Module 1

Introduction : Conventional and Non conventional energy resources, General structure of electrical power ~~Generation~~ systems using single line diagram approach.

Power Generation : Hydel, Nuclear, solar, & wind power generation. (Block diagram approach).

DC Circuits :

Ohm's Law and its limitations, KCL & KVL, series, parallel, series - parallel circuits. Simple Numerical.

Electric Circuit

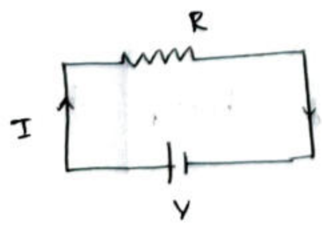
An electric circuit or network is an interconnection of the various electrical elements such as voltage source, a current source, resistor, capacitor & inductor.

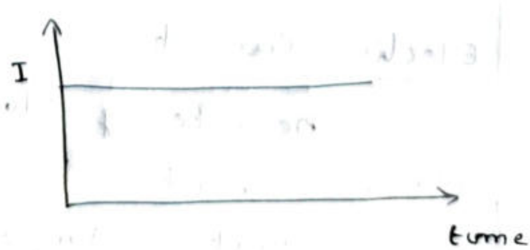
DC Circuits

A direct current circuit is a circuit where the electric current flows in one direction. A direct current circuit is an electrical circuit that consists of any combination of constant voltage sources, constant current sources & resistors.

The closed path in which an electric direct current flows is called the DC circuits. The current flows in only one direction. The resistor is the main component of dc circuit.

A direct current does not vary with time.





Basic definitions

Resistance (R)

The property of a material due to which it opposes the flow of current through it is called resistance. The unit of resistance is ohms (Ω)

The resistance of a material is directly proportional to the length and inversely proportional to area of cross section.

$$R \propto \frac{l}{A}$$

$$R = \rho \frac{l}{A}$$

$\rho \rightarrow$ Resistivity or specific resistance in Ωm

$l \rightarrow$ length in m

$A \rightarrow$ Area of cross section in m^2.

If $l = 1m$ & $A = 1m^2$ then $R = \rho$

Resistivity of a material may be defined as the resistance offered by one meter length of the material having an area of cross section $1m^2$.

$$\rho = \frac{AR}{l} \qquad \frac{m^2 \Omega}{m}$$

unit - Ohm. meter (Ωm)

Electric Current

The rate of flow of charge in an electric circuit

unit - Ampere

$$I = \frac{Q}{t}$$

Electric Potential

The ability of a charged particle to do work is called its electric potential.

unit → volt

$$\text{Electric potential} = \frac{\text{Work done}}{\text{charge}} = \frac{W}{Q}$$

Potential Difference.

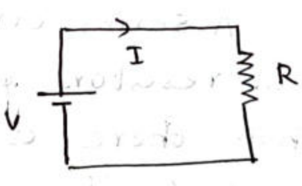
The difference between the electric potentials at any two given points in a circuit is known as potential difference in volts.

Ohm's Law

Ohm's law states that "The current ~~[illegible]~~ flowing through a conductor is directly proportional to the voltage applied across the ends of the conductor, provided temperature remains constant.

$I \propto V$, when temperature is constant

$V \propto IR$



$$I = \frac{V}{R}$$

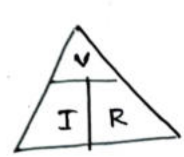
$$R = \frac{V}{I}$$

V → Potential difference in Volts

I → Current in ampere

R → Resistance of the conductor in Ω (ohm)

$$\boxed{R = \frac{V}{I} \qquad I = \frac{V}{R} \qquad V = IR}$$



Note: The law was named after German Scientist George Ohm

Limitations of Ohm's law

(1) Ohm's law cannot be applied to unilateral networks. A unilateral network has elements like diode, transistors etc which do not have same voltage - current relation for both direction of current.

(2) It is not applicable for non-linear devices such as diodes, zener diode, transistor etc.

The resistance for non-linear elements changes for different values of voltage & current.

(3) It does not hold good for non-metallic conductors such as silicon carbide. since

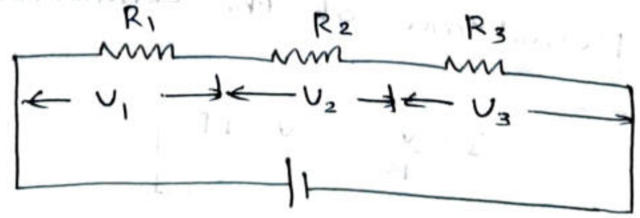
$V = k I^m \rightarrow k$ & m are constant.

(4) It is applicable only where temperature is constant.

Resistances in series

A series circuit is a circuit in which several resistors are connected end to end so that there is only one path for the current to flow.

Consider the circuit shown in fig. where three resistors are connected in series.



$V = V_1 + V_2 + V_3$

$V = IR \qquad V_1 = IR_1 \qquad V_2 = IR_2 \qquad V_3 = IR_3$

$$\therefore \quad IR = IR_1 + IR_2 + IR_3$$

$$IR = I(R_1 + R_2 + R_3)$$

$$\boxed{R_{eq} = R_1 + R_2 + R_3}$$

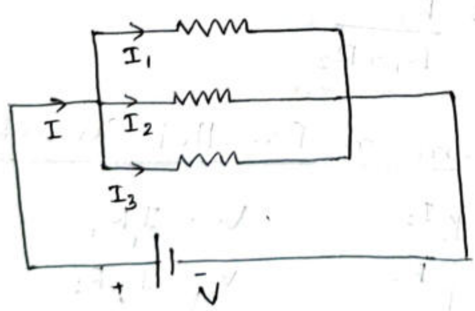
The equivalent resistance of series circuit is sum of the resistors connected in series.

Resistances in Parallel

A parallel circuit is a circuit in which several resistors are connected ~~in p~~ with their one end (starting ends) connected together and the other ends connected together to another common points.

The total current gets divided into the number of paths in parallel & The voltage across the resistors in parallel remains the same.

Consider the circuit in parallel shown below.



$$I = I_1 + I_2 + I_3$$

$I = \frac{V}{R} \qquad I_1 = \frac{V}{R_1} \qquad I_2 = \frac{V}{R_2} \qquad I_3 = \frac{V}{R_3}$

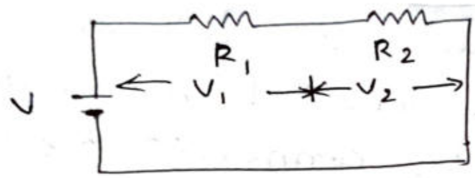
$$\therefore \quad \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{V}{R} = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

The reciprocal of the equivalent resistance of a parallel circuit is the sum of the reciprocal of the individual resistance.

Voltage division in series circuit of resistance



$$I = \frac{V}{R_1 + R_2}$$

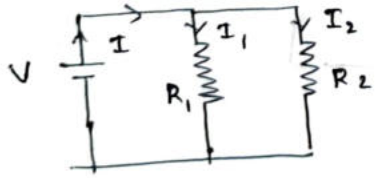
$$V_1 = I R_1 \qquad \text{ie} \qquad V_1 = \frac{V}{R_1 + R_2} \cdot R_1$$

$$\boxed{V_1 = V \cdot \frac{R_1}{R_1 + R_2}}$$

$$V_2 = I R_2$$

$$\text{ie} \qquad \boxed{V_2 = V \frac{R_2}{R_1 + R_2}}$$

Current Division in Parallel Circuit of Resistors



$$V = I_1 R_1$$
$$V = I_2 R_2$$

$$V = I_1 R_1 = I_2 R_2 \qquad I_2 = I - I_1$$

$$I_1 R_1 = I_2 R_2$$

$$I_1 R_1 = (I - I_1) R_2$$

$$I_1 R_1 = I R_2 - I_1 R_2$$

$$I_1 R_1 + I_1 R_2 = I R_2$$

$$I_1 (R_1 + R_2) = I R_2$$

$$\boxed{I_1 = I \frac{R_2}{R_1 + R_2}}$$

Similarly $\boxed{I_2 = I \frac{R_1}{R_1 + R_2}}$

Electrical Power.

The rate at which electrical work is done is called as electric Power

$P = VI$ The unit of Power is watts.

$P = \frac{V^2}{R}$

$P = I^2 R$.

Electrical Energy

It is the total amount of electrical work done in an electric circuit.

Electrical energy = Power x time.

$E = VIt$

The unit of energy is Joules or watt sec.

Kirchoff's Laws

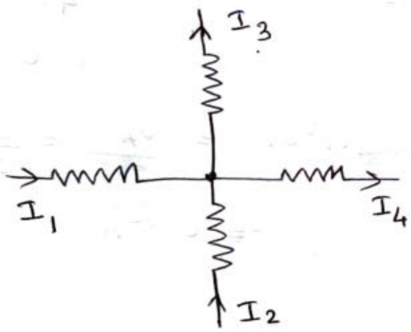
Kirchoff's laws are first discussed in 1845 by German Physicist Gustav Kirchoff. It is widely used in electrical engineering for network simplification.

(i) Kirchoff's Current Law (KCL)

It states that algebraic sum of currents meeting at a junction is zero.

OR

Sum of the currents entering the junction is equal to the sum of the currents leaving the junction.



$\Sigma I = 0$

$I_1 + I_2 - I_3 - I_4 = 0$

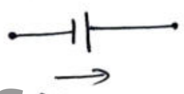
$I_1 + I_2 = I_3 + I_4$

(ii) Kirchoff's Voltage law.

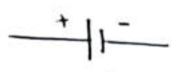
In any closed electrical circuit, the algebraic sum of all voltages & the voltage drops is equal to zero

Algebraic sum of emfs + algebraic sum of voltage drop = 0

Sign Convention



voltage rise (+)

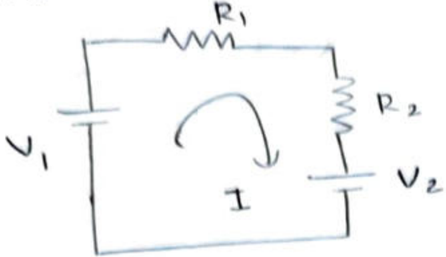


voltage drop (−ve)

voltage drop (-ve)

voltage rise (+ve)

Consider the network given



$$V_1 - V_2 = I\,(R_1 + R_2)$$

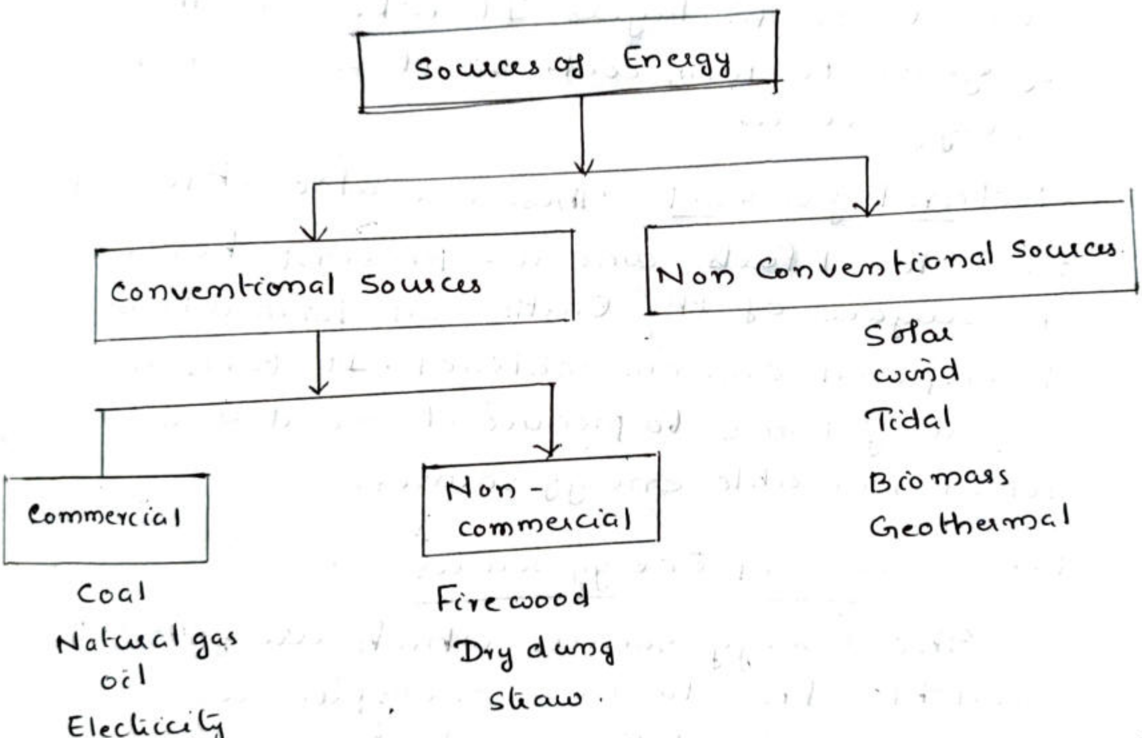
Conventional & Non Conventional Energy Sources

The natural sources of energy are divided into two categories

1. Conventional Sources of Energy
2. Non-Conventional Sources of Energy

Conventional Sources of Energy

The energy sources which we are using from past many years like petrol, coal, diesel, gas are called as Conventional Source of Energy Also more advanced mechanisms are available to extract energy from theses sources.



The energy sources that are present for a long time, found naturally on or beneath the Earth and take a to produce or replenish are known as Conventional sources of energy. Generally, these are non-renewable source of energy.

The conventional energy sources are further divided into commercial & Non commercial energy sources.

Commercial energy Sources

To get energy from commercial sources, we need to pay for it. Few examples of commercial source of energy are coal, oil, gas & electricity.

Electricity is produced by various commercial energy sources in power plants like nuclear power plant, Thermal power plant & hydro electric power plants.

Coal is a type of fossil fuel which is present beneath the surface of the Earth and was formed by decomposed organic materials due to the high compression and temperature due to Earth's layers. It takes millions of years to form coal. So it is a non-renewable energy sources.

Natural gas & oil : These are also obtained from fossil fuels and are present beneath the surface of the Earth and formed from decomposed organic material.. It takes a very long time to produce it. So it is a non-renewable energy sources.

Non Commercial Energy Sources.

The energy sources which are generally available free to use. Examples are Firewoods, cow dung and straw.

Fire woods are obtained from the trees & plants, dung is obtained from animal waste. and straw is obtained from the crop plants like wheat crops, rice crops etc.

Non Conventional Sources of Energy

The natural sources of energy that can produce useful energy continuously for a long period of time and are available again & again for use are non-conventional sources of energy. They are ~~no~~ renewable source of energy. Examples are solar energy, wind energy, bio mass energy, Geothermal energy.

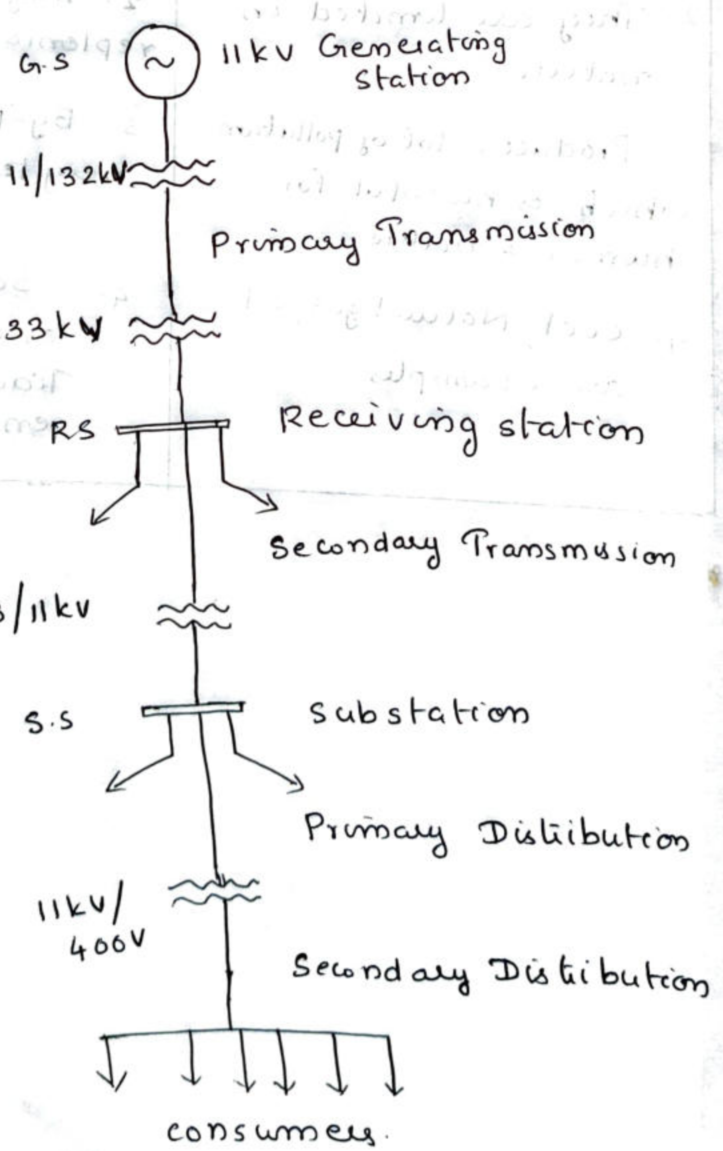
Difference between Conventional & Non Conventional Sources of Energy

Conventional Sources of Energy	Non Conventional Source of Energy
1. These sources of energy are generally known as non-renewable source of energy	1. These sources of energy are generally known as renewable source of energy.
2. They are limited in nature	2. They are continuously replenishing source of energy
3. Produce a lot of pollution which is harmful for human & nature.	3. By-products are very less very less & negligible.
4. coal, Natural gas, oil are examples	4. Solar energy, wind energy, biomass energy, Tidal energy, Geothermal energy etc are examples.

General Structure of Electrical Power system using Single Line diagram approach

The electrical energy is produced at the generating stations and through transmission & distribution network, it is transmitted to the consumers. Between generating station and distribution station ~~three~~ different levels of voltages (transmission, sub transmission and distribution level) of voltages are used.

The single line diagram of the Electrical Power system is shown below.



Generating Station

In the fig. G.S represents generating station where electrical power is produced by 3 phase alternators operating in parallel. The usual generating voltage is 11 kV. For economy in the transmission of electric power, the generation voltage (11kV) is stepped up to 132 kV (or more) at the generating station with the help of 3 phase transformers.

Primary Transmission

The electric power at 132 kV is transmitted by 3Phase 3 wire system. This forms the primary transmission.

Secondary Transmission

The primary transmission line terminates at the Receiving station (RS) which usually lies at the outskirts of the city. At the receiving station, the voltage is reduced to 33 kV by step-down transformer. From this station, electric power is transmitted at 33kV by 3 phase 3 wire overhead system to various substations (SS). This forms the secondary transmission.

Primary Distribution

The secondary transmission terminates at the substation (ss). where the voltage is reduced from 33kV to 11kV, 3 phase 3 wire. The 11kV lines run along the important road sides of the city. This forms primary distribution. It may be noted that big consumers (having demand more than 50kW) are generally supplied power at 11kV for further handling. with their own substations.

Secondary Distribution.

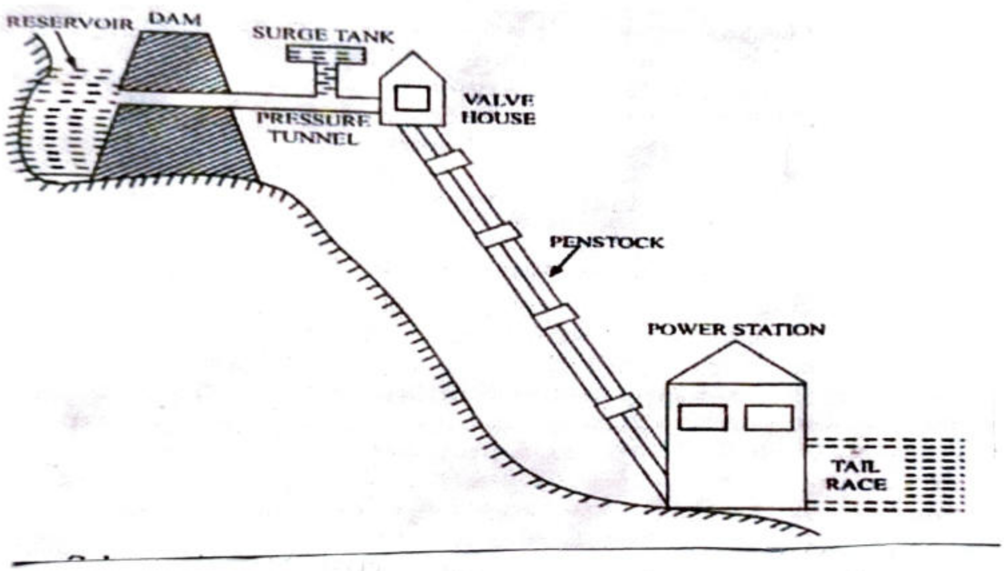
The electric power from primary distribution line (11kV) is delivered to distribution substation (DS). These substations are located near the consumers localities and step down the voltage to 400V, 3ϕ 4 wire for secondary distribution.

The voltage between any two phases is 400V and between phase and neutral is 230V. The single phase residential lighting load is connected between one phase & neutral where as 3 phase, 400V motor load is connected across 3 phase lines directly.

Power Generation : Hydro electric Powerplant

General Arrangement of Hydro electric Powerplant

The hydro energy is converted into electrical energy in hydro electric powerplants. In this powerplant the production of electricity mainly depends on the water level from the ground, volume of water and efficiency of turbine. The schematic arrangement of the hydro electric Powerplant is shown in fig.



An artificial reservoir is made by constructing a dam across the river or lake. The water surface in the storage reservoir is known as head race. Water is stored in the dam which is located upper level from the ground. This water head has huge potential energy.

A pressure tunnel is taken from the reservoir ~~at~~ to the valve house at the start of the penstock. The valve house contain main sluice valve to control the water flow. Penstocks are pipes of large diameter usually made of steel and concrete which carry water under pressure. Water from the storage reservoir is carried through the penstock to the turbine through the inlet valve. In water turbine the kinetic energy of water is converted to mechanical energy ie it rotates the turbine. The alternator coupled to the turbine converts the mechanical energy to electrical energy.

The water after doing the useful work in the turbine is discharged to tail race. Surge tank is also provided for the better regulation of water pressure in the system. Trash rack prevents the debris from getting into power house.

Elements of Hydroelectric Powerplant

Ther main components of typical hydro electric Powerplants are

→ Reservoir
→ Dam
→ Penstock (Water Conduit system)
→ surge tank
→ Tail race
→ Turbine
→ Generator
→ Trash rack
→ spill way
→ Control valve.

Reservoir

The function of reservoir is to store the water during raining season and supply the same during dry season. This is simple water storage area. Reservoir can be natural or artificial.

Dam

The function of Dam is to store water and increase the height of water level. Dams are usually built of concrete or stone masonary, earth or rock fill. Dams are most important and expensive part of hydro electric power system.

Penstock

A penstock is a huge pipe of large diameter usually made of steel or concrete. It carries water from the reservoir to the turbine.

Surge tank

Surge tank is an additional storage in which the water level rises or falls to reduce the pressure variation in penstock.

Tail race

The water, after doing useful work in the turbine (ie after rotating the turbine) discharges to tail race. The tail race ~~d~~ may discharge water to river.

Turbine (Prime mover)

Water from the penstock is taken into the water turbine. Kinetic energy of the water drives the turbine and turbine rotates. The turbine is mechanically coupled with the electric generator. There are two main types of water turbine - Impulse turbine & reaction turbine.

Generator

A generator is mounted in the power house and is mechanically coupled to the turbine shaft.

When the turbine blades are rotated, it drives the generator and electricity is generated which is then stepped up with the help of transformer for the transmission purposes.

Trash rack

The water intake from Dam are provided with trash rack. The main function of trash rack is to prevent the entry of any debris which may damage the turbine runners.

Spill way

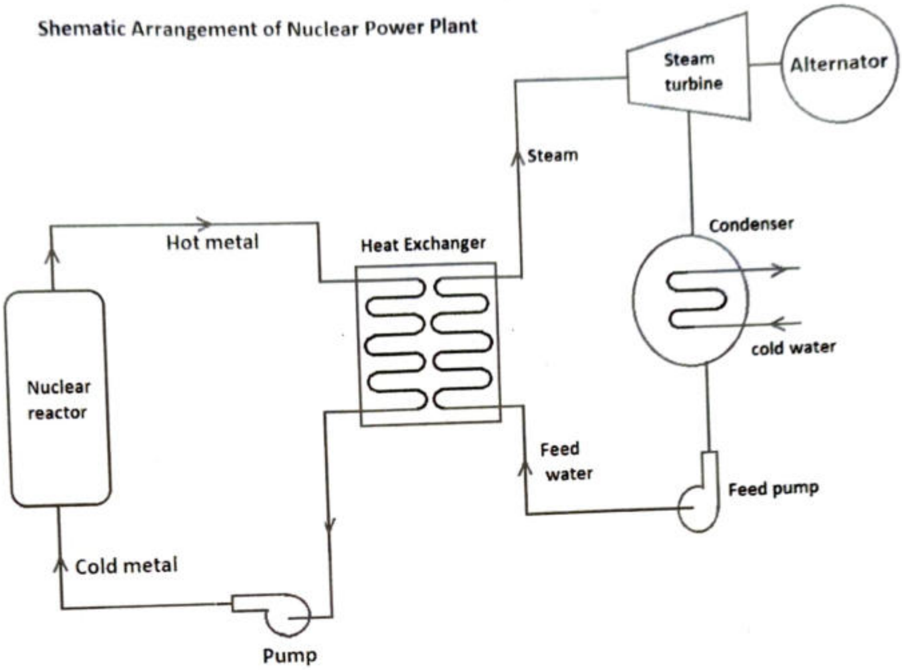
The function of spillway is to provide safety of the dam. It discharges the excess water of reservoir beyond the permitted level and acts as a safety value of reservoir.

Control value.

Water from the reservoir is allowed to flow through the penstock. The amount of water which is to be released in the penstock can be controlled by a control gate.

Nuclear Powerplant

In Nuclear powerplant nuclear energy is converted to electrical energy. The principle of nuclear fission is used in Nuclear Powerplant. The schematic arrangement is shown in fig.



The whole arrangement is divided into the following main stages.

1. Nuclear Reactor
2. Heat Exchanger
3. Steam Turbine.
4. Alternator
5. Condensor.

1. Nuclear Reactor

Nuclear Reactor is an apparatus in which the nuclear fuel (U-235) is subjected to nuclear fission. In nuclear fission energy is released

by splitting of the Uranium nucleus.
Nuclear reactor is a cylindrical stout pressure vessel and houses fuel rods of Uranium, Moderator and control rods.

~~The~~ A heavy isotope of Uranium - 235 or Plutonium 239 can undergo nuclear chain reaction yielding vast amount of energy. This energy is released in the form of heat energy.

The fuel rods in the nuclear reactor 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 slow down the neutron before they bombard the fuel rods for sustained chain reaction.

The control rods are of cadmium and are inserted into the reactor. Cadmium is a strong neutron absorber and thus regulate the supply of neutron for fission process. If the chain reaction is not controlled, it causes explosion ~~due~~ to fast increase in the energy released. So ~~nu~~ Nuclear chain reaction has to be controlled by control rods.
The reactor and cooling circuit are heavily shielded to eliminate radiation hazards.

2. Heat Exchanger

The heat produced in the reactor is removed by the primary coolant. Sodium metal or pressurized water is generally used as primary coolant. In heat exchanger, the primary coolant transfers the heat energy to secondary coolant (water). Thus water from the secondary loop is converted to steam.

The primary system and secondary system are closed loop and they are never allowed to mix up each other. Thus the heat exchanger helps in keeping the secondary system free from radio active stuff.

3. Steam Turbine.

Generated steam is passed through the steam Turbine, which runs due to the pressure of the steam. The steam is expanded in the steam turbine and rotates the blades of turbine. The steam turbine is coupled to the alternator through a rotating shaft.

4. Alternator.

The steam turbine rotates the shaft of the alternator. Thus it generates electrical energy. Electrical output of the alternator is delivered to a step-up transformer to transmit it to distances.

5. Condenser.

The steam coming out of the turbine after doing useful work in turbine (ie rotating the turbine blades) is converted back to ~~steam~~ water in condenser. The steam is cooled by passing cooling water in condenser. This condensed water can be reused for generating steam.

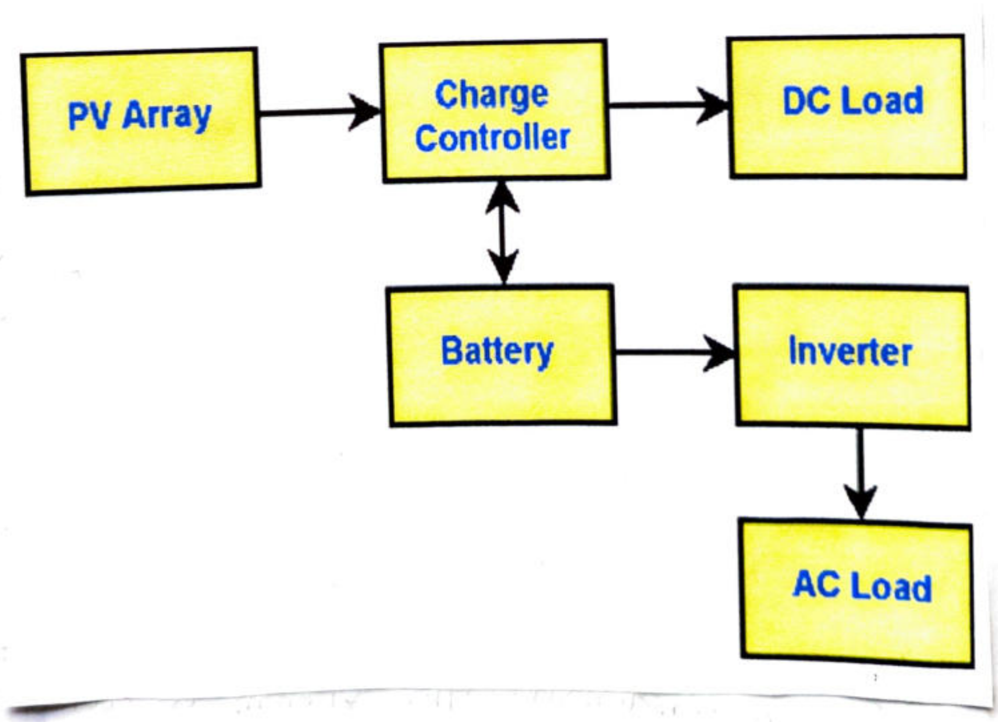
Solar Power Generation

The solar powerplant uses solar energy to produce electric power. There are many techniques for converting solar energy to electrical energy. Two of them are

1. Solar Powerplant (Solar Photovoltaic Power plant)
2. Solar thermal Power Plant

Solar Photovoltaic Powerplant

Solar photovoltaic power plant converts solar energy directly to electrical energy. The schematic diagram of solar photo voltaic system is shown in fig.



The main components of solar photovoltaic system are given below.

1. Photovoltaic cell panel (solar cell panel)
2. Charge Controller
3. Inverter
4. Energy Storage devices (batteries)

Photovoltaic panel (PV Panel)

A PV panel is an assembly of photovoltaic solar cells mounted on a frame. Solar panels capture solar radiation & converts into electrical energy. Generally Silicon is used as semi conductor material in solar cells. Number of cells are connected in series & parallel and makes a module. A number of modules forms a solar panel.

Charge Controller.

Solar charge controllers are electronic device that manages power going into the battery bank from solar array. It ensures that the batteries are not overcharged.

Inverter

The output of the solar panel is in the form of dc. The most of the loads connected to the power system networks uses ac. So inverters are used to convert DC to AC.

Energy Storage Devices.

The batteries are used to store electrical energy generated by the solar panels. Solar energy is intermittant in nature. Solar batteries are used to store the excess energy generated by solar panel. (may be during day time.) This stored energy can be utilized when the solar panel do not generate enough energy (during night, cloudy days etc.)

Solar Thermal Powerplant

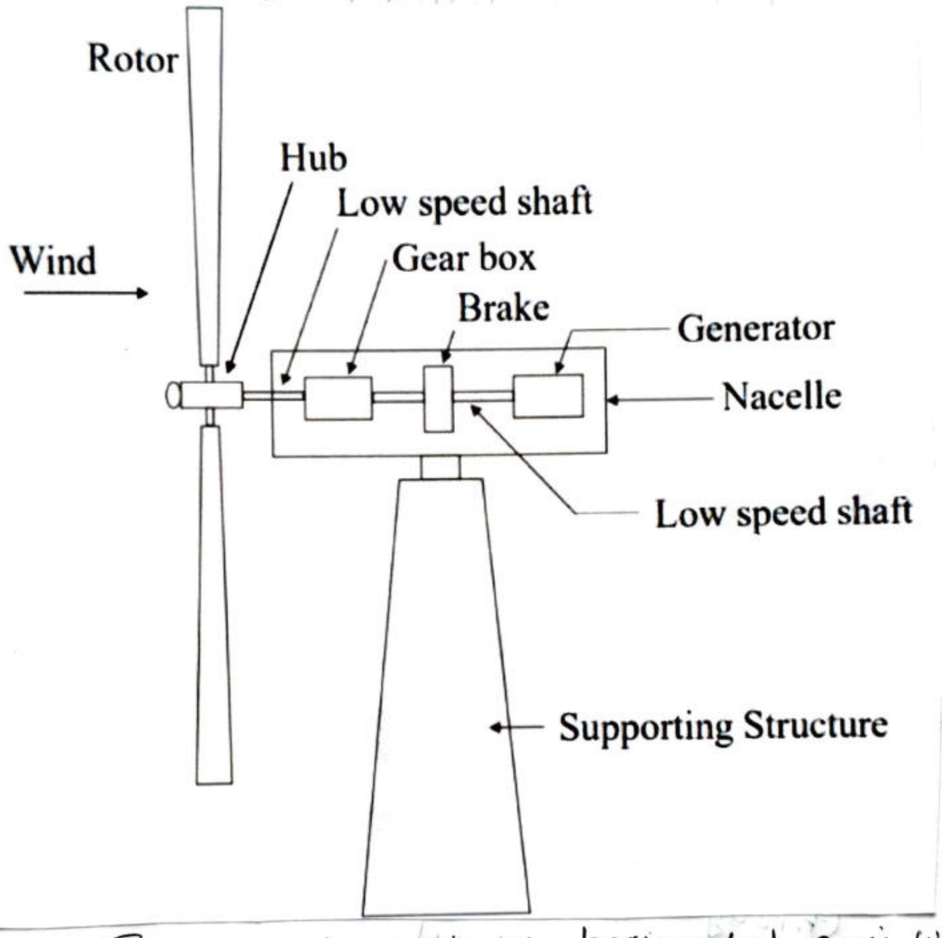
In this type solar thermal energy is collected and this heat energy is used to ~~generati~~ convert fluid to gas of high pressure. This gas is used to operate turbine coupled with generator. The generator produces electricity.

Wind ~~Energy~~ Power Generation

Wind energy is converted to electrical energy with the help of wind Turbines.

Horizontal axis wind Power generators are being used all over the world successfully.

The main components of a horizontal axis wind Power generator is shown in fig.



The main parts of horizontal axis wind turbine are turbine blades, hub, nacelle, yaw control mechanism and Tower. The Nacelle contains the rotor brakes, gear box, generator and electrical switch gear and control.

Turbine blades

Usually it has two or three blades made of high density glass fiber reinforced plastic. The diameter of rotor ranges from 2 to 25m. Modern rotors may be upto 100m. in diameter.

Hub

The central solid portion of the rotor is known as the hub. All blades are attached to the hub. The mechanism for pitch angle control is also provided inside hub. Pitch control, adjust the angle of blades in a wind turbine to get optimum angle of attack.

Nacelle

The hub, brakes, gearbox, generator with electric controls are accommodated in a box called nacelle.

Electromagnetic brakes are provided for automatic application of brakes if wind speed exceeds the designed speed.

Gearbox wind energy is converted to mechanical energy in an aero turbine. The speed of rotation of wind turbine ranges between 40 to 400 rpm. Generators typically require 1200 to 1800 rpm. So this mechanical power is transferred through gears to the generator to increase its speed.

Generator

Generator ~~controls~~ converts this mechanical energy to electrical energy.

yaw Control mechanism

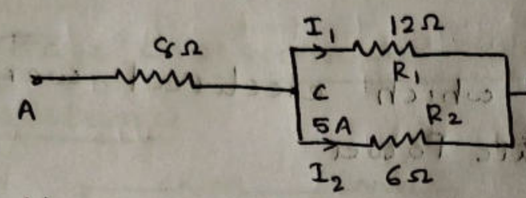
Adjusting the nacelle about the vertical axis to bring the rotor facing the wind is known as yaw control mechanism.

Tower The whole system is mounted on a tower top. It is designed for support & to bear up the wind loads during storms.

—x—

Problems

1. An 8Ω resistor is connected in series with a parallel combination of two resistors 12Ω & 6Ω. If the current in 6Ω resistor is $5A$, determine the total power dissipated in the circuit.



$$V_{CB} = I_2 R_2$$
$$= 5 \times 6 = 30V$$

$$I_1 = \frac{V_{CB}}{R_1} = \frac{30}{12} = 2.5A$$

$$I = I_1 + I_2$$

Total Resistance of the circuit

$$R_{AB} = 8 + [12 \| 6]$$

$$\frac{1}{R_{CB}} = \frac{1}{12} + \frac{1}{6} = \frac{12 \times 6}{12+6} = 4\Omega$$

$$R_{AB} = 8 + 4 = \underline{\underline{12\Omega}}$$

Total power dissipated in the circuit

$$= I_{AB}^2 R_{AB}$$

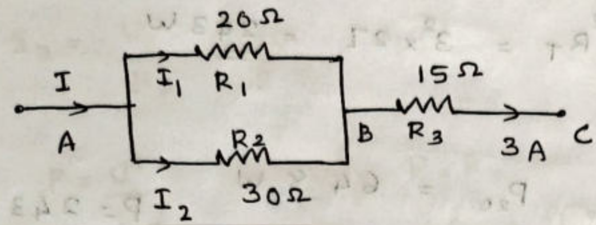
$$= (7.5)^2 \times 12$$

$$= \underline{\underline{675\Omega}}$$

2. A circuit consists of two parallel resistors having resistances of 20Ω & 30Ω respectively, connected in series with 15Ω. If the current through 15Ω resistor is $3A$, find (i) current in 20Ω & 30Ω

(ii) Voltage across the complete circuit.

(iii) Total power & power consumed in all resistors.



(i) $I = 3\,A$

$$I_1 = I\frac{R_2}{R_1+R_2} = 3 \times \frac{30}{20+30} = 1.8\,A$$

$$I_2 = I\frac{R_1}{R_1+R_2} = 3 \times \frac{20}{20+30} = 1.2\,A$$

$\left(\text{or} \quad I_2 = I - I_1 = 3 - 1.8 = 1.2\,A \right)$

(ii) $V = IR_T$

Total Resistance $R_T = R_{AB} + R_{BC}$

$$= (20 \| 30) + 15$$

$$= \frac{20 \times 30}{20+30} + 15$$

$$R_T = 27\,\Omega.$$

$V = IR_T$

$= 3 \times 27\,\Omega = \underline{\underline{81\,V}}$

(iii) Power consumed in R_1,

$$P_{20\Omega} = I_1^2 R_1$$
$$= (1.8)^2 \times 20 = 64.8\,W$$

Power consumed in R_2

$$P_{30} = I_2^2 \times R_2$$
$$= (1.2)^2 \times 30 = 43.2\,W$$

Power consumed in R_3

$$P_{15} = (I^2) R_3 = 3^2 \times 15 = 135$$

$$\text{Total Power} = P_{20} + P_{30} + P_{15}$$
$$= 64.8 + 43.2 + 135$$
$$= \underline{\underline{243\,W}}$$

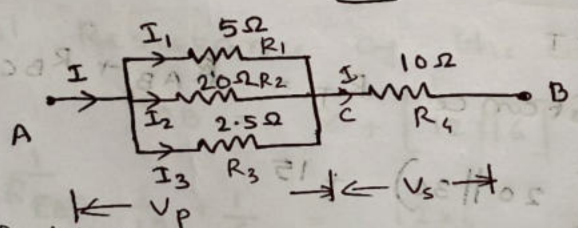
or

$$P = I^2 R_T = 3^2 \times 27 = \underline{\underline{243\,W}}$$

Answers

$I_1 = 1.8\,A$ $\quad P_{20} = 64.8\,W$
$I_2 = 1.2\,A$ $\quad P_{30} = 43.2\,W$ $\quad P = \underline{\underline{243\,W}}$
$V = 81\,V$ $\quad P_{15} = 135\,W$

3. For the circuit shown below, the total power dissipated is 488W. Calculate the current flowing in each resistance & potential difference between A & B.



Solution

$$R_P = ?$$

$$\frac{1}{R_P} = \frac{1}{5} + \frac{1}{20} + \frac{1}{2.5}$$

$$R_P = \underline{\underline{1.54\,\Omega}}$$

$$R_T = R_P + 10 = \underline{\underline{11.54\,\Omega}}$$

$$P = I^2 R_T$$

$$488 = I^2 \times 11.54$$

$$I^2 = \frac{488}{11.54} = 42.29\,A$$

$$I = \underline{\underline{6.5\,A}}$$

$R_P = 1.54$ $\qquad V_P = I R_P$

$$= 6.5 \times 1.54 = \underline{\underline{10V}}$$

$$I_1 = \frac{V_P}{R_1} = \frac{10}{5} = 2A$$

$$I_2 = \frac{V_P}{R_2} = \frac{10}{20} = 0.5A$$

$$I_3 = \frac{V_P}{R_3} = \frac{10}{2.5} = 4A$$

$$\therefore P = \frac{V^2}{R_T} \qquad V^2 = P \times R_T$$
$$= 488 \times 11.54$$

$$\underline{\underline{V = 75V}}$$

Ans:

$I_1 = 2A$

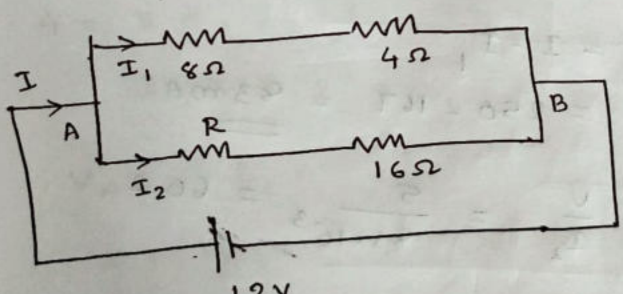
$I_2 = 0.5A$

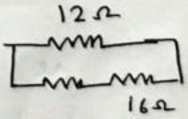
$I_3 = 4A$

$I = 6.5A$

$\underline{\underline{V = 75V}}$

4. If the total power dissipated in the circuit shown is 18W. find the value of R & its current.





$$P = VI$$

$$18W = 12 \times I$$

$$I = \frac{18}{12} = \underline{\underline{1.5A}}$$

$$I_1 = \frac{V_{AB}}{R_{AB}} = \frac{12}{12} = 1A$$

$$I_2 = I - I_1 = \cancel{1.5-0.5}\ 1.5 - 1$$
$$= 0.5A$$

$$I_2 = \frac{V_{AB}}{R+16} = \underline{\underline{0.5A}}$$

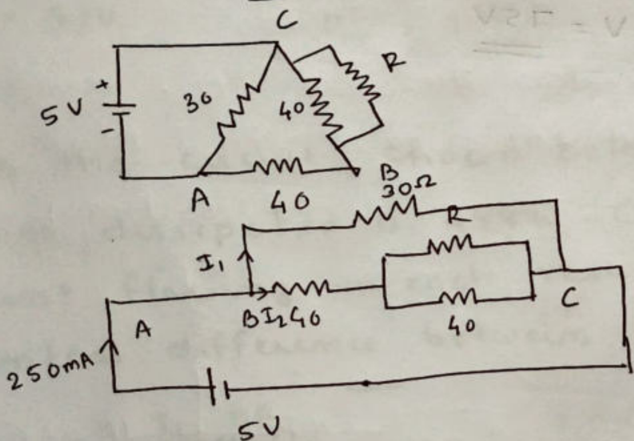
ie $\frac{12}{R+16} = 0.5A$

$$R + 16 = \frac{12}{0.5}$$

$$R + 16 = 24$$

$$R = 8\Omega$$

5. Find the value of resistance R as shown below so that the current drawn from the source is 250mA. All the resistance values are in Ω



$$I_1 = \frac{V_{AC}}{30\Omega} = \frac{5}{30} = 0.167A$$

$$= 167mA$$

$$I_2 = I - I_1$$

$$= 250 - 167 = 83mA$$

$$R_{2eq} = \frac{V}{I_2} = \frac{5}{83\times10^{-3}} = 60\Omega$$

ie

$$40 + \frac{40R}{40+R} = 60$$

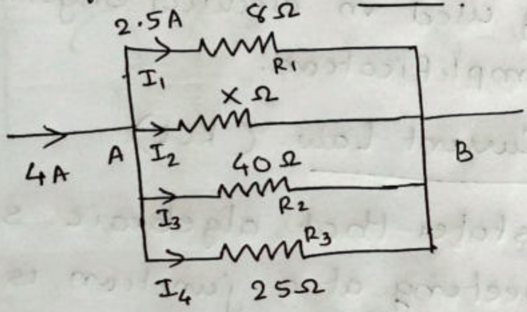
$$\frac{40R}{40+R} = 20$$

$$40R = 800 + 20R$$

$$20R = 800$$

$$R = 40$$

6. In the parallel arrangements of ~~circuits~~ resistors shown current flowing in 8Ω resistor is 2.5A. Find the (1) current in other resistors (2) Resistor X (3) equivalent resistance.



$V_{AB} = I_1 R_1 = \cancel{20V}\ 2.5 \times 8 = 20V$

In parallel circuit drop across all resistors will be same.

Current through 40Ω resistor $= \frac{V_{AB}}{40} = \frac{20}{40}$

$= 0.5A$

Current through 25 resistor $= \frac{V_{AB}}{25} = \frac{20}{25}$

$= 0.8A$

$I = I_1 + I_2 + I_3 + I_4$

$4 = 2.5 + I_2 + 0.5 + 0.8$

$I_2 = \underline{\underline{0.2A}}$

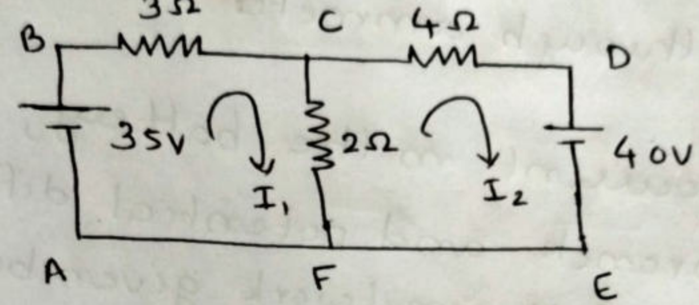
$V_{AB} = I_2 X$

$X = \frac{V_{AB}}{I_2} = \frac{20}{0.2} = \underline{\underline{100\Omega}}$

Equivalent Resistance, $R_{eq} = \frac{V}{I} = \frac{20}{4} = 6\Omega$

Problems

1) Find the currents in the various branches of the given network shown below.



Applying KVL to the mesh ABCFA

$$5I_1 - 2I_2 = 35 \quad \text{——— (1)}$$

Applying KVL to the mesh CDEFC

$$-2I_1 + 6I_2 = -40 \quad \text{—— (2)}$$

$I_1 = 5A$

$I_2 = -5A$

Branch Currents

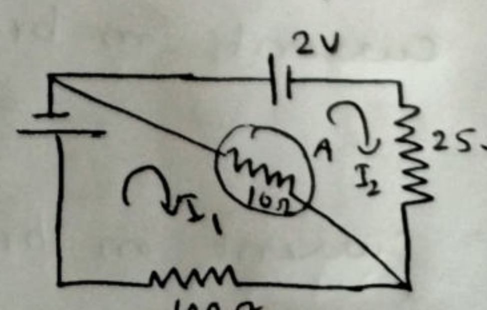
$I_{BC} = 5A$

$I_{CD} = 5A$

$I_{CF} = I_1 - I_2$

$= 5 - (-5) = \underline{\underline{10A}}$

2. In the network shown below determine the current flows in the ammeter A, having resistance of 10A.



KVL to loop 1

$$110 I_1 - 10 I_2 = -4 \quad \text{——— (1)}$$

KVL to loop 2

$$-10 I_1 + 35 I_2 = -2 \quad \text{——— (2)}$$

$$I_1 = -0.043 \text{ A}$$

$$I_2 = -0.069 \text{ A}$$

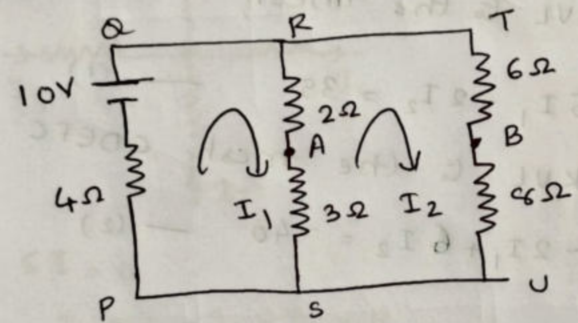
$$I_A = I_1 - I_2 = -0.043 - (-0.069)$$

$$= 0.026 \text{ A}$$

$$= \underline{\underline{26 \text{ mA}}}$$

Current through ammeter = 26 mA

3. Find the current in the battery, the current in each branch and potential difference across AB in the network given below.



KVL to loop 1

$$9 I_1 - 5 I_2 = 10 \quad \text{——— (1)}$$

KVL to loop 2

$$-5 I + 19 I_2 = 0 \quad \text{——— (2)}$$

$$I_1 = 1.3 \text{ A} \qquad I_2 = \underline{\underline{0.342 \text{ A}}}$$

Current in battery $= I_1 = \underline{\underline{1.3 \text{ A}}}$

Current in branch PQ $= I_1 = 1.3$ A

Current in branch RS $= I_1 - I_2$

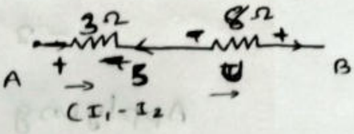
$$= 1.3 - 0.342$$

$$= \underline{\underline{0.958 \text{ A}}}$$

Current in branch TU $= I_2 = \underline{\underline{0.342 \text{ A}}}$

Potential difference across AB

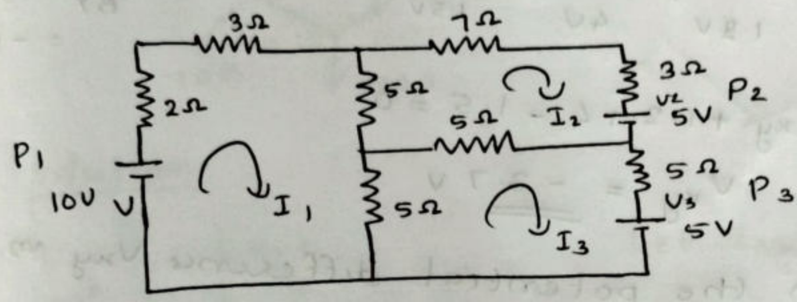
$V_{AB} \mp 3 \times (I_1 - I_2) + 8 \times I_2 = 0$



$V_{AB} = 3 \times 0.958 + 8 \times 0.342$

$= +0.138V$ with A +ve

4. Find the Power delivered by the voltage sources.



$15 I_1 - 5 I_2 - 5 I_3 = 10$

$-5 I_1 + 20 I_2 - 5 I_3 = -5$

$-5 I_1 - 5 I_2 + 15 I_3 = -5$

$I_1 = 0.542 A$

$I_2 = 0.167 A$

$I_3 = 0.208 A$

Power delivered by V_1, $P_1 = V_1 I_1 = 10 \times 0.542$

$= 5.42W$

Power delivered by V_2, $P_2 = V_2 I_2$

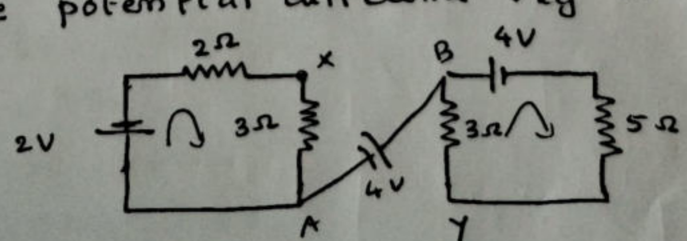
$= 5 \times 0.167$

$= 0.835W$

Power delivered by V_3, $P_3 = I_3 V_3$

$= 1.04W$

5. Obtain the potential difference V_{xy} in the following circuit.



Applying KVL to loop 1

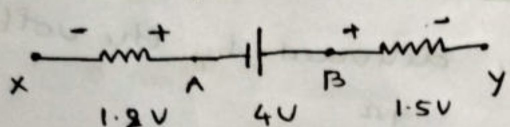
$-2 = 5I_1 \qquad I_1 = -0.4\,A$

Applying KVL to loop 2

$8I_2 = -4 \qquad I_2 = -0.5\,A$

$V_{xA} = 3 \times 0.4 = 1.2$

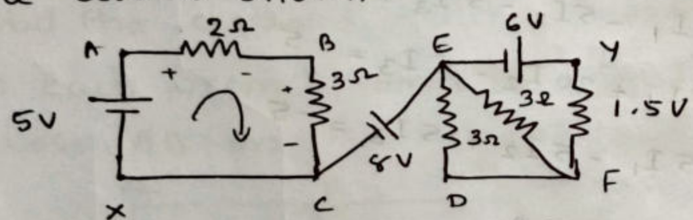
$V_{BY} = -3 \times 0.5 = -1.5$



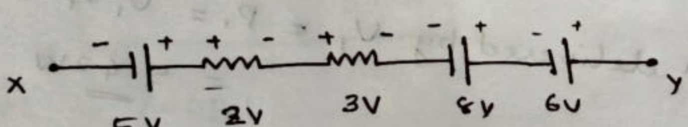
$V_{xy} + 1.2 + 4 - 1.5 = 0$

$V_{xy} = \underline{\underline{-3.7\,V}}$

6. Obtain the potential difference V_{xy} in the circuit shown.



$5I_1 = 5 \qquad I_1 = 1\,A$

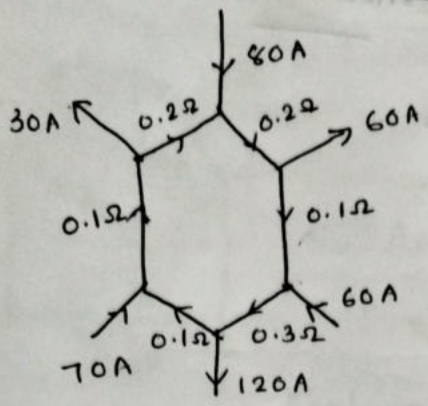


$V_{xy} + 5 - 2 - 3 + 8 + 6 = 0$

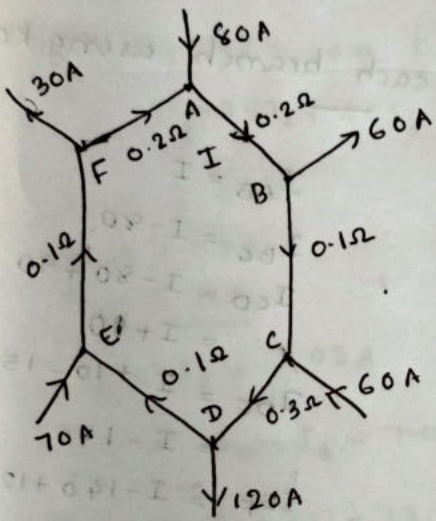
$V_{xy} + 19 - 5 = 0$

$V_{xy} = \underline{\underline{-14\,V}}$

7. Find the values of currents in all the branches of the network shown below.



Solution



Let $I_{AB} = I$, then

$I_{BC} = I - 60$

$I_{CD} = I - 60 + 60 = I$

$I_{DE} = I - 120$

$I_{EF} = I - 120 + 70$

$= I - 50$

$I_{FA} = I - 80$

Applying KVL to the mesh ABCDEFA

$$0.2I + 0.1(I-60) + 0.3(I) + 0.1(I-120) + 0.1(I-50) + 0.2(I-80) = 0$$

$$0.2I + 0.1I - 6 + 0.3I + 0.1I - 12 + 0.1I - 5 + 0.2I - 16 = 0$$

$I = 39A$

Branch Currents

$I_{AB} = I = 39A$

$I_{BC} = I - 60 = -21A$

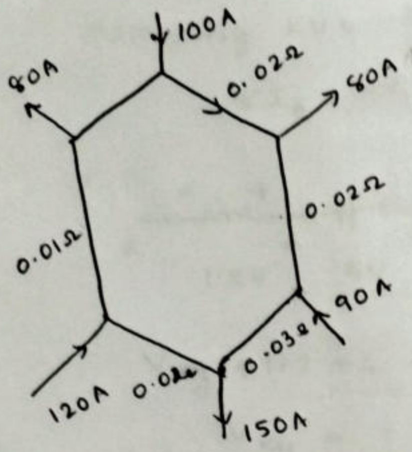
$I_{CD} = I = 39A$

$I_{DE} = I - 120 = 81A$

$I_{EF} = I - 50 = -11A$

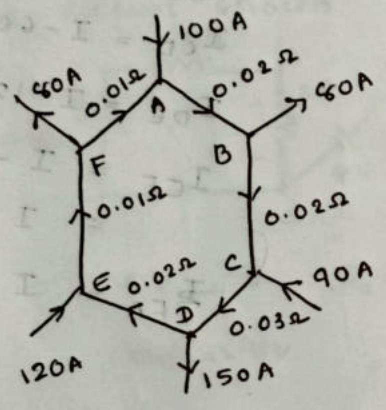
$I_{FA} = I - 80 = -41A$

8. Find the currents in various branches of the given network as shown below.



Solution

Find the current in each branch using KCL.



$I_{AB} = I$

$I_{BC} = I - 80$

$I_{CD} = I - 80 + 90$

$= I + 10$

$I_{DE} = I + 10 - 150$

$= I - 140$

$I_{EF} = I - 140 + 120$

$= I - 20$

$I_{FA} = I - 20 - 80$

$= I - 100$

Apply KVL to the loop ABCDEFA

$$0.02I + 0.02(I-80) + 0.03(I+10) + 0.02(I-140) + 0.01(I-20) + 0.01(I-100) = 0$$

$$0.11I = 5.3 \qquad I = 48.18\text{A}$$

$I_{AB} = 48.18\text{A}$

$I_{BC} = -31.8\text{A}$

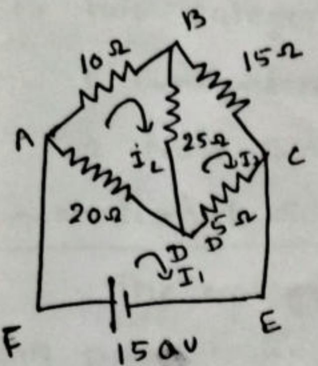
$I_{CD} = I + 10 = 58.18\text{A}$

$I_{DE} = I - 140 = -91.82\text{A}$

$I_{EF} = I - 20 = 28.18\text{A}$

$I_{FA} = I - 100 = -51.82\text{A}$

9. Find the currents in the various branches in the various branches of given network.



By loop current Method,

Applying KVL to loop ADCEF

$$25I_1 - 20I_2 - 5I_3 = 150$$

Applying KVL to ABDA

$$-20I_1 - 55I_2 - 25I_3 = 0$$

Applying KVL on BCDB

$$-5I_1 - 25I_2 + 45I_3 = 0$$

$$I_1 = 12.68A$$
$$I_2 = 7.03A$$
$$I_3 = 5.31A$$

$$I_{AB} = I_2 = 7.03A$$

$$I_{BC} = \cancel{I_2}\ I_3 = \cancel{7.03 - 1.72} = 5.31A$$

$$I_{AD} = I_1 - I_2 = 12.68 - 7.03 = 5.67A$$

$$I_{BD} = I_2 - I_3 = 7.03 - 5.31A = 1.72A$$

$$I_{DC} = I_1 - I_3 \cancel{= 12.68 - 7.03 =}$$
$$= 12.68 - 5.31 = 7.37A$$