COLLEGE OF ENGINEERING & TECHNOLOGY

LABORATORY MANUAL

POWER SYSTEM 1

SUBJECT CODE: 3140914

ELECTRICAL ENGINEERING DEPARTMENT

B.E. 4th SEMESTER

NAME:____________________

ENROLLMENT NO: ____________________

BATCH NO: ____________________

YEAR: ____________________

Amiraj College of Engineering and Technology,
Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

Amiraj College of Engineering and Technology,

Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

CERTIFICATE

This is to certify that Mr. / Ms. ____

Of class___________________ Enrolment No _________________________has Satisfactorily completed the course in __________________________________as by the Gujarat Technological University for ____ Year (B.E.) semester___ of Electrical Engineering in the Academic year_________.

Date of Submission:-

Faculty Name and Signature
(Subject Teacher)

Head of Department
(Electrical)

AMIRAJ

COLLEGE OF ENGINEERING & TECHNOLOGY

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List Of Experiments

Sr. No.	Title	Date of Performance	Date of submission	Sign	Remark
1.					
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POWER SYSTEM 1

LAB MANUAL

Experiment no: 01

Date of Performance: _________

Date of Submission: __________

Aim: Study of Steam Power Plant (Thermal Power Plant).

Theory:

A. Introduction.

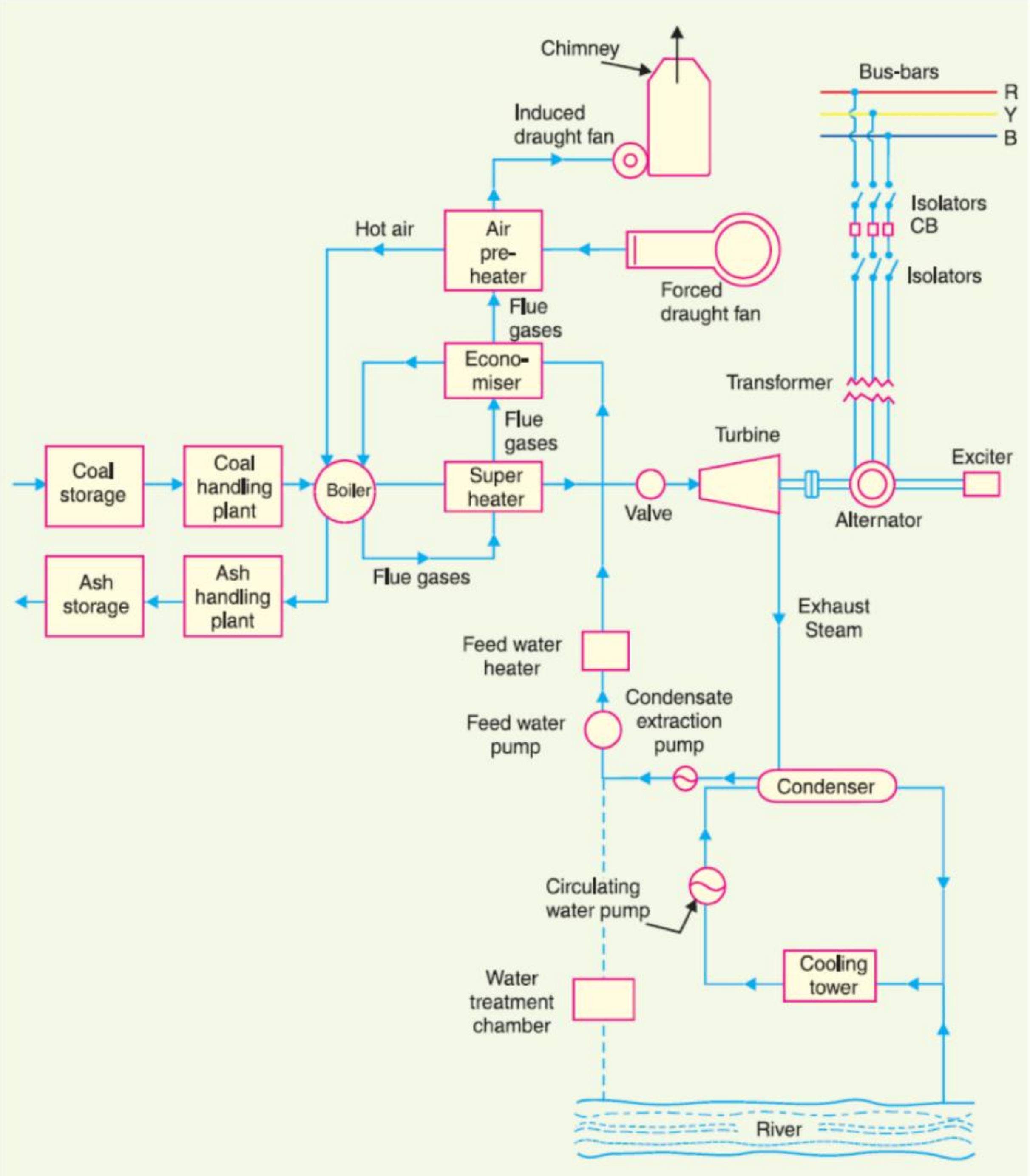
A generating station which converts heat energy of coal combustion into electrical energy is known as a **steam power station.** A steam power station basically works on the Rankine cycle. Steam is produced in the boiler by utilizing the heat of coal combustion. The steam is then expanded in the prime 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.

B. Schematic Arrangement of Steam Power Station

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 Figure placed on next page. 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

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. Storage of coal is primarily a matter of protection against coal strikes, failure of transportation system and general coal shortages. From the coal storage plant, coal is delivered to the coal handling plant where it is pulverized (i.e., crushed into small pieces) in order to increase its surface exposure, thus promoting rapid combustion without using large quantity of excess air. The pulverized 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. The removal of the ash from the



Schematic arrangement of Steam Power Station boiler furnace is necessary for proper burning of coal. It is worthwhile to give a passing reference to the amount of coal burnt and ash produced in a modern thermal power station. A 100 MW station operating at 50% load factor may burn about 20,000 tons of coal per month and ash produced may be to the tune of 10% to 15% of coal fired i.e., 2,000 to 3,000 tons. In fact, in a thermal station, about 50% to 60% of the total operating cost consists of fuel purchasing and its handling.

2. **Steam Generating Plant.** The steam generating plant consists of a boiler for the production of steam and other auxiliary equipment for the utilization of flue gases.

(a) Boiler. The heat of combustion of coal in the boiler is utilized to convert water into steam at high temperature and pressure. The flue gases from the boiler make their journey through super heater, economizer, and air pre-heater and are finally exhausted to atmosphere through the chimney.

(b) Super heater. The steam produced in the boiler is wet and is passed through a super heater where it is dried and superheated (i.e., steam temperature increased above that of boiling point of water) by the flue gases on their way to chimney. Superheating provides two principal benefits. Firstly, the overall efficiency is increased. Secondly, too much condensation in the last stages of turbine (which would cause blade corrosion) is avoided. The superheated steam from the super heater is fed to steam turbine through the main valve.

(c) Economizer. An economizer is essentially a feed water heater and derives heat from the flue gases for this purpose. The feed water is fed to the economizer before supplying to the boiler. The economizer extracts a part of heat of flue gases to increase the feed water temperature.

(d) Air-Preheater. An air preheater increases the temperature of the air supplied for coal burning by deriving heat from flue gases. Air is drawn from the atmosphere by a forced draught fan and is passed through air preheater before supplying to the boiler furnace. The air preheater extracts heat from flue gases and increases the temperature of air used for coal combustion. The principal benefits of preheating the air are: increased thermal efficiency and increased steam capacity per square meter of boiler surface.

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. In case the availability of water from the source of supply is not assured throughout the year, cooling towers are used. During the scarcity of water in the river, hot water from the condenser is passed on to the cooling towers where it is cooled. The cold water from the cooling tower is reused in the condenser.

C. Equipment of Steam Power Station

A modern steam power station is highly complex and has numerous equipment and auxiliaries. However, the most important constituents of a steam power station are:

1. Steam generating equipment
2. Condenser.
3. Prime mover.
4. Water treatment plant.
5. Electrical equipment.

1. Steam Generating Equipment. This is an important part of steam power station. It is concerned with the generation of superheated steam and includes such items as boiler, boiler furnace, super heater, economiser, air pre-heater and other heat reclaiming devices.

(a) **Boiler.** A boiler is closed vessel in which water is converted into steam by utilizing the heat of coal combustion. Steam boilers are broadly classified into the following two types:

(i) Water tube boilers **(ii)** Fire tube boilers

In a water tube boiler, water flows through the tubes and the hot gases of combustion flow over these tubes. On the other hand, in a fire tube boiler, the hot products of combustion pass through the tubes surrounded by water. Water tube boilers have a number of advantages over fire tube boilers *viz*., require less space, smaller size of tubes and drum, high working pressure due to small drum, less liable to explosion etc. Therefore, the use of water tube boilers has become universal in large capacity steam power stations.

(b) **Boiler furnace**. A boiler furnace is a chamber in which fuel is burnt to liberate the heat energy. In addition, it provides support and enclosure for the combustion equipment *i.e.*, burners. The boiler furnace walls are made of refractory materials such as fire clay, silica, kaolin etc. These materials have the property to resist change of shape, weight or physical properties at high temperatures. There are following three types of construction of furnace walls:

(i) Plain refractory walls
(ii) Hollow refractory walls with an arrangement for air cooling
(iii) Water walls.

The plain refractory walls are suitable for small plants where the furnace temperature may not be high. However, in large plants, the furnace temperature is quite high* and consequently, the refractory material may get damaged. In such cases, refractory walls are made hollow and air is circulated through hollow space to keep the temperature of the furnace walls low. The recent development is to use water walls. These consist of plain tubes arranged side by side and on the inner face of the refractory walls. The tubes are connected to the upper and lower headers of the boiler. The boiler water is made to circulate through these tubes. The water walls absorb the radiant heat in the furnace which would otherwise heat up the furnace walls.

(c) **Super heater**. A super heater is a device which superheats the steam *i.e.*, it raises the temperature of steam above boiling point of water. This increases the overall efficiency of the plant. A super heater consists of a group of tubes made of special alloy steels such as chromium-molybdenum. These tubes are heated by the heat of flue gases during their journey from the furnace to the chimney.

(c) **Economiser.** It is a device which heats the feed water on its way to boiler by deriving heat from the flue gases. This results in raising boiler efficiency, saving in fuel and reduced stresses in the boiler due to higher temperature of feed water. An economiser consists of a large number of closely spaced parallel steel tubes connected by headers of drums. The feed water flows through these tubes and the flue gases flow outside. A part of the heat of flue gases is transferred to feed water, thus raising the temperature of the latter.

(d) **Air Pre-heater.** Super heaters and economisers generally cannot fully extract the heat from flue gases. Therefore, pre-heaters are employed which recover some of the heat in the escaping gases. The function of an air pre-heater is to extract heat from the flue gases and give it to the air being supplied to furnace for coal combustion. This raises the furnace temperature and increases the thermal efficiency of the plant. Depending upon the method of transfer of heat from flue gases to air.

2. Condensers. A condenser is a device which condenses the steam at the exhaust of turbine. It serves two important functions. Firstly, it creates a very low *pressure at the exhaust of turbine, thus permitting expansion of the steam in the prime mover to a very low pressure. This helps in converting heat energy of steam into mechanical energy in the prime mover. Secondly, the condensed steam can be used as feed water to the boiler.

3. Prime Mover. The prime mover converts steam energy into mechanical energy. There are two types of steam prime movers *viz*., steam engines and steam turbines. A steam turbine has several advantages over a steam engine as a prime mover *viz*., high efficiency, simple construction, higher speed, less floor area requirement and low maintenance cost. Therefore, all modern steam power stations employ steam turbines as prime movers. Steam turbines are generally classified into two types according to the action of steam on moving blades *viz*.

(a) Impulse Turbines (b) Reaction Turbines

In an impulse turbine, the steam expands completely in the stationary nozzles (or fixed blades), the pressure over the moving blades remaining constant. In doing so, the steam attains a high velocity and impinges against the moving blades. This results in the impulsive force on the moving blades which sets the rotor rotating. In a reaction turbine, the steam is partially expanded in the stationary nozzles, the remaining expansion takes place during its flow over the moving blades. The result is that the momentum of the steam causes a reaction force on the moving blades which sets the rotor in motion.

4. Water Treatment Plant. Boilers require clean and soft water for longer life and better efficiency. However, the source of boiler feed water is generally a river or lake which may contain suspended and dissolved impurities, dissolved gases etc. Therefore, it is very important that water is first purified and softened by chemical treatment and then delivered to the boiler. The water from the source of supply is stored in storage tanks. The suspended impurities are removed through sedimentation, coagulation and filtration. Dissolved gases are removed by aeration and degasification. The water is then *'softened'* by removing temporary and permanent hardness through different chemical processes. The pure and soft water thus available is fed to the boiler for steam generation.

5. Electrical Equipment. A modern power station contains numerous electrical equipment. However, the most important items are :

(a) **Alternator.** Each alternator is coupled to a steam turbine and converts mechanical energy of the turbine into electrical energy. The alternator may be hydrogen or air cooled. The necessary excitation is provided by means of main and pilot exciters directly coupled to the alternator shaft.

(b) **Transformers.** A generating station has different types of transformers, *viz*.

(i) **Main step-up transformers.** This transformer steps-up the generation voltage for transmission of power.

(ii) **Station Transformers.** These transformers are used for general service (*e.g*., lighting) in the power station.

(iii) **Auxiliary transformers.** These transformers supply to individual unit-auxiliaries.

(iv) **Switchgear.** It comprises of such equipment which locates the fault on the system and isolate the faulty part from the healthy section. It contains circuit breakers, relays, switches and other control devices.

QUESTIONS TO BE ANSWERED

Q 01. Discuss advantages and disadvantages of a steam power plant.

Q 02. Draw the schematic diagram of Feed Water &Steam Circuit and explain functions of its main components.

Q 03. Explain Heat Balance Sheet of a thermal Power plant.

Q 04. Draw Air and flue gases circuit and explain functions of its main components.

Q 05. Explain what is de-aerator plant and demineralization plant. What happens if these plans are non functional.

Conclusion.

Experiment No. 02

Date of Performance: _________

Date of Submission: __________

Aim: Study of Hydro-Electric Power Station.

A. Theory.

Introduction.

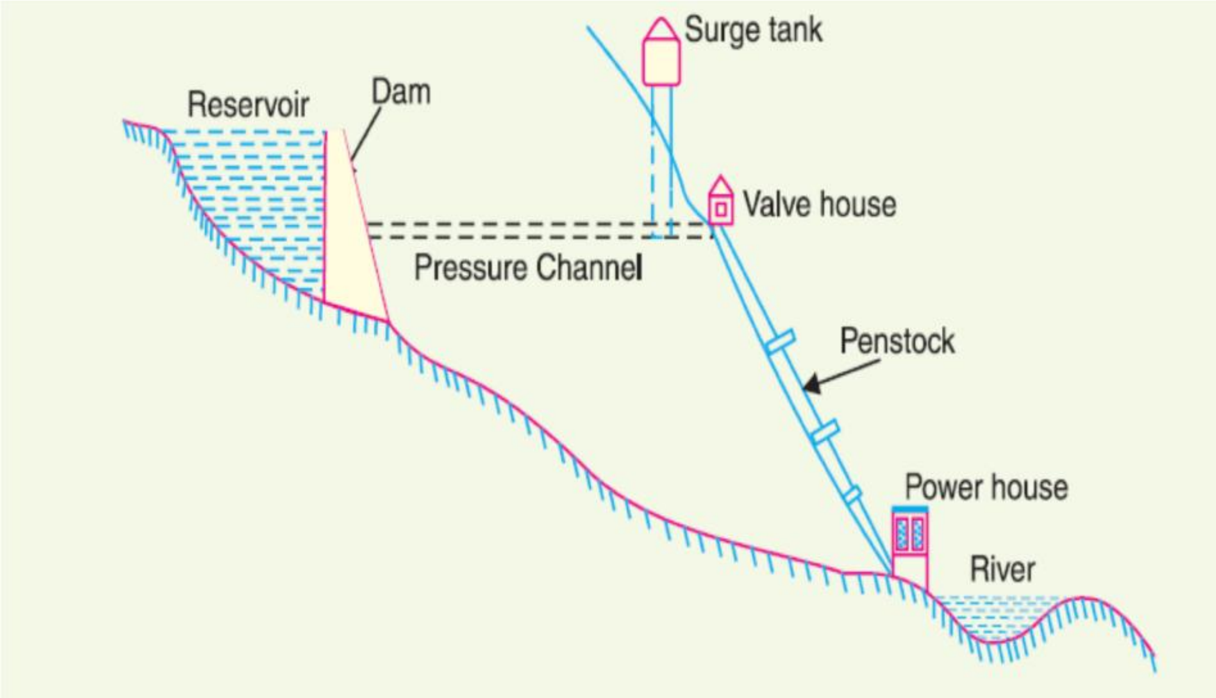
Hydro-electric power stations are generally located in hilly areas where dams can be built conveniently and large water reservoirs can be obtained. In a hydro-electric power station, water head is created by constructing a dam across a river or lake. From the dam, water is led to a water turbine. The water turbine captures the energy in the falling water and changes the hydraulic energy (*i.e.*, product of head and flow of water) into mechanical energy at the turbine shaft. The turbine drives the alternator which converts mechanical energy into electrical energy. Hydro-electric power stations are becoming very popular because the reserves of fuels (*i.e.*, coal and oil) are depleting day by day. They have the added importance for flood control, storage of water for irrigation and water for drinking purposes.

B. Schematic Arrangement of Hydro-electric Power Station

Although a hydro-electric power station simply involves the conversion of hydraulic energy into electrical energy, yet it embraces many arrangements for proper working and efficiency. The schematic arrangement of a modern hydro-electric plant is shown in Figure on next page. 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. 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.

A surge tank (open from top) is built just before the valve house and protects the penstock from bursting in case the turbine gates suddenly close* due to electrical load being thrown off. When the gates close, there is a sudden topping of water at the lower end of the penstock and consequently the penstock can burst like a paper log. The surge tank absorbs this pressure swing by increase in its level of water.

Schematic Diagram of Hydro Electric Power Plant



Pelton Wheel

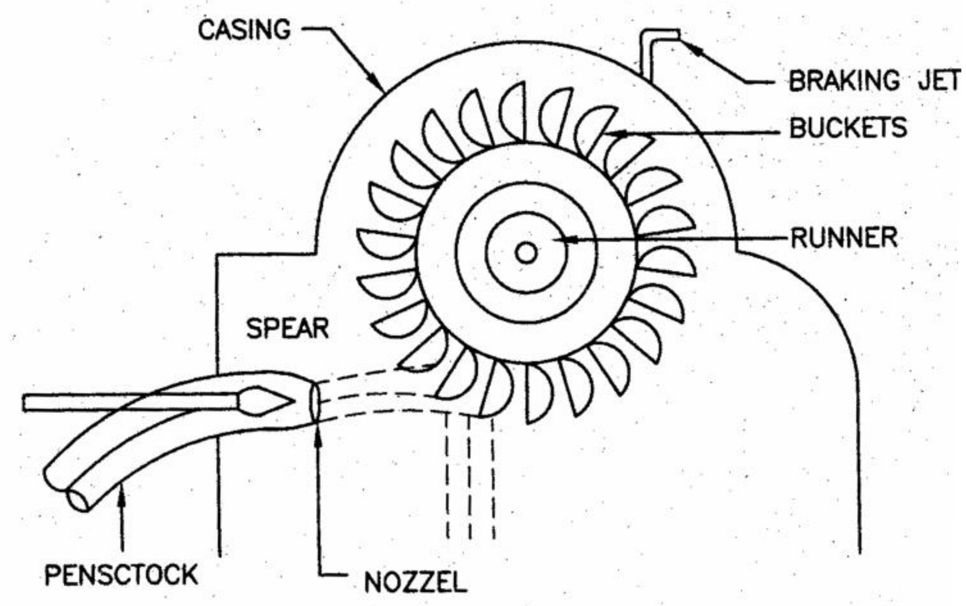


FIG. 3.6 IMPULSE TURBINE

C. **Constituents of Hydro-electric Plant** The constituents of a hydro-electric plant are ;

(a) Hydraulic Structures
(b) Water turbines.
(c) Electrical equipment.

Let us discuss these items in turn.

1. Hydraulic structures. Hydraulic structures in a hydro-electric power station include dam, spillways, headworks, surge tank, penstock and accessory works.

(a) Dam. A dam is a barrier which stores water and creates water head. Dams are built of concrete or stone masonry, earth or rock fill. The type and arrangement depends upon the Generating Stations topography of the site. A masonry dam may be built in a narrow canyon. An earth dam may be best suited for a wide valley. The type of dam also depends upon the foundation conditions, local materials and transportation available, occurrence of earthquakes and other hazards. At most of sites, more than one type of dam may be suitable and the one which is most economical is chosen.

(b) Spillways. There are times when the river flow exceeds the storage capacity of the reservoir. Such a situation arises during heavy rainfall in the catchment area. In order to discharge the surplus water from the storage reservoir into the river on the down-stream side of the dam, spillways are used. Spillways are constructed of concrete piers on the top of the dam. Gates are provided between these piers and surplus water is discharged over the crest of the dam by opening these gates.

(c) Headworks. The headworks consists of the diversion structures at the head of an intake. They generally include booms and racks for diverting floating debris, sluices for by-passing debris and sediments and valves for controlling the flow of water to the turbine. The flow of water into and through headworks should be as smooth as possible to avoid head loss and cavitation. For this purpose, it is necessary to avoid sharp corners and abrupt contractions or enlargements.

(d) Surge tank. Open conduits leading water to the turbine require no protection. However, when closed conduits are used, protection becomes necessary to limit the abnormal pressure in the conduit. For this reason, closed conduits are always provided with a surge tank. A surge tank is a small reservoir or tank (open at the top) in which water level rises or falls to reduce the pressure swings in the conduit. A surge tank is located near the beginning of the conduit. When the turbine is running at a steady load, there are no surges in the flow of water through the conduit *i.e.*, the quantity of water flowing in the conduit is just sufficient to meet the turbine requirements. However, when the load on the turbine decreases, the governor closes the gates of turbine, reducing water supply to the turbine. The excess water at the lower end of the conduit rushes back to the surge tank and increases its water level. Thus the conduit is

Impulse Turbine-Pelton Wheel

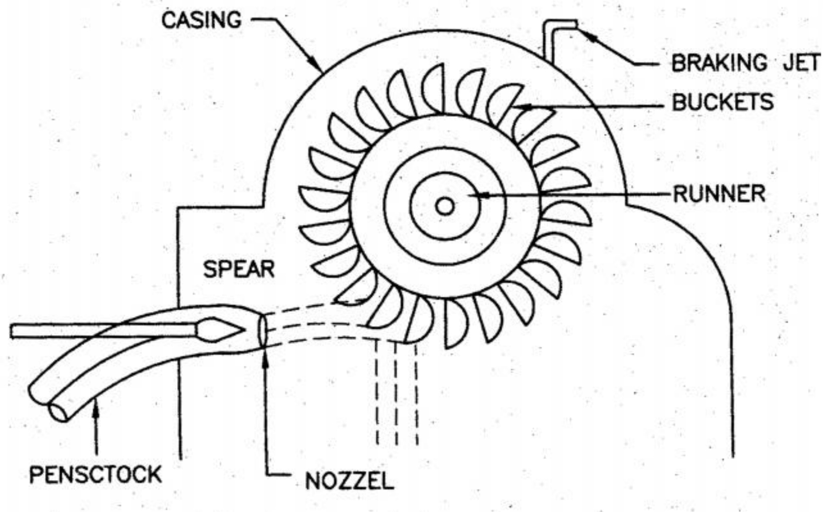


FIG. 3.6 IMPULSE TURBINE

Prevented from bursting. On the other hand, when load on the turbine increases, additional water is drawn from the surge tank to meet the increased load requirement. Hence, a surge tank overcomes the abnormal pressure in the conduit when load on the turbine falls and acts as a reservoir during increase of load on the turbine.

(e) Penstocks. Penstocks are open or closed conduits which carry water to the turbines. They are generally made of reinforced concrete or steel. Concrete penstocks are suitable for low * Because in case of open conduits, regulating gates control the inflow at the headworks and the spillway discharges the surplus water heads (< 30 m) as greater pressure causes rapid deterioration of concrete. The steel penstocks can be designed for any head; the thickness of the penstock increases with the head or working pressure. Various devices such as automatic butterfly valve, air valve and surge tank are provided for the protection of penstocks. Automatic butterfly valve shuts off water flow through the penstock promptly if it ruptures. Air valve maintains the air pressure inside the penstock equal to outside atmospheric pressure. When water runs out of a penstock faster than it enters, a vacuum is created which may cause the penstock to collapse. Under such situations, air valve opens and admits air in the penstock to maintain inside air pressure equal to the outside air pressure.

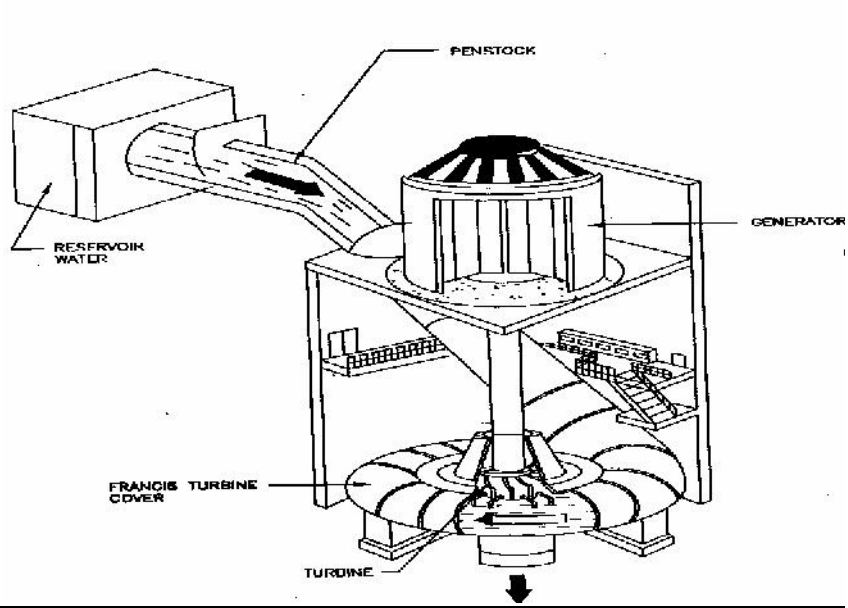
(f) Tailrace. Tailrace is a water way through which water is discharged from hydro turbine.

2. Water turbines. Water turbines are used to convert the energy of falling water into mechanical energy. The principal types of water turbines are:

(a) **Impulse turbines.**
(b) Reaction turbines.

(a) Impulse turbines. Such turbines are used for high heads. In an impulse turbine, the entire pressure of water is converted into kinetic energy in a nozzle and the velocity of the jet drives the wheel. The example of this type of turbine is the Pelton wheel. It consists of a wheel fitted with elliptical buckets along its periphery. The force of water jet striking the buckets on the wheel drives the turbine. The quantity of water jet falling on the turbine is controlled by means of a *needle* or *spear* placed in the tip of the nozzle. The movement of the needle is controlled by the governor. If the load on the turbine decreases, the governor pushes the needle into the nozzle, thereby reducing the quantity of water striking the buckets. Reverse action takes place if the load on the turbine increases.

Reaction Turbine-Francis Turbine



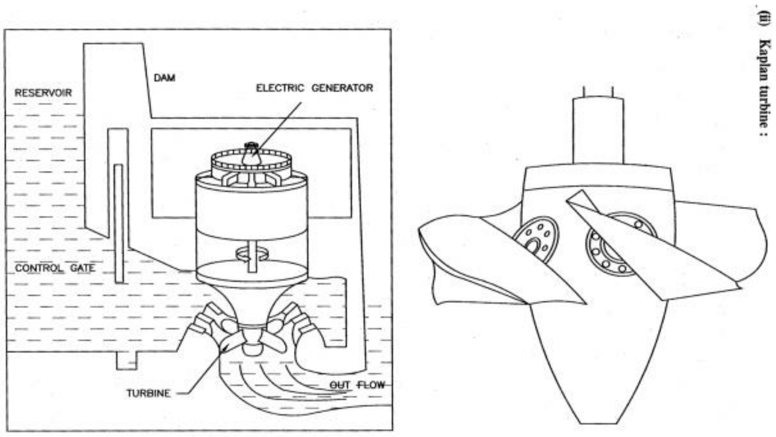


FIG 3.8 KAPLAN TURBINE

Reaction Turbine- Kaplan Turbine

(b) Reaction turbines. Reaction turbines are used for low and medium heads. In a reaction turbine, water enters the runner partly with pressure energy and partly with velocity head. The important types of reaction turbines are :

(I) Francis turbines
(II) Kaplan turbines

A Francis turbine is used for low to medium heads. It consists of an outer ring of stationary guide blades fixed to the turbine casing and an inner ring of rotating blades forming the runner. The guide blades control the flow of water to the turbine. Water flows radially inwards and changes to a downward direction while passing through the runner. As the water passes over the “rotating blades” of the runner, both pressure and velocity of water are reduced. This causes a reaction force which drives the turbine. A Kaplan turbine is used for low heads and large quantities of water. It is similar to Francis turbine except that the runner of Kaplan turbine receives water axially. Water flows radially inwards Bhakra Dam Generating Stations through regulating gates all around the sides, changing direction in the runner to axial flow. This causes a reaction force which drives the turbine.

3. Electrical equipment. The electrical equipment of a hydro-electric power station includes alternators, transformers, circuit breakers and other switching and protective devices.

Questions to be answered

Q. 01. Explain factor affecting the choice for sitting of a Hydro-electric Power Plant.

Q. 02. Give out advantages and Disadvantages of Hydro-Electric Power Station.

Q. 03. Explain Fly ball type of governor Mechanism used for speed control.

Q. 04. Compare Steam Power Plant and Hydro-Electric Power Plant.

Q. 05. Explain operation of Pumped storage peak load plant.

Conclusion.

Experiment No. 03

Date of Performance: _________

Date of Submission: __________

Aim: Study of Nuclear Power Plant.

D. Theory.

Introduction.

A generating station in which nuclear energy is converted into electrical energy is known as a **nuclear power station.** In nuclear power station, heavy elements such as Uranium (U235) or Thorium (Th232) are subjected to nuclear fission* in a special apparatus known as a reactor. The heat energy thus released is utilized 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.

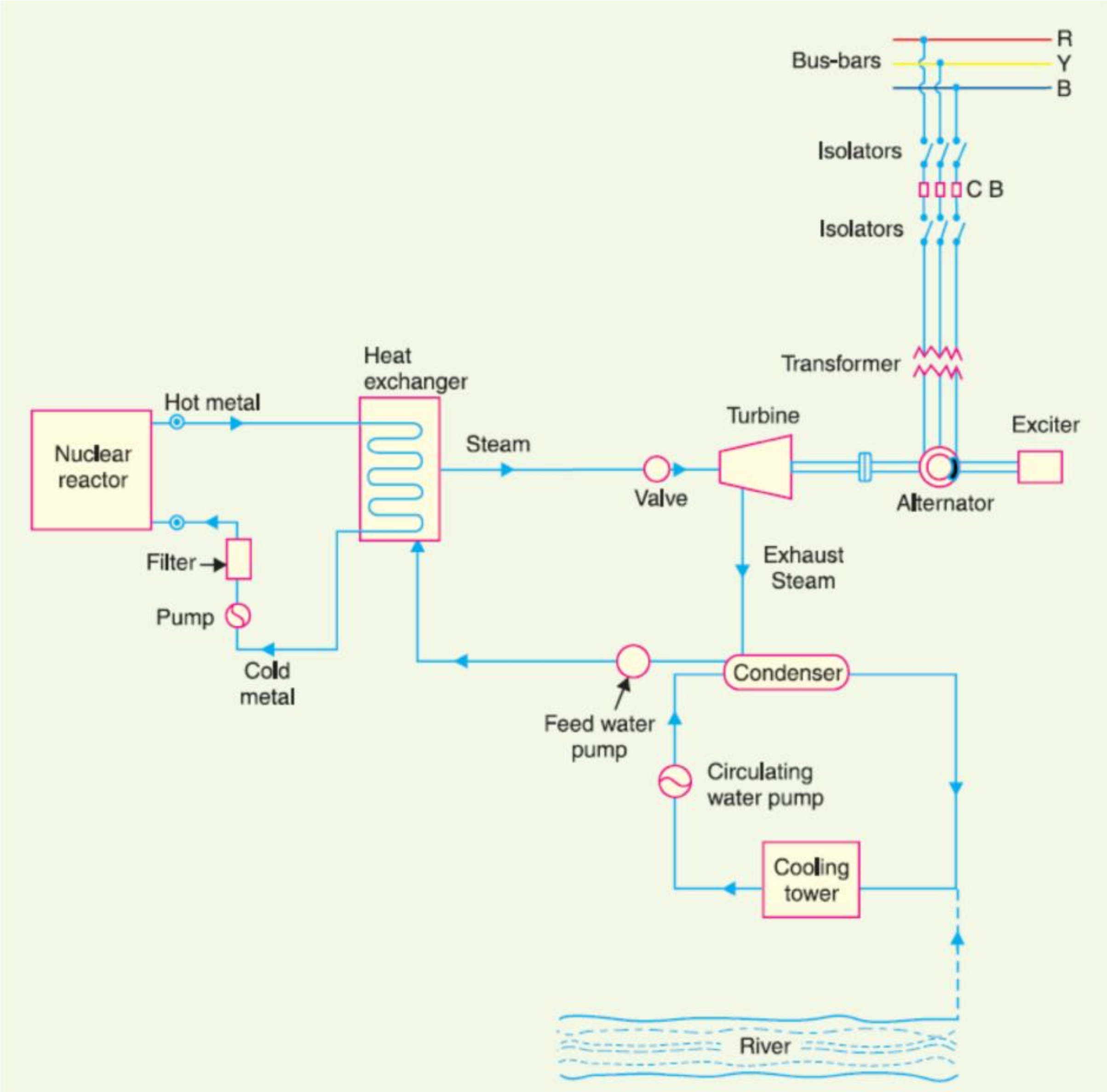
The most important feature of a nuclear power station is that huge amount of electrical energy can be produced from a relatively small amount of nuclear fuel as compared to other conventional types of power stations. It has been found that complete fission of 1 kg of Uranium (U235) can produce as much 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.

E. Schematic Arrangement of Nuclear Power Plant.

The schematic arrangement of a nuclear power station is shown in Figure. The whole arrangement can be divided into the following main stages:

1. **Nuclear reactor**
2. **Heat exchanger**
3. **Steam turbine**
4. **Alternator.**

Schematic Diagram of a Nuclear Power Plant



1. **Nuclear reactor.** It is an apparatus in which nuclear fuel (U235) 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. A nuclear reactor is a cylindrical stout pressure vessel and houses fuel rods of Uranium, moderator and control rods (See Figure). The fuel rods constitute the fission material and release huge amount of energy when bombarded with slow moving neutrons. The moderator consists of graphite rods which enclose the fuel rods. The moderator slows down the neutrons before they bombard the fuel rods. The control rods are of cadmium and are inserted into the reactor. Cadmium is strong neutron absorber and thus regulates the supply of neutrons for fission. When the control rods are pushed in deep enough, they absorb most of fission neutrons and hence few are available for chain reaction which, therefore, stops. However, as they

are being withdrawn, more and more of these fission neutrons cause fission and hence the intensity of chain reaction (or heat produced) is increased. Therefore, by pulling out the control rods, power of the nuclear reactor is increased, whereas by pushing them in, it is reduced. In actual practice, the lowering or raising of control rods is accomplished automatically according to the requirement of load. The heat produced in the reactor is removed by the coolant, generally a sodium metal. The coolant carries the heat to the heat exchanger.

2. **Heat exchanger.** The coolant gives up heat to the heat exchanger which is utilized 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.

Questions to be answered

Q. 01. Explain factors affecting the choice for sitting of a Nuclear Power Plant.

Q. 02. Explain working of a Nuclear Reactor with the help of its cross sectional diagram and material used for various components.

Q. 03. Discuss Advantages and Disadvantages of a Nuclear Power Plant.

Q. 04. Explain special precautions to be taken for disposal of nuclear ash.

Q. 05. Explain critical state of nuclear reactor.

Conclusion.

Experiment no: 04

Date of Performance: _________

Date of Submission: __________

Aim: Measurements of the voltage and current of the solar cells by changing the direction of solar panel

Theory:

D. Solar Cell.

A solar cell is any device that directly converts the energy in light into electrical energy through the process of photovoltaic. The development of solar cell technology begins with the 1839 research of French physicist Antoine-César Becquerel. Becquerel observed the photovoltaic effect while experimenting with a solid electrode in an electrolyte solution when he saw a voltage developed when light fell upon the electrode. *Photovoltaic* is the field of technology and research related to the practical application of photovoltaic cells in producing electricity from light, though it is often used specifically to refer to the generation of electricity from sunlight. Cells can be described as *photovoltaic* even when the light source is not necessarily sunlight (lamplight, artificial light, etc.). In such cases the cell is sometimes used as a photo detector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity.

The operation of a photovoltaic (PV) cell requires 3 basic attributes:

1. The absorption of light, generating either electron-hole pairs.
2. The separation of charge carriers of opposite types.
3. The separate extraction of those carriers to an external circuit.

E. Solar Panel

A **solar panel** is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. A photovoltaic module is a packaged, connected assembly of solar cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output - an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring.

Electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. The cells must be connected electrically to one another and to the rest of the system.

F. Voltage and Current of Solar Cells

Two important quantities to characterize a solar cell are

- Open circuit voltage (V_{oc}): The voltage between the terminals when no current is drawn (infinite load resistance)
- Short circuit current (I_{sc}): The current when the terminals are connected to each other (zero load resistance)

The short circuit current increase with the light intensity, as higher intensity means more photons, which in turn means more electrons. Since the short circuit current I_{sc} is roughly proportional to the area of the solar cell, the short circuit current density, $J_{sc} = I_{sc}/A$, is often used to compare solar cells.

When a load is connected to the solar cell, the current decreases and a voltage develops as charge builds up at the terminals. The resulting current can be viewed as a superposition of the short circuit current, caused by the absorption of photons, and a ***dark current***, which is caused by the potential built up over the load and flows in the opposite direction. As a solar cell contains a PN-junction (LINK), just as a diode, it may be treated as a diode. For an ideal diode, the dark current density is given by

$$J_{dark}(V) = J_0(e^{qV/k_BT} - 1) \quad (1)$$

Here J_0 is a constant, q is the electron charge and V is the voltage between the terminals. The resulting current can be approximated as a superposition of the short circuit current and the dark current:

$$J = J_{sc} - J_0(e^{qV/k_BT} - 1) \quad (2)$$

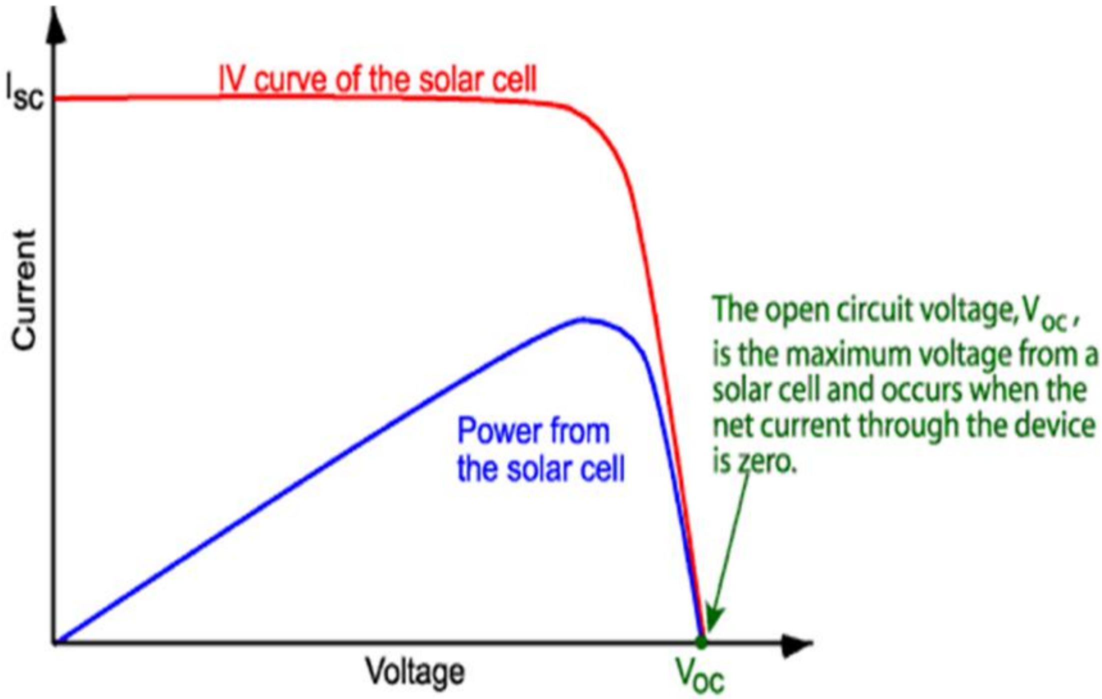
To find an expression for the open circuit voltage, V_{oc}, we use (2) setting J = 0. This means that the two currents cancel out so that no current flows, which exactly is the case in an open circuit. The resulting expression is

$$V_{oc} = \frac{k_BT}{q} \ln\left(\frac{J_{sc}}{J_0} + 1\right) \quad (3)$$

The current and power output of photovoltaic solar panels are approximately proportional to the sun’s intensity. At a given intensity, a solar panel’s output current and operating voltage are determined by the characteristics of the load. If that load is a battery, the battery’s internal resistance will dictate the module’s operating voltage.

A solar panel, which is rated at 17 volt, will put out less than its rated power when used in a battery system. That's because the working voltage will be between 12 and 15 volts. Because wattage (or power) is the product of volts multiplied by the amps, the module output will be reduced. For example, a 50-watt solar panel working at 13.0 volts will products 39.0 watts (13.0 volts x 3.0 amps = 39.0 watts). This is important to remember when sizing a PV system.

An I-V curve is simply all of a solar panel's possible operating points (voltage/current combinations) at a given cell temperature and light intensity. Increases in cell temperature increase solar panels current slightly.



Apparatus:

1. Solar Energy Trainer NV6005
2. DB15 connector
3. Solar cell
4. Ammeter
5. Patch cords
4. Voltmeter

Circuit diagram:

Procedure:

1. Take the Solar Energy Trainer NV6005 along with Solar Panel**.**
2. Place the solar panel in the stand and adjust the panel at an angle of about 45º with the ground. Direct the sunlight straight at the solar panel (angle of 90º).
Note: If sunlight is not properly available then any source of light like lamp can Be used.
3. With the DB15 connector connect the Solar Energy Trainer NV6005 with the Solar Panel. Then wait for 1 minute to avoid errors due to temperature fluctuations.
4. Measure the voltage (V_1) of S_1 solar cell by connecting its output across voltmeter with the help of patch cords. Similarly, you can measure the voltages of other solar cells. Record the voltage of all cells (V_1, V_2, V_3, V_4, V_5, and V_6), respectively in the observation Table.
5. Measure the current (I_1) of S_1 solar cell by connecting the ammeter across S_1 Solar cell with the help of patch cords. Similarly, you can measure the current of other solar cells. Record the current of all cells (I_1, I_2, I_3, I_4, I_5, and I_6) respectively in the observation table.

Observation table:

Sr. No.	Solar cell	DC Voltage(V)	DC Current(mA)
1	S_1		
2	S_2		
3	S_3		
4	S_4		
5	S_5		

Conclusion:

Questions to be answered

Q. 01. Explain the working of solar cell.

Q. 02. Explain the advantages and disadvantages of solar power utilization.

Q. 03. Do the solar panels store energy?

Q. 04. Explain the terms with proper diagrams and notations.
1. **Zenith angle**
2. **Solar declination angle**
3. **Solar azimuth angle**

Experiment No. 05

Date of Performance: _________

Date of Submission: __________

Aim: Measurements of the voltage and current of the solar cells in series and parallel combinations.

Apparatus:

1. Solar Energy Trainer NV6005
2. Voltmeter
3. Ammeter
4. Connecting wires

Theory:

A. Introduction.

We have seen previously seen the behavior and design of solar cells in isolation. In practice they are connected together and packaged as a module to provide specific power output and to protect the solar cells from the elements. We need to understand how the different connections between solar cells affect performance
– Series: give greater voltage
– Parallel: gives greater current

B. Series connection of Solar cells.

Series resistance in PV devices includes the resistance of a cell, its electrical contacts, module interconnections, and system wiring. These resistances are in addition to the resistance of the electrical load. Some amount of series resistance in a PV system is unavoidable because all conductors and connectors have some resistance. However, increasing series resistance over time can indicate problems with electrical connections or cell degradation. Series resistance reduces the voltage over the entire I-V curve. See Figure A.

Increasing series resistance also decreases maximum power, fill factor, and efficiency. If a PV device is operated at constant voltage (such as for battery charging), increasing series resistance results in decreasing operating current. Individual cells are connected in series by soldering thin metal strips from the top surface (negative terminal) of one cell to the back surface (positive terminal) of the next. Modules are connected in series with other modules by connecting conductors between the negative terminals of one module to the positive terminal of another module. When individual devices are electrically connected in series, the positive connection of the whole circuit is made at the device on one end of the string and the negative connection is made at the device on the opposite end. See Figure B.

Figure A

Figure B

Only PV devices having the same current output should be connected in series. When similar devices are connected in series, the voltage output of the entire string is the sum of the voltages of the individual devices, while the current output for the entire string remains the same as for a single device. Correspondingly, the I-V curve for a string of similar PV devices is the sum of the I-V curves of the individual devices. See Figure C.

[redacted]

Figure C

B. <u>Shunt (Parallel) connection of Solar cells.</u>

Shunt (parallel) resistance accounts for leakage currents within a cell, module, or array. Shunt resistance has an effect on an I-V curve opposite to the effect of series resistance. Decreasing shunt resistance reduces fill factor and efficiency, and lowers maximum voltage, current, and power, but does not affect short-circuit current. See Figure D. Decreasing shunt resistance over time can indicate short-circuits between cell circuits and module frames, or ground faults within an array.

[redacted]

Figure D

Parallel connections are not generally used for individual PV devices, especially cells, but for series strings of cells and modules. Parallel connections involve connecting the positive terminals of each string together and all the negative terminals together at common terminals or bus bars. See Figure E.

Figure E

Procedure:

A. <u>Series combination of cells.</u>

1. Take the Solar Energy Trainer NV6005 along with Solar Panel.

2. Place the Solar Panel in the stand and adjust the panel at an angle of about 45º with the ground. Direct the sunlight straight at the solar panel (angle of 90º).

Note: If sunlight is not properly available then any source of light like lamp can Be used.

3. With the DB15 connector connect the Solar Energy Trainer NV6005 with the Solar Panel. Then wait for 1 minute to avoid errors due to temperature Fluctuations.

4. With the patch cords, connect outputs of all cells one by one in series such that the positive terminal of one connected to the negative terminal of the other as

5. Connect the positive and negative terminal of the series combination across the voltmeter. Record the total voltage of the series combination.

6. Now connect the positive and negative terminal of the series combination across the ammeter. Record the current of the series combination in the Observation Table given below.

Circuit Diagram:

Observation table:

Sr. No.	Solar cell	Voltage(V)	Current (mA)	Voltage of series combination(V)	Current of series combination (mA)
1	S_1+S_2				
2	$S_1+S_2+S_3$				
3	$S_1+S_2+S_3+S_4$				
4	$S_1+S_2+S_3+S_4+S_5$				
5	$S_1+S_2+S_3+S_4+S_5+S_6$				

Calculations:

Sum of the voltages of all solar cells V_{Total} = V1+ V2 +V3 + V4 + V5+V6 = ……………V
Total voltage of series combination =……….V. Hence it is clear that the total voltage of the series combination is equal to the sum of the voltage of all solar cells.

Total current in series combination =…………….mA
Hence it is clear that the total current of the series combination is equal to the individual current of each solar cell.

B. Parallel combination of cells.

7. Take out all the cords from the trainer.

8. With the patch cords, connect all cells one by one in parallel such that the positive terminal of one connected to the positive terminal of the other, and also the negative terminal of one connected to the negative terminal.

9. Connect the positive and negative terminal of the parallel combination across the voltmeter as shown in circuit diagram. Record the voltage of the parallel combination in the Observation Table given below.

10. Now, connect the positive and negative terminal of the parallel combination across the ammeter as shown in figure6. Record the total current of the parallel combination in the Observation Table given below.

Note: To measure current by on board ammeter, do not connect more than 3 solar cells in parallel. For measuring total current of parallel combination of more than 3 solar cells, arrange a digital multimeter or analog ammeter of 1 Ampere rating in the laboratory.

Circuit Diagram:

Observation table:

Sr. No.	Solar cell	Voltage(V)	Current(mA)	Voltage of Parallel combination(V)	Current of Parallel combination(mA)
1	S_1 || S_2				
2	S_1 || S_2 || S_3				
3	S_1 || S_2 || S3 || S4				
4	S_1 || S_2 || S3 || S4 || S_5				
5	S_1 || S_2 || S3 || S4 || S5 || S6				

Calculations:

Total voltage of parallel combination =………..V
Hence it is clear that the total voltage of the parallel combination is equal to the individual voltage of each solar cell.
Sum of the current of all solar cells = $I_{Total} = I_1 + I_2 + I_3+I_4+I_5+I_6$ = ……………mA
Total current of parallel combination =……….mA
Hence it is clear that the total current of the parallel combination is equal to the sum of the current of all solar cells.

Conclusion:

QUESTIONS TO BE ANSWERED

Q1. Explain the difference between Solar Cell, Solar Module and Solar Array.

Q2. Why the Solar panel is kept south facing in India?

Q3. What are the natural factors which affect the performance of Solar Panels?

Q4. What are the different types of solar cell?

Experiment No. 06

Date of Performance: _________

Date of Submission: __________

Aim: Study of Measurement of voltage and current of wind energy based DC supply with Change in direction of wind.

Apparatus:

1. Wind Energy Trainer NV6008
2. Table Fan
3. Connecting wires

Theory:

A. Introduction.

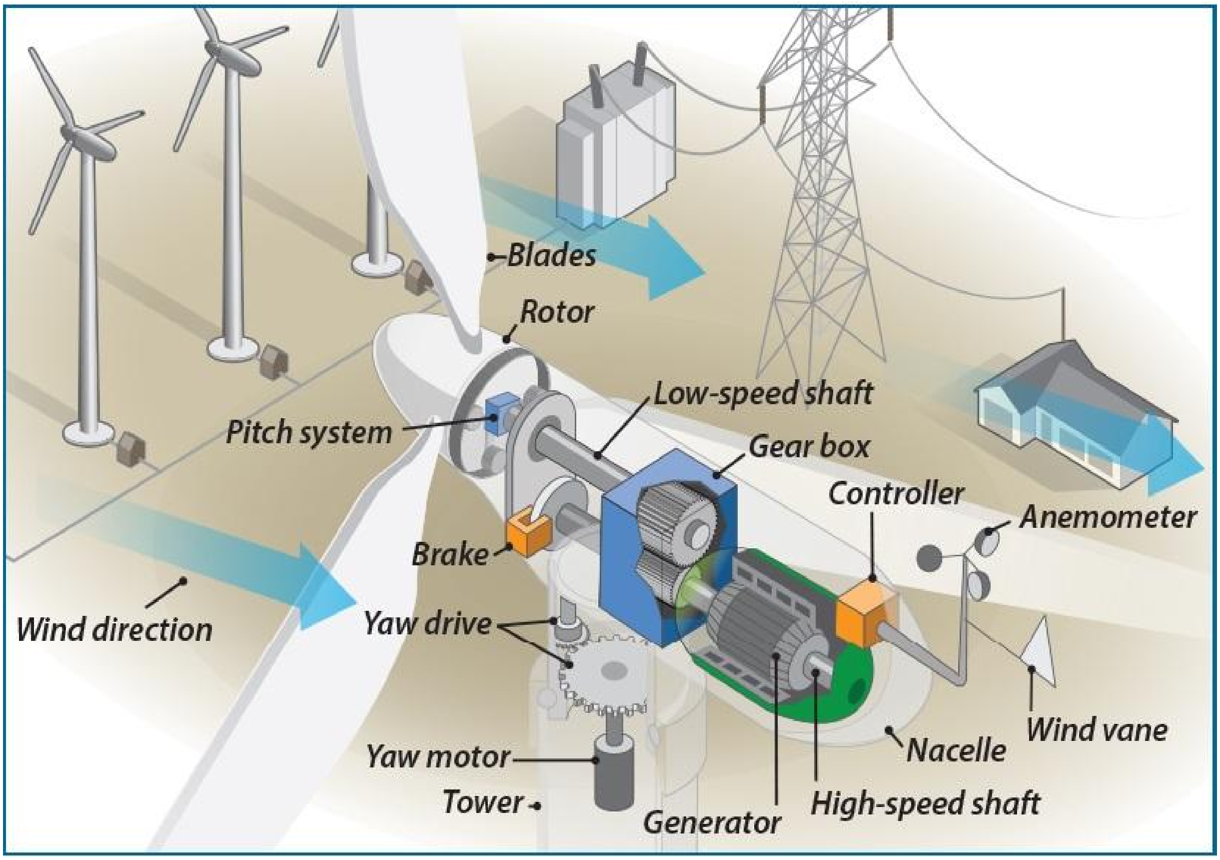
Wind power is the most common form of renewable energy. Here, electricity is generated by blades turning turbines which run a generator. Wind power has a potentially infinite energy supply and a number of advantages to its use. Wind is a free commodity and is in infinite supply and thus an affordable renewable energy source. Further, generating wind does not produce toxins or pollutants to the environment and thus assists in the fight against global warming

Wind is a completely renewable energy source. As long as the sun shines, the winds will blow. It will not pollute our air and water, and it will not produce wastes that will pile up year after year. We can continue to use wind turbine effectively and efficiently for centuries, without worrying about how it will affect future generations.

The terms wind energy or wind power describes the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity. So how do wind turbines make electricity? Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity.

The wind turns the blades, which spin a shaft, which connects to a generator and generates electricity. Wind energy is the fastest growing energy technology in the world. It currently makes up a small percentage of our total energy picture, but the rate at which it is growing promises to make it an important part of our energy mix in the future. The benefits of wind energy are numerous.

B. Components of Wind Generator.



Wind turbines harness the power of the wind and use it to generate electricity. Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity. This illustration provides a detailed view of the inside of a wind turbine, its components, and their functionality.

1. **Anemometer:**
   Measures the wind speed and transmits wind speed data to the controller.
2. **Blades:**
   Lifts and rotates when wind is blown over them, causing the rotor to spin. Most turbines have either two or three blades.
3. **Brake:**
   Stops the rotor mechanically, electrically, or hydraulically, in emergencies.

4. **Controller:**
   Starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 55 mph. Turbines do not operate at wind speeds above about 55 mph because they may be damaged by the high winds.
5. **Gear box:**
   Connects the low-speed shaft to the high-speed shaft and increases the rotational speeds from about 30-60 rotations per minute (rpm), to about 1,000-1,800 rpm; this is the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don’t need gear boxes.
6. **Generator:**
   Produces 50/60-cycle AC electricity; it is usually an off-the-shelf induction generator or synchronous generator.
7. **High-speed shaft:**
   Drives the generator.
8. **Low-speed shaft:**
   Turns the low-speed shaft at about 30-60 rpm.
9. **Nacelle:**
   Sits atop the tower and contains the gear box, low- and high-speed shafts, generator, controller, and brake. Some nacelles are large enough for a helicopter to land on.
10. **Pitch:**
    Turns (or pitches) blades out of the wind to control the rotor speed, and to keep the rotor from turning in winds that are too high or too low to produce electricity.
11. **Rotor:**
    Blades and hub together form the rotor. Modern rotor may be up to 100m diameter.
12. **Tower:**
    Made from tubular steel (shown here), concrete, or steel lattice. Supports the structure of the turbine. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.
13. **Wind vane:**
    Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.
14. **Yaw drive:**
    Orients upwind turbines to keep them facing the wind when the direction changes. Downwind turbines don’t require a yaw drive because the wind manually blows the rotor away from it.
15. **Yaw motor:**
    Powers the yaw drive.

C. <u>Wind Power.</u>

For a wind turbine operating in a wind velocity of V (m/s) with a rotor swept area of A (m^2) and air density ρ, the theoretical power available would be

$$P = \frac{1}{2} \rho A V^3$$

This however is only the theoretical power and in practice the value will be a lot less. A value known as the power coefficient (Cp) is the ratio of the actual power output compared to the theoretical available.

$$Cp = \frac{\text{Actual Power}}{\text{Theoretical Power}}$$

An analysis from Betz states that the value of Cp is very unlikely to exceed the value of 0.593

Circuit Diagram :

Procedure:

1. Place the Wind Turbine Setup in front of wind i.e. in opposite direction to that of wind
2. Take the Wind Energy Trainer NV6008.
3. Now connect the DC output of Wind Turbine (or Generator) to the Wind Energy Trainer NV6008 at the indicated positions of Wind Energy Generator Section.
4. Connect the output of Wind Turbine (or Generator) to the voltmeter and verify which terminal of wind energy supply is positive and which one is negative. If the pointer of voltmeter deflects towards positive direction then consider the red connector as positive terminal and black connector as negative terminal of the DC supply. If the pointer of voltmeter deflects towards negative direction then consider the red connector as negative terminal and black connector as positive terminal of the DC supply.
5. Measure the open circuit voltage of the Wind Turbine Supply.
6. Connect the output of Wind Turbine (or Generator) to the ammeter and measure the short circuit current.
7. Change the direction of wind with the help of table fan.
8. Repeat steps from 4 to 6 of procedure.

Observation Table:

Sr. No.	Direction of Wind	Voltage V	Current mA
1			
2			
3			
4			

Conclusion:

QUESTIONS TO BE ANSWERED

Q 01. **How much electricity does one wind turbine produce?**

Q 02. **How many wind farms are there in the State Gujarat?**

Q 03. **Explain Pitch Control & Yarn Control?**

Experiment No. 07

Date of Performance: _________

Date of Submission: __________

Aim: Introduction to MATLAB

- **Solve the following problems using MATLAB commands**

1. $x = e^{-2.5\times10^{-4}} + 1.5 \times 10^{-6}$
2. y= $log20 - \log_{10}100 + \sqrt{3}(log5)$
3. find y=$e^{x} + logx + x\sqrt[3]{2}$ for -5<x<5
4. Create a matrix $A = \begin{matrix} 25 & 3 & 20 \\ 1 & 6 & 9 \\ 65 & 7 & 84 \end{matrix}$
   (i) extract the second row of the matrix A.
   (ii) Multiply matrix A with 5.
   (iii) Add 3 to each and every element of matrix A.
   (iv) Find the size of the given matrix A.
5. Write a program to create a sine wave.
6. Write a program to create a circle with centre (2,2) and radius 5cm .
7. Evaluate the given function and plot its response for the values of a ranging from 0 to 10 with a step size of 0.1.

   $$S(t) = \sin(2\pi5t) + \cos(2\pi3t) + e^{-0.1t}$$

8. Calculate the inverse of matrix

   $$A = \begin{matrix} 1 & 1 & 1 \\ 1 & 0 & 1 \\ -1 & 0 & 0 \end{matrix}$$

9. Consider two complex numbers and convert them into polar form.
10. Consider the voltage measurement system having 10 different voltage values measured. If the values are within the range of 220 to 240 volts then display actual value else if the

values are within 210 to 220 add 10 to it. and if the values are within 240 to 250 volts, subtract 10 from it.

Answers

1. x=exp(-2.5*(10)^(-4))+1.5*(10)^(-6)   Ans: 0.9998

2. y= log (20) - log10(100)+ sqrt(3)*log (5)   Ans: 3.7834

3. y= exp(x)+log (x)+ x* nthroot (2,3)   Ans: define value of x .

```
H=input('enter the value of x')
if H >-5 && H <5
   y= exp(H)+log (H)+ H* nthroot (2,3)
   else
      printf('Invalid input')
end
```

4. A=[25 3 20;1 6 9;65 7 84]

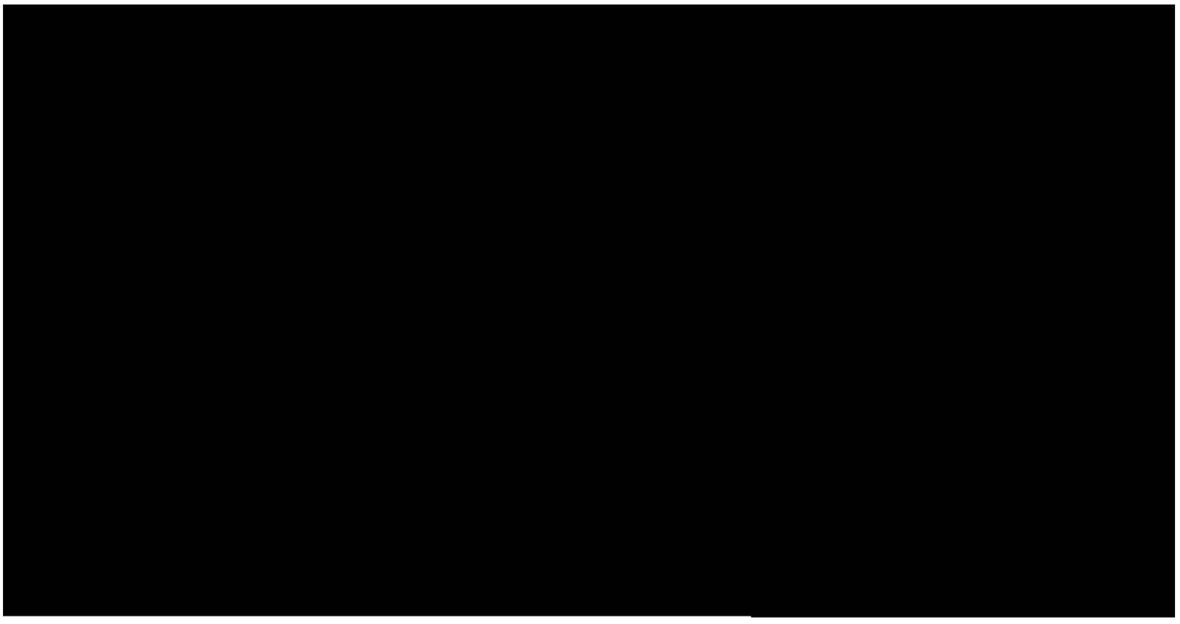
```
B=A(2,:)
G=(A*5)
H= (A+3)
Size (A)
```

5. t=0:0.02:10

```
sin (t)
plot(sin(t))
xlabel('Time')
ylabel('Voltage')
title('Sine Wave')
grid
```

6. [a,b]=scircle1(2,2,5)

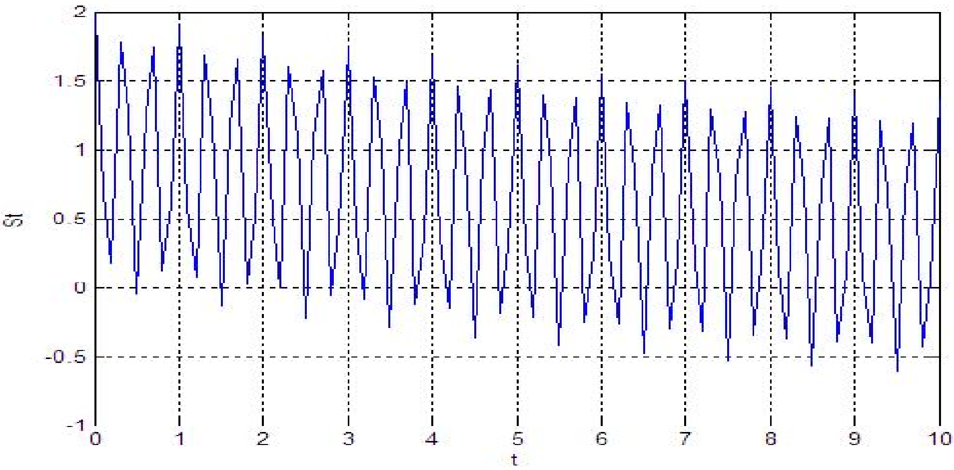
```
plot(a,b)
title('Circle')
grid
```



7. t=0:0.1:10

```
St=sin(2*pi*5*t)+cos(2*pi*3*t)+exp(-0.1*t)
plot(t,St)
xlabel('t')
```

```
ylabel('St')
grid
```



8. a=[1 1 1;1 0 1;-1 0 0]
   b=inv(a)
   Ans :- b =

0	0	-1
1	-1	0
0	1	1

9. a= 3+j*5;
   b=4+j*5;
   valuea =abs(a)
   anglea= atan(5/3)
   valueb =abs(b)
   angleb= atan(5/4)

   Ans :- valuea = 5.8310
   anglea = 1.0304
   valueb = 6.4031
   angleb = 0.8961

10. a=input('enter the value of the voltage:')
    if a>210 && a<220
    b=a+10
    else if a>240 && a<250

[redacted]


```
        b=a-10
    else b=a
    end
end
```

Ans:-

enter the value of the voltage:245

a =   245

b =   235

Experiment No. 08

Date of Performance: _________

Date of Submission: __________

Aim: MATLAB program for Short transmission line analysis

[1] An overhead single phase line delivers 1100 KW at 33KV at 0.8 p.f. lagging. The total resistance of the line is 10 Ohm and the total inductive reactance is 15 ohm. Find percentage regulation, sending end power factor and efficiency of transmission line.

Matlab code

```
% Analysis of short transmission line- Prcatical-2-Example-1

clc

pr=input('Enter the value of pr=') % Receiving end power
vr=input('Enter the value of vr=') % Receiving end voltage
R=input('Enter the value of R=') % Receiving end Resistance
X=input('Enter the value of X=') % Receiving end Reactance

cospir=input('Enter the value of cospir=') % Receiving end power
factor

Vr=vr*1000;
Pr=pr*1000;

% VR=(Vs-Vr)/Vr

I=Pr/(Vr*cospir);

sinphir=sqrt(1-(cospir*cospir));

Vs=Vr+I*(R*cospir+X*sinphir);

Voltageregulation = (Vs-Vr)*100/Vr;

% Sending end power factor

cospis=((Vr*cospir)+ (I*R))/Vs;

% effficiecy= Pr/Ps
```

[redacted]


```
losses=(I^2*R);
Ps=Pr+ losses;

efficency = (Pr/Ps)*100;


fprintf('\n Results of calculations for short transmission line')

fprintf('\n Sending end Currennt=%f Amp,\n Sending end voltage=%f V,\n Sending end power factor=%f lagging\n',I,Vs,cospis)

fprintf('\n Efficiency of line=%f,\n Voltage Regulation=%f %\n',efficency,Voltageregulation)
```

OUTPUT

```
Enter the value of pr=1100

pr =1100

Enter the value of vr=33

vr =33

Enter the value of R=10

R = 10

Enter the value of X=15

X = 15

Enter the value of cospir=0.8

cospir = 0.8000



Results of calculations for short transmission line
Sending end Current=41.666667 Amp,
Sending end voltage=33708.333333 V,
Sending end power factor=0.795550 lagging

Efficiency of line=98.446240,
Voltage Regulation=2.146465 >>
```

[2] A single phase 11KV line with a length of 15 Km is to transmit 500 KVA. The inductive reactance of the line is 0.5 ohm per km and the resistance 0.3 ohm per Km. Calculate the efficiency and regulation for 0.8 p.f lagging.

```
%  Anlaysis of short transsmisison line- Prcatical-2-Exapmle-2

clc
sr=input('Enter the value of sr=') % Receiving end power
vr=input('Enter the value of vr=') % Receiving end vooltage
r=input('Enter the value of r=') % Receiiving end Resistance
x=input('Enter the value of x=') % Receiving end Reactance
l=input ('Enter the value of length=')% transmission line length

cospir=input('Enter the value of cospir=') % Receiving end power
factor

pr=sr*cospir


Vr=vr*1000;
Pr=pr*1000;

R=r*l;
X=x*l;

% VR=(Vs-Vr)/Vr

I=Pr/(Vr*cospir);

sinphir=sqrt(1-(cospir*cospir));

Vs=Vr+I*(R*cospir+X*sinphir);

Voltageregulation = (Vs-Vr)*100/Vr;

% Sending end power factor

cospis=((Vr*cospir)+ (I*R))/Vs;

% effficiecy= Pr/Ps
```

```
losses=(I^2*R);
Ps=Pr+ losses;

efficency = (Pr/Ps)*100;

fprintf('\n Results of calculations for short transmission line')

fprintf('\n Sending end Currennt=%f Amp,\n Sending end voltage=%f V,\n Sending end power factor=%f lagging\n',I,Vs,cospis)
fprintf('\n Efficiency of line=%f,\n Voltage Regulation=%f %\n',efficency,Voltageregulation)
```

OUTPUT

```
Enter the value of sr=500

sr = 500

Enter the value of vr=11

vr =11

Enter the value of r=0.3

r = 0.3000

Enter the value of x=0.5

x =0.5000

Enter the value of length=15

l = 15

Enter the value of cospir=0.8

cospir = 0.8000

pr = 400

Results of calculations for short transmission line
Sending end Current=45.454545 Amp,
Sending end voltage=11368.181818 V,
Sending end power factor=0.792083 lagging

Efficiency of line=97.728420,
```

```
Voltage Regulation=3.347107 >>
```

CONCLUSION:

[redacted]

Experiment No. 09

Date of Performance: _________

Date of Submission: __________

Aim: MATLAB based Simulation of Uncompensated Transmission Line

- **Specific Objective**

After performing this experiment we should able to:

- Know the importance of compensation in a system.

[redacted]

Fig 10.1 Simulink diagram of uncompensated transmission line

Waveforms:

[redacted]

Fig 10.2 Waveforms of sending & receiving end voltages and currents

Fig 10.3 Waveforms of sending & receiving end Active and Reactive power

CONCLUSION:

With the above simulation of uncompensated transmission line we get voltage regulation: 25% and Efficiency: 87.80 %.

Experiment No. 10

Date of Performance: _________

Date of Submission: __________

Aim: Prepare layout of substation for a given bus arrangement and given voltage rating with all necessary equipment.