical energy. The turbine drives the alternator which converts mechanical energy into electrical energy.

The most important feature of a nuclear power station is that huge amount of electrical energy can be produced from a relatively small amount of nuclear fuel as compared to other conventional types of power stations. It has been found that complete fission of 1 kg of Uranium (U^{235}) can produce as much energy as can be produced by the burning of 4,500 tons of high grade coal. Although the recovery of principal nuclear fuels (*i.e.*, Uranium and Thorium) is difficult and expensive, yet the total energy content of the estimated world reserves of these fuels are considerably higher than those of conventional fuels, *viz*., coal, oil and gas. At present, energy crisis is gripping us and, therefore, nuclear energy can be successfully employed for producing low cost electrical energy on a large scale to meet the growing commercial and industrial demands.

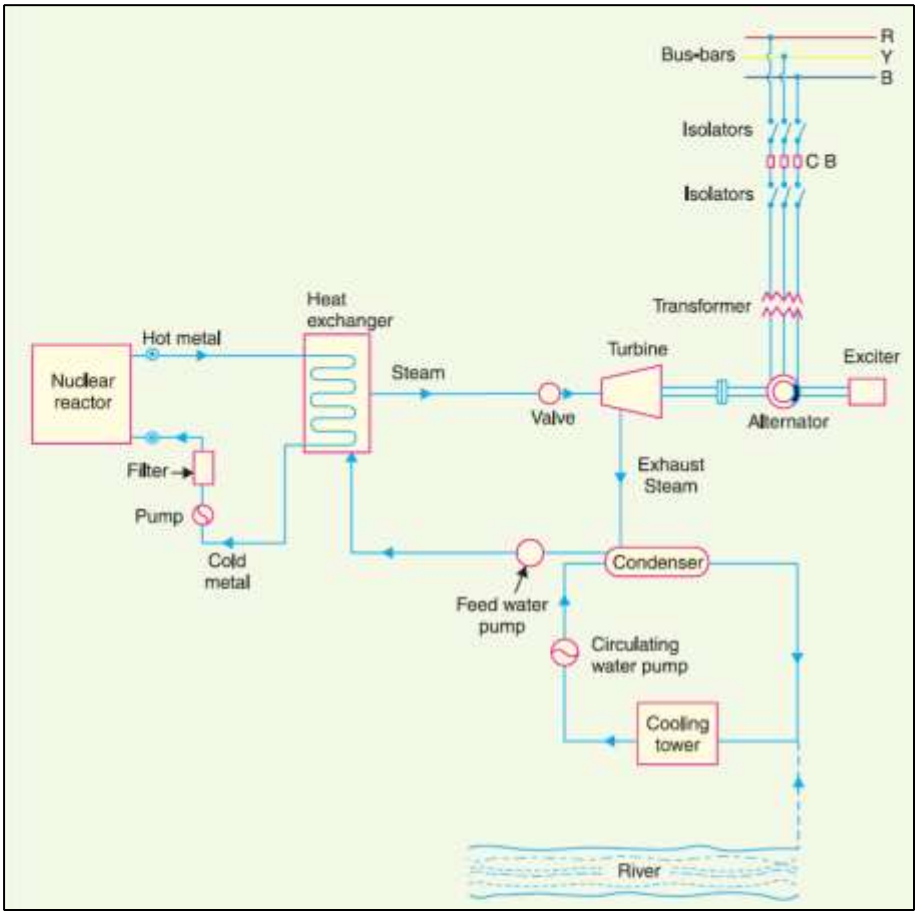


Fig. 3.1: Schematic Diagram of Nuclear Power Plant

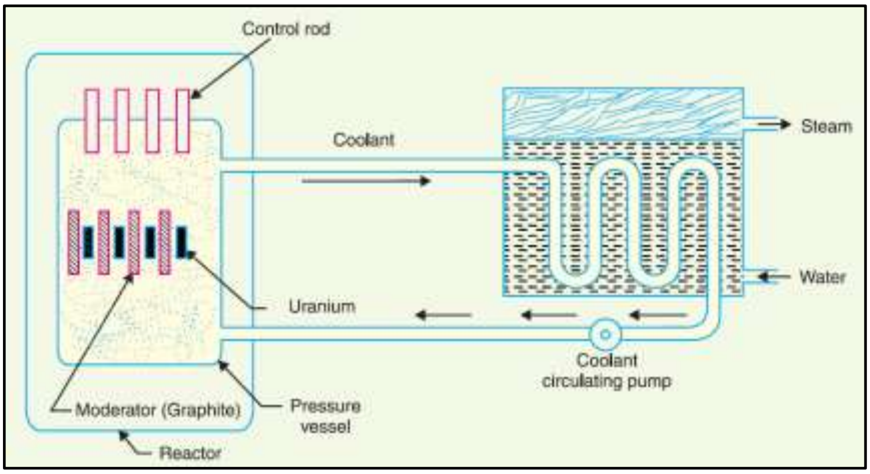


Fig. 3.2: Schematic Showing Nuclear Reactor

The whole arrangement can be divided into the following four main stages :

(i) Nuclear reactor (*ii*) Heat exchanger

(*iii*) Steam turbine (*iv*) Alternator.

1. **Nuclear reactor :-** It is an apparatus in which nuclear fuel (U-235) is subjected to nuclear fission. It controls the *chain reaction* that starts once the fission is done. If the chain reaction is not controlled, the result will be an explosion due to the fast increase in the energy released.
2. **Heat exchanger :-** The coolant gives up heat to the heat exchanger which is utilised in raising the steam. After giving up heat, the coolant is again fed to the reactor.
3. **Steam turbine :-** The steam produced in the heat exchanger is led to the steam turbine through a valve. After doing a useful work in the turbine, the steam is exhausted to condenser. The condenser condenses the steam which is fed to the heat exchanger through feed water pump.
4. **Alternator :-** The steam turbine drives the alternator which converts mechanical energy into electrical energy. The output from the alternator is delivered to the bus-bars through transformer, circuit breakers and isolators.

Result:

Thus, the nuclear power station and its schematic diagram has been studied successfully.

Experiment No: 4

AIM: To study and determine A, B, C, D parameters of short and medium transmission line.

Theory:

A transmission line has three constants R, L and C distributed uniformly along the whole length of the line. The resistance and inductance form the series impedance. The capacitance existing between conductors for 1-phase line or from a conductor to neutral for a 3-phase line forms a shunt path throughout the length of the line. The important considerations in the design and operation of a transmission line are the determination of voltage drop, line losses and efficiency of transmission. These values are greatly influenced by the line constants R, L and C of the transmission line.

Depending upon the manner in which capacitance is taken into account, the overhead transmission lines are classified as :

Short transmission lines- When the length of an overhead transmission line is up to about 50km and the line voltage is comparatively low (< 20 kV), it is usually considered as a short transmission line. Due to smaller length and lower voltage, the capacitance effects are small and hence can be neglected.

Medium transmission lines-When the length of an overhead transmission line is about 50-150 km and the line voltage is moderately high (>20 kV < 100 kV), it is considered as a medium transmission line. Due to sufficient length and voltage of the line, the capacitance effects are considered.

Long transmission lines-When the length of an overhead transmission line is more than 150km and line voltage is very high (> 100 kV), it is considered as a long transmission line. For the treatment of such a line, the line constants are considered uniformly distributed over the whole length of the line.

This experiment deals with the characteristics of short and medium transmission lines. It is convenient to represent a transmission line by the two port network, wherein the end voltage V_S and Current I_S are related to receiving end voltage V_R and current I_R through A, B, C and D parameters as given equations below

$$V_S = A \, . \, V_R + B \, . \, I_R \quad \text{Volts}$$

$$I_S = C \, . \, V_R + D \, . \, I_R \quad \text{Volts}$$

A, B, C, and D are the parameters that depends on the transmission line constants R, L, C and G. The ABCD parameters are in general complex numbers. A and D are dimensionless. B has units of ohms and C has units of siemens.

Also, the following identity holds for ABCD constants

$$AD - BC = 1$$

Short Transmission Line

Capacitance may be ignored without much error if the lines are less than 80 km long or if the voltage is not over 66 kV. The short transmission line on a per-phase basis is shown in figure below

This is a simple series circuit. The relationship between sending end, receiving end voltages and currents can be written as:

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

A = D = 1, B = Z, C = 0

The phasor diagram for the short line is shown in fig 4.1 for lagging load current.

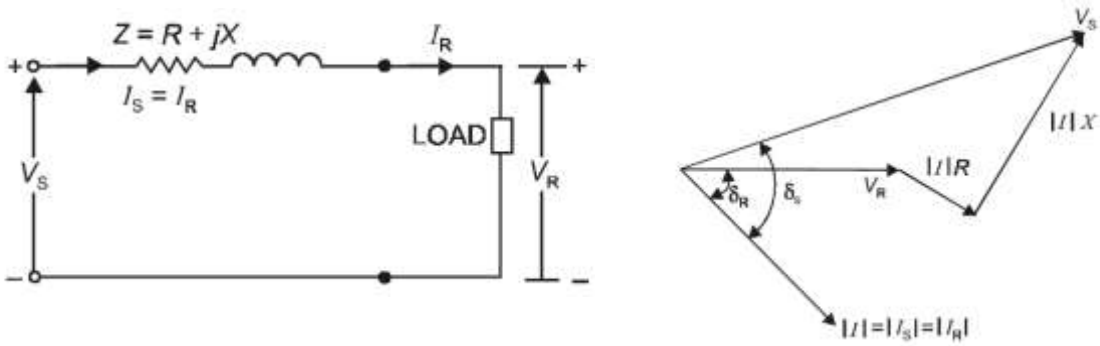


Fig. 4.1: Short Transmission Line Model
and its Phasor Diagram

Medium Transmission Line

For the lines more than 80 km long and below 250 km in length are treated as medium length lines, and the line charging current becomes appreciable and the shunt capacitance must be considered. For medium length lines, half of the shunt capacitance may be considered to lumped at each end of the line. This is referred to as the nominal π model as shown in the fig 4.2. The sending end voltage and current for the nominal π model are obtained as follows:

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} \left(1 + \frac{ZY}{2}\right) & Z \\ Y\left(1 + \frac{ZY}{4}\right) & \left(1 + \frac{ZY}{2}\right) \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

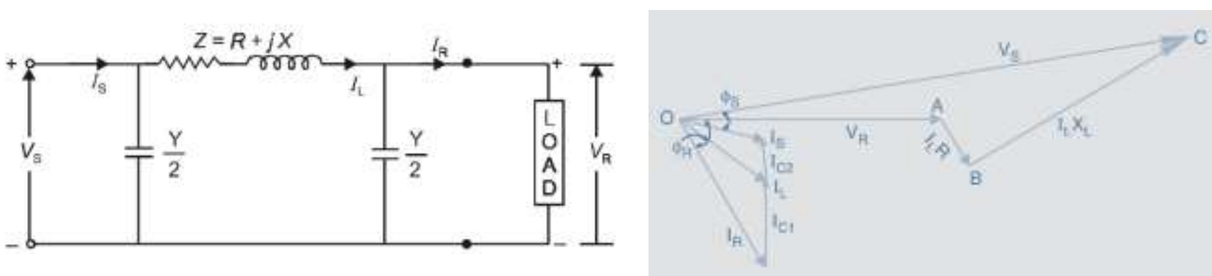


Fig. 4.2: Medium Transmission Line Model
and its Phasor Diagram

Therefore, the ABCD constants for the nominal π model are given by

$$A = \left(1 + \frac{ZY}{2}\right), \quad B = Z,$$

$$C = Y\left(1 + \frac{ZY}{4}\right), \quad D = \left(1 + \frac{ZY}{2}\right)$$

Result:

Thus, the A, B, C, D parameters of short and medium transmission line has been studied successfully.

Experiment No: 5

AIM: Prepare a report based on survey of the connected loads in your institute premise and find the relevant specifications of different switches, MCBs and panels.

Theory:

The connected load is the sum of continuous ratings of all the equipment connected to supply system or power system. A power station supplies load to thousands of consumers. Each consumer has certain equipment installed in his premises. The sum of the continuous ratings of all the equipment in the consumer's premises is the "connected load" of the consumer. In this experiment, we will try to find the total connected load and their associated rating for our college campus (specifically the electrical lab).
Different Miniature Circuit Breaker (MCBs), switches and panels comes with a suitable current rating. The objective of this experiment is to note down ratings all connected load in the lab, in a tabular form.

Fig. 5.1: Different Types of Inductive Loads and Miniature Circuit Breaker (MCBs).

Procedure:

- Divide the whole class in group. Each group should consist of 3 students.
- Now make a brief inspection in the lab and note down various appliances connected to the supply. Also note the power rating of the appliances (like air conditioner, water purifier etc.) along with that also note the MCB rating for that particular appliance.
- Note down all the readings in a tabular form.
- Make a report on the power consumption comprising of load curve for one day power consumption in college campus.

Observation Table

Place of Observation……………………………………….

S. No.	Appliance	Quantity	Rating in Watt	Connected Load
1.	Air Conditioner			
2.	CFL Lamp			
3.	Wall Socket			
4.				
5.				

Total = ………………………………… Watts

Result:

Thus, the report based on survey of the connected loads in our institute has been prepared successfully.

Precautions:

- All the readings should be taken under the supervision of lab staff.
- It should be noted that the values of each component of the circuit does not exceed to their maximum ratings.
- Do not touch any appliance under running condition.
- Quickly inform teacher/lab attendant in case of short circuit.

Experiment No: 6

AIM: To study the effect of transmission line parameters (R, L, C) using a simulated transmission line model.

Theory:

When a transmission line is loaded, it either generates or absorbs reactive power based on the level of loading. A line which is loaded above its surge impedance loading (SIL) will experience a drop is voltage at its receiving end. The sending end power factor depends on the load power factor and also the line parameters and loading level. Further owing to certain resistance present in the line, the sending end real power is a summation of the line losses and the load power. The aim of this experiment is to observe the changes in various electrical parameters at the two ends during various loading condition. The impact of line parameters on can be studied on a simulated model. A pi-model is selected for simulation purpose.

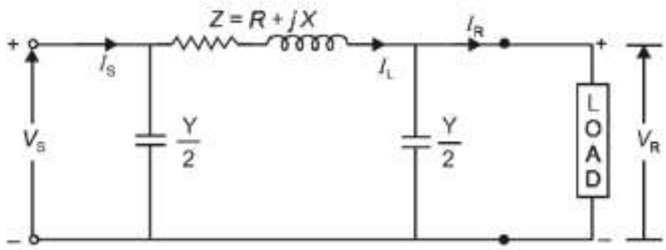


Fig. 6.1: Pi-Model of Transmission Line.

Procedure:

i. Connect the components in Multi-sim software as per circuit diagram.
ii. Ensure that the load end contactor is off.
iii. Simulate the circuit.
iv. Slowly increase and adjust the sending voltage to measure 110 V, line to line.
vi. Connect the resistive load.
vii. Connect the inductive load.
viii. Vary the load side to adjust the loading to the required power factor.
ix. Record the various electrical parameters at the two ends.
x. Take the reading at different loading values.

Observation Table

S. No.	Loading		V_R (Volts)	I_R (A)	V_S (Volts)	I_S (A)
	I_L (Amp)	PF				
1	0	0				
2	0.3	0.9				
3	0.6	0.9				

Result:

Thus, the effect of transmission line parameters (R, L, C) using a simulated transmission line model has been studied and simulated successfully.

Precautions:

- All the components in use should be rated properly.
- It should be noted that the values of each component of the circuit does not exceed to their maximum ratings.
- Before the circuit connection, make sure everything is connected as per circuit diagram and power is switched OFF.
- Quickly inform teacher/lab attendant in case of doubt.

Experiment No: 7

AIM: Prepare a load curve for the complete calendar year of your institution electrical load and analyze it.

Theory:

The curve showing the variation of load on the power station with respect to time is known as a ***load curve.*** The load on a power station is never constant; it varies from time to time. These load variations during the whole day (*i.e.,* 24 hours) are recorded half-hourly or hourly and are plotted against time on the graph. The curve thus obtained is known as *daily load curve* as it shows the variations of load with respect to time during the day.

The *monthly load curve* can be obtained from the daily load curves of that month. For this purpose, average values of power over a month at different times of the day are calculated and then plotted on the graph. The monthly load curve is generally used to fix the rates of energy. The *yearly load curve* is obtained by considering the monthly load curves of that particular year. The yearly load curve is generally used to determine the annual load factor.

Fig. 7.1: Typical Load Curve Showing Variation of Power Demand Through-out the Day.

Procedure:

- Divide the whole class in group. Each group should consist of 3 students.
- Now make a brief inspection in the lab and note down various appliances connected to the supply. Also note the power rating of the appliances (like air conditioner, water purifier etc.) along with that also note the MCB rating for that particular appliance.
- Note down all the readings in a tabular form.
- Calculate the power and energy consumed by each appliance during a particular time period on hourly basis say 10:30 AM to 05:00 PM. Repeat the observations daily.
- Make a report on the power consumption comprising of load curve for one day power consumption in college campus.
- Based on the above data, compute the yearly load curve.

Observation Table

Time of taking the readings……………………………..

S. No.	Appliance	Quantity	Rating in Watt	Total Power	Total Energy
1.	Air Conditioner				
2.	CFL Lamp				
3.	Wall Socket				
4.					
5.					

Result:

Thus, a load curve for our institution's electrical load has been studied successfully.

Precautions:

- All the readings should be taken under the supervision of lab staff.
- It should be noted that the values of each component of the circuit does not exceed to their maximum ratings.
- Do not touch any appliance under running condition.
- Quickly inform teacher/lab attendant in case of short circuit.

Experiment No: 8

AIM: Collect different samples of Overhead Conductors, Underground Cables, Line supports and Line Insulators.

Theory:

An overhead line may be used to transmit or distribute electric power. The successful operation of an overhead line depends to a great extent upon the mechanical design of the line. While constructing an overhead line, it should be ensured that mechanical strength of the line is such so as to provide against the most *probable* weather conditions. In general, the main components of an overhead line are:

(i) *Conductors* which carry electric power from the sending end station to the receiving end station.

(ii) *Supports* which may be poles or towers and keep the conductors at a suitable level above the ground.

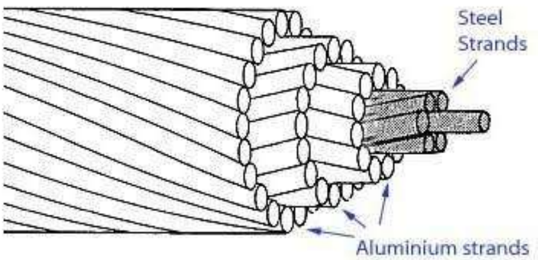
(iii) *Insulators* which are attached to supports and insulate conductors from ground.

(*iv*) *Cross arms* which provide support to the insulators.

(iv) *Miscellaneous items* such as phase plates, danger plates, lightning arrestors, anti-climbing wires etc.

In this experiment, the students are made familiar with power transmission components like overhead conductors, underground cables, line supports etc. by showing them the real components in the lab.

1. Overhead conductor – The schematic shows an overhead conductor



2. Under ground cable – Image shows various insulation layers around the cable.

3. Line Insulators –

Pin type insulator

Suspension insulator

Result:

Thus, different samples of overhead conductors, underground cables, line supports and line insulators, have been studied successfully.

Precautions:

- All the components should be observed under the supervision of lab staff.
- Avoid sharp edges of overhead conductors and cables.
- Do not touch any appliance under running condition.
- Quickly inform teacher/lab attendant in case of any mishap.