CMR INSTITUTE OF TECHNOLOGY			USN						
Internal Assesment Test –II									
Sub:	Introduction to Electrical Engineering						Code:	22ESC142	
Date:	06/03/2023	Duration:	90 mins	Max Marks:	50	Sem:	1st sem	Branch:	CS/EC

Answer any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1	Explain in detail about conventional & Non-conventional energy resources. What are the advantages of non-conventional energy sources?	[10]	CO5	L2

Conventional and Non-conventional Sources of Energy

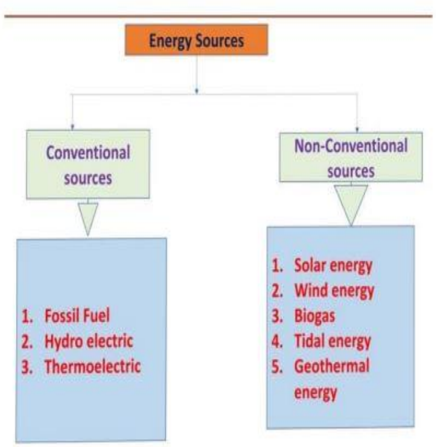
Energy is the ability of a physical system to perform work. We use energy in our daily lives from various sources for doing work. We use muscular energy for carrying out physical work, electrical energy for running multiple appliances, chemical energy for cooking food, etc. For this, we need to know the different energy sources to obtain energy in its usable form. This article will familiarize you with two important sources of energy: conventional energy and non-conventional energy.

Sources of Energy

The two major sources of energy is classified as:

- Conventional Sources
- Non-Conventional Sources

The classification of the sources of energy is given in the below image.



Classification of energy sources

Conventional sources of energy

Convection energy sources are naturally present and have been in use for years. The use of conventional sources is done for heating, lighting, cooking, running machinery, and provision of electricity. The examples for which include firewood, fossil fuels, and others. In addition, firewood has been extensively used for cooking purposes in remote regions of India.

The fossil fuels are plants, and animal remains, which have been buried from millions of years ago within the earth. These remains are decomposed and formed primary energy sources like coal, petroleum, natural gas, etc.

The reserves for such energy sources are in limited quantities and soon will be depleted with a growth rate of population. Since they are naturally occurring and take a considerable time, they cannot be renewed manually or by applying scientific methods. It is essential for judicious use of non-renewable or conventional energy sources.

a) Coal

Coal is the most abundant conventional source of energy which could last for at least 200 years. It is a black-brown sedimentary rock. Formation of coal occurs when the remains of plants convert into lignite and then into anthracite. This involves a long process that takes place over a long period of time. Coal helps for various proposes such as heating of the house, as fuel for boilers and steam engines and for generation of electricity by thermal plants. It constitutes about 70% of total commercial energy consumption in the country.

b) Oil

Out of all the conventional sources of energy, oil is used abundantly all over. Considering, oil is one of the most important conventional sources of energy in India, the resources for same are even smaller. The extraction of oil from deposits is known as **oil resources.**

c) Petroleum and Natural Gas

Petroleum is the mixture of hydrocarbons like alkanes and cycloalkanes. In crude form black liquid is known as petroleum and the formation of a natural gas occurs when the gas comes in contact with petroleum layer. Natural gas is a mixture of 50-90% of Methane, Ethane, Propane, Butane, and Hydrogen sulphide. After refining and purifying crude petroleum, it is available as petrol, diesel, lubricating oil, plastic etc. Natural gas is also making a significant contribution to the household sector. It causes less air pollution as compared to other fossil fuel.

d) Fuel Woods

Rural people use the fuelwood for their day to day cooking which comes from natural forests and plantations. The availability of fuelwood has become difficult due to rapid deforestation. We can avoid this problem by planting more trees on degraded forest land, culturable wasteland, barren land grazing land.

e) Thermal Power Plant

Power stations burn a large number of fossil fuels to heat up water, to produce steam, which further runs the turbine to generate electricity. Transmission of electricity is more efficient than, transporting coal or petroleum over the same distance. It is called as the thermal plant because fuel is burnt to produce heat energy which is converted into electrical energy.

f) Nuclear energy

A small amount of radioactive substance can produce a lot of energy through the nuclear substances all over the world. In order to obtain nuclear energy, nuclear reactions are essential and there are about 300 nuclear reactions. Nuclear energy is one of the most environmentally friendly conventional sources of energy as it produces fewer greenhouse gas emissions during the production of electricity in comparison to sources like coal power plants. Although in case of accidents, this same nuclear energy releases in high amount in the environment. Also, the nuclear waste that remains is radioactive and hazardous.

Non- Conventional energy of sources

Non- Conventional energy sources are the best alternatives to conventional sources while also non- polluting. In 1973, the oil crisis encouraged a focus on non – conventional sources, which has increased in recent times due to high environmental pollution.

Non-conventional sources could be obtained from sun, wind, hot springs, and others that support heat and power generation. They are non-polluting and present in abundance within the earth's atmosphere.

a)Solar Energy-

Solar Energy is produced by sunlight. The photovoltaic cells are exposed to sunlight based on the form of electricity that needs to be produced. The energy is utilized for cooking and distillation of water.

The light from the sun is used to generate electricity by trapping the solar cells within the panels. Solar energy is present in abundance although it can be only trapped during the daytime, during the hours of intense rays. It is being used for lighting, heating, and others.

b) Wind-

Wind energy is generated by harnessing the power of wind and mostly used in operating water pumps for irrigation purposes. India stands as the second-largest country in the generation of wind power. Wind energy has been used for many years for grinding grains in mills. Although, in recent years, it has been used to generate electricity by harnessing the energy of winds by turbines attached to substantial capacity generators. Usually, such wind farms are located near coastal areas or mountains with the high wind flow. In India, my desert regions, like the outskirts of Gujarat and Rajasthan, have built substantial wind farms.

c) Nuclear Power Plants-

Nuclear energy is acquired from nuclei atoms that occur naturally in radioactive sources like uranium, thorium, and others. Nuclear fuels emit power when undergone in nuclear reactors. Globally, the USA and Europe are the largest nuclear power producers, although in India, uranium is found in Jharkhand, and thorium is found in Kerala.

d) Geothermal Energy-

The heat acquired from the earth is geothermal energy. In many areas, hot springs are witnessed as part of geothermal energy. The heat from within the earth has been used for generating power. New Zealand, Iceland, Central America, and the USA have the largest geothermal power plants. India also has geothermal power plants located in Himachal Pradesh and Ladakh.

e) Tidal Energy-

Tidal waves also generate energy harnessed by erecting dams. The narrow dams are built near the end of tides, where the turbines help to capture the energy. India has vast tidal mill farms at the Gulf of Kachchh, while other countries include Russia and France. Tidal energy is generated by exploiting the tidal waves of the sea. This source is yet to be tapped due to the lack of cost-effective technology.

2	Explain the working of (a)Nuclear Power Plant (b)Solar and Wind Power Generation with necessary Block diagram.	[10]	CO5	L2

Solar power generation

The working principle is that we use the energy of photons to get the drift current flowing in the circuit using reversed bias p-n junction diode (p-type and n-type silicon combination).

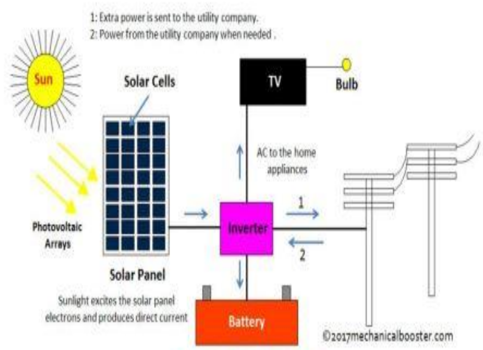
Solar Panels: It is the heart of the solar power plant. Solar panels consists a number of solar cells. We have got around 35 solar cells in one panel. The energy produced by each solar cell is very small, but combining the energy of 35 of them we have got enough energy to charge a 12 volt battery.

Solar Cells: It is the energy generating unit, made up of p-type and n-type silicon semiconductor. It's the heart of solar power plant.

Battery: Batteries are used to produce the power back or store the excess energy produced during day, to be supplied during night.

D.C. to A.C. Converter (Inverter): Solar panels produce direct current which is required to be converted into alternating current to be supplied to homes or power grid.

Energy Storage: Storage of the energy generated by the solar panels is a important issue. Sometimes the unused energy generated during daytime is used to pump water to some height, so that it could be used to generate electricity using its potential energy when required or mainly at night time.



Working of Solar Power Plant

Working of Solar Power Plant: As sunlight falls over a solar cells, a large number of photons strike the p-type region of silicon. Electron and hole pair will get separated after absorbing the energy of photon. The electron travels from p-type region to n-type region due to the action of electric field at p-n junction. Further the diode is reversed biased to increase this electric field. So this current starts flowing in the circuit for individual solar cell. We combine the current of all the solar cells of a solar panel, to get a significant output. Solar power plant have a large number of solar panels connected to each other to get a large voltage output. The electrical energy coming from the combined effort of solar panels is stored in the Lithium ion batteries to be supplied at night time, when there is no sunlight.

Wind power generation

The wind kinetic energy first converted to rotational motion and by the use of gear box it is matches the speed of turbine and generator. The function of generator is to convert the mechanical energy of turbine to electrical energy.

The kinetic energy of the turbine is converted to mechanical energy and the turbine shaft is connected to rotor shaft of the generator. The power is transmitted from turbine to generator with the help of shaft. The generator rotor winding is known as armature which is rotates in between the magnetic stationary field and produce electrical voltage according to general generator principle. A rectifier is used to convert the AC voltage to DC and a battery is connected in such a way that it can charged both the way i.e a bidirectional converter is used to charge the battery.

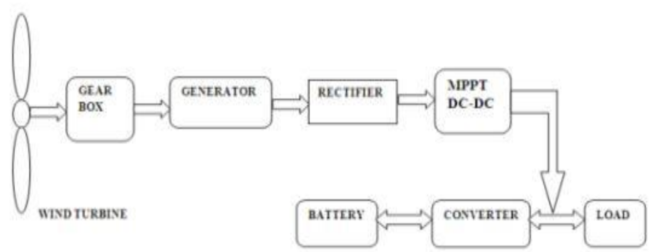


Figure 2. Wind energy system block diagram

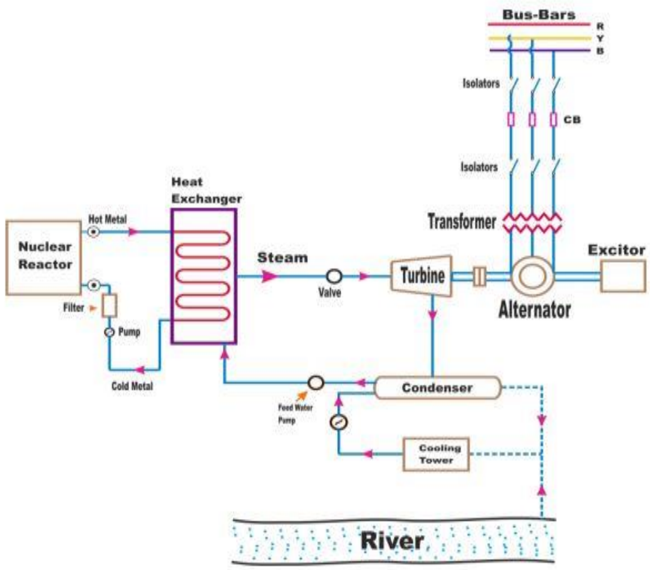
Nuclear power plant

In a nuclear power plant, heat energy is generated by a nuclear reaction called as nuclear fission. Nuclear fission of heavy elements such as Uranium or Thorium is carried out in a special apparatus called as a nuclear reactor. A large amount of heat energy is generated due to nuclear fission. Rest parts of a nuclear power plant are very similar to conventional thermal power plants. It is found that fission of only 1 Kg of Uranium produces as much heat energy as that can be produced by 4,500 tons of high grade coal. This considerably reduces the transportation cost of fuel, which is a major advantage of nuclear power plants.

The *working principle of nuclear power plant* depends upon mainly four components.

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

Nuclear reactor is used to produce heat and heat exchanger performs to convert water into steam by using the heat generated in nuclear reactor. This steam is fed into steam turbine and condensed in condenser. Now steam turbine is turn to run an electric generator or alternator which is coupled to steam turbine and thereby producing electric energy. This is a very basic working principle of Nuclear power plant.Here is the detail operation of the individual unit of this plant. The block diagram of nuclear power plant shown in figure:-



1. Nuclear Reactor:-*Nuclear reactor* is the main component of nuclear power plant and nuclear fuel is subjected to nuclear fission. Nuclear fission is a process where a heavy nucleus is spitted into two or more smaller nuclei. . A heavy isotope generally uranium-235(U-235) is used as a nuclear fuel in the nuclear reactor because it has the ability to control the chain reaction in the nuclear reactor. Nuclear fission is done by bombarding uranium nuclei with slow moving neutrons. The energy released by the fission of nuclei is called nuclear fission energy or nuclear energy. By the braking of uranium atom, tremendous amount of heat energy and radiation is formed in the reactor and the chain reaction is continuously running until it is controlled by a reactor control chain reaction. A large amount of fission neutrons are removed in this process, only small amount of fission uranium is used to generate the electrical power.

The nuclear reactor is cylindrical type shape. Mainly Nuclear reactor consists, some fuel rods of uranium, moderator and control rods. A coolant, basically sodium metal is used to reduce the heat produce in the reactor and it carries the heat to the heat exchanger.

2. Heat Exchanger:-Coolant is used to raise the heat of the heat exchanger which is utilised in raising the steam. After that, it goes back to the reactor.

3. Steam Turbine:- Steam is coming from the heat exchanger to fed into the steam turbine through the valve. After that the steam is exhausted to the condenser. This condensed steam is fed to the heat exchanger through feed water pump.

4. Alternator:-Steam turbine is coupled to an alternator which converts mechanical energy to electrical energy. The output of alternator produces electrical energy to bus bars via major electrical apparatus like transformer, circuit breakers, isolators etc.

3(a)	A series circuit with a resistance of 100 Ω, capacitance of 25 μF and inductance of 0.15 H is connected to a 220 V, 50 Hz supply. Calculate impedance, current, power and power factor in the circuit.	[5]	CO2	L3

Phase angle, $\phi = \phi_V - \phi_I$ [R_L ckt]

$= 0 - -54.98 = \underline{54.98^\circ}$

Power factor, $\cos\phi = \cos 54.98 = 0.57$

Power, $P = VI\cos\phi = 100 \times 8.2 \times 0.57$

$= \underline{470.51 W}$

5. A Series circuit with a Resistance of 100 Ω, capacitance of 25 μF, and Inductance of 0.15 H is Connected to a 220 V, 50 Hz Supply. Calculate impedance, current power and power factor in the circuit.

Solution,

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Given $R = 100\,\Omega$

$C = 25\,\mu F$ $\quad X_C = \frac{1}{C\omega} = \frac{1}{25 \times 10^{-6} \times 2 \times \pi \times 50}$

$= \underline{127.39\,\Omega}$

$L = 0.15 H$ $\quad X_L = L\omega = 0.15 \times 2 \times \pi \times 50$

$= \underline{47.1\,\Omega}$

$$Z = \sqrt{100^2 + (X_L - X_C)^2}$$

$Z = 100 - j\,80.29 = \underline{128.24 \angle -38.76}\,\Omega$

$$I = \frac{V}{Z} = \frac{220}{128.24 \angle -38.76} = \underline{1.72 \angle 38.76 A}$$

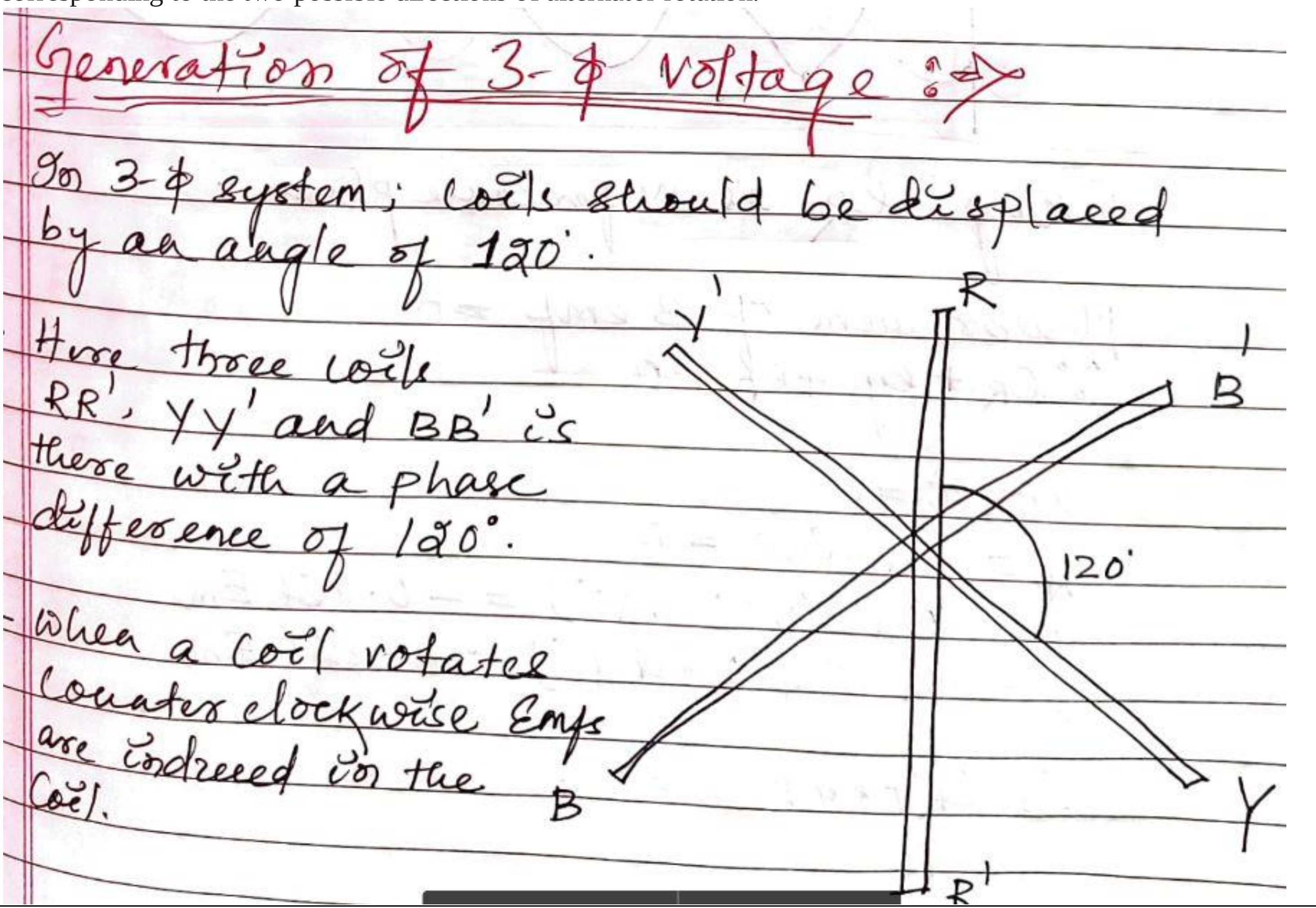
$P = VI\cos\phi$

$Pf = \cos\phi = \frac{R}{Z} = \frac{100}{128.24 \angle -38.76} = 0.78 \angle 38.76$

leading

3(b)	Define phase sequence. Also explain the generation of 3phase waveform	[5]	CO2	L2

Phase rotation, or phase sequence, is the order in which the voltage waveforms of a polyphase AC source reach their respective peaks. For a three-phase system, there are only two possible phase sequences: 1-2-3 and 3-2-1, corresponding to the two possible directions of alternator rotation.



Generation of 3-ϕ voltage :->

For 3-ϕ system; coils should be displaced by an angle of 120°.

Here three coils RR', YY' and BB' is there with a phase difference of 120°.

When a coil rotates counter clockwise Emfs are induced in the coil.

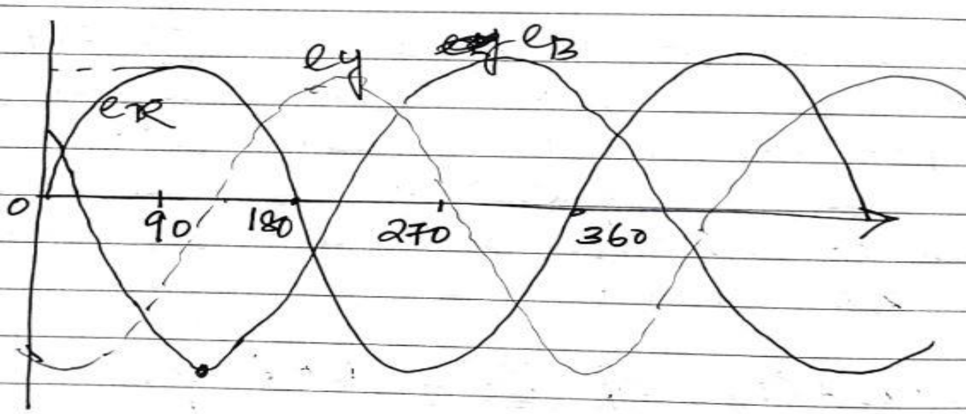
- 3 1-ϕ emfs of same amplitude and frequency but some phase displacement of 120° are generated.
- emf induced of magnitude E_{mR}, E_{mY}, E_{mB}

$$E_m = E_{mR} = E_{mY} = E_{mB}$$

Instantaneous emfs : $e_R = E_{mR} \sin\omega t$
$= E_m \sin\omega t$

$$e_Y = E_{mY}\sin(\omega t - 120^\circ) = E_m \sin(\omega t - 120^\circ)$$

$$e_B = E_{mB}\sin(\omega t - 240^\circ) = E_m \sin(\omega t - 240^\circ)$$



Taking e_R as reference phase.

Phasor sum of 3 emf = 0

$\therefore e_R + e_Y + e_B = 0$

Proof :- at $t = 0$

$$e_R = E_m \sin 0 = 0$$

$$e_Y = E_m \sin(0 - 120^\circ) = -0.866\, E_m$$

$$e_B = E_m \sin(0 - 240^\circ) = 0.866\, E_m$$

$\therefore e_R + e_Y + e_B = 0.$

4(a)	List the Advantages and Disadvantages of Three phase system	[5]	CO2	L1

Advantage of 3-ϕ system :-

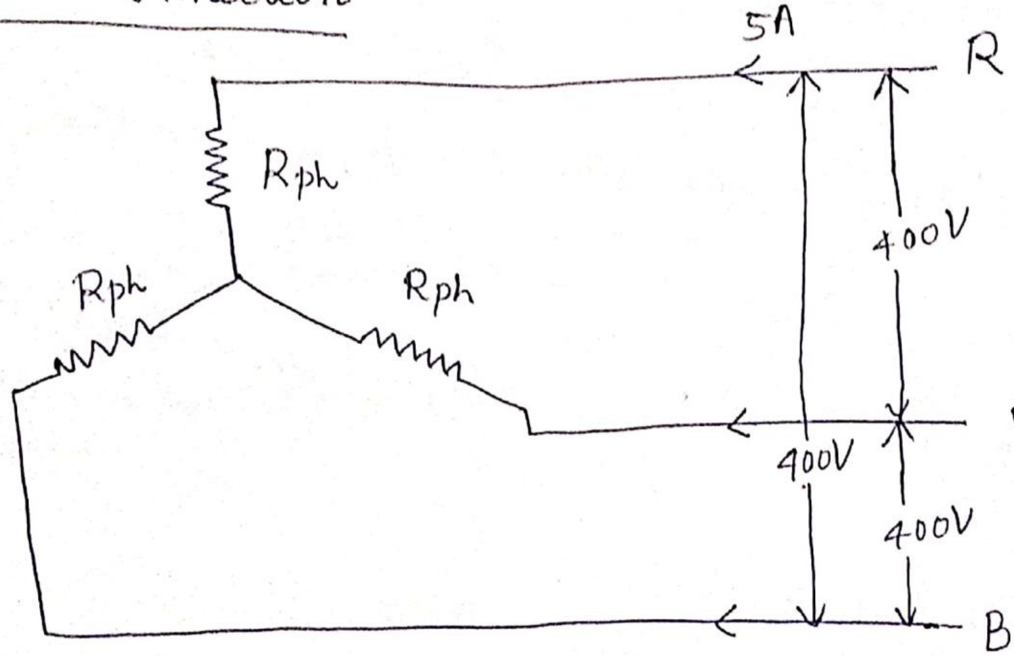
- O/P of a 3-ϕ machine is higher than a 1-ϕ machine.
- For transmission & distribution, 3-ϕ system needs less conductor material than 1-ϕ system for given voltamper & voltage rating so transmission becomes economical.
- 3-ϕ system produces rotating field so; 3-ϕ motors are self starting.
- Power in 1-ϕ system produces pulsating torque where as in 3-ϕ system produces uniform torque.
- 3-ϕ supply can be for domestic as well as industry.
- Voltage regulation is better in 3-ϕ than 1-ϕ supply.
- Efficiency is more in 3-ϕ supply than 1-ϕ.

Limitation :-

- The biggest disadvantage of 3-ϕ system is that it cannot handle the overload; It might damage the equipment.
- Chances of repairing the instrument is higher. Bcoz cost of individual components are expensive.

Three similar resistors are connected in star across 400V, 3phase lines. The line current is 5A. Calculate the value of each resistor. To what value should the line voltage be changed to obtain the same line current with the resistors delta connected?

Star connection



Line current = Phase current = 5A

$\therefore I_L = I_{ph} = 5A$

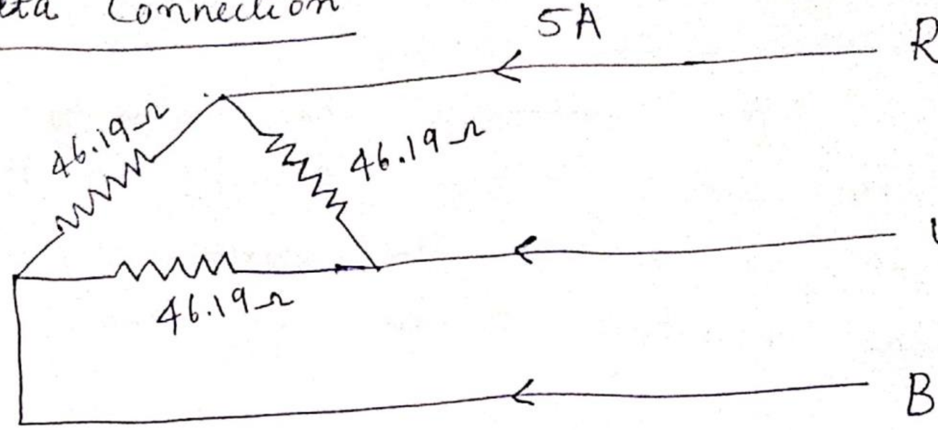
Line voltage, $V_L = 400V$

Phase voltage, $V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}} = 230.95V$

Resistance per phase, $R_{ph} = \frac{V_{ph}}{I_{ph}} = \frac{230.95}{5}$

$= 46.19 \Omega$

Delta Connection



Here line current, $I_L = 5A$

Resistance per phase, $R_{ph} = 46.19\Omega$

$$I_{ph} = \frac{I_L}{\sqrt{3}} = \frac{5}{\sqrt{3}} = 2.89\,A$$

Phase voltage, $V_{ph} = I_{ph} R_{ph} = 2.89 \times 46.19$
$= 133.49V$

$\therefore V_L = V_{ph} = 133.49V$

2) Three identical impedances are connected in delta to a 3 phase supply of 400V. The line current is 35A lagging and the total power taken from the supply is 15 KW. Calculate the resistance and reactance values of each impedance

5(a)	Derive the Emf Equation of a DC Generator	[5]	CO3	L2

EMF Equation of DC GENERATOR :-

Let Φ = flux/pole in webers.

Z = total number of armature Conductors

i = No. of [stator] slots × Conductor/slot.

P = No. of poles

A = No. of parallel path in armature.

N = Armature rotation in rpm.

E_g = EMF induced in any parallel path in the armature.

Generated Emf E_g =

Emf generated in any one of Armature parallel path.

Average Emf generated / Conductor

$$= n \frac{d\phi}{dt} \text{ volt.}$$

$$= \frac{d\phi}{dt} \text{ volt} \quad [\text{if } n = 1]$$

flux Cut / Conductor in one revolution

$$= \phi P \text{ weber.}$$

$$d\phi = \phi P$$

No. of revolution / second $= N/60$.

Time for one revolution $= \frac{60}{N}$ Second

$$dt = \frac{60}{N} \text{ second.}$$

flux Cut per Conductor / second $= \frac{d\phi}{dt}$.

$$= \frac{\phi P}{(60/N)}$$

$$= \frac{\phi N P}{60} \text{ Wb/s.}$$

* Emf generated / Conductor $= \frac{\phi P N}{60}$ Volt.

For Wave wound generator

No. of parallel paths = 2.

No. of Conductor in one path = $Z/2$.

Emf generated / path $= \frac{\phi P N}{60} \times \frac{Z}{2}$ Volt.

For Lap wound generator

No. of parallel paths = P (no. of poles)

No. of Conductors in one path = $\frac{Z}{P}$.

EMF generated / path $= \frac{\phi P N}{60} \times \frac{Z}{P}$ Volt

In General,

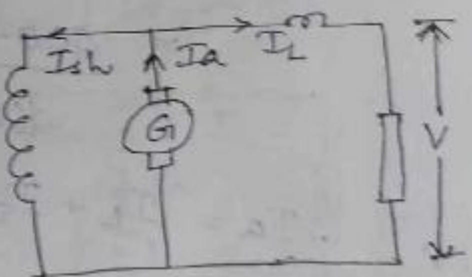
Generated Emf is $E_g = \frac{\phi Z N}{60} \times \frac{P}{A}$ (Volts)

Different Types of

5(b)	A 4 Pole, Short shunt Compound Generator has armature, shunt field and series field resistances of 0.4 Ω, 160 Ω and 0.2 Ω respectively. The armature is lap connected with 440 conductors and is driven at 600 rpm. Calculate the flux per pole when the machine is delivering 120 A at 400 V.	[5]	CO3	L3
6a)	Obtain the Torque equation of a DC Motor	[5]	CO3	L2
6(b)	A 230 V DC Shunt motor takes a current of 40 A and runs at 1100 rpm. If armature and shunt field resistances are 0.25 Ω and 230 Ω respectively, find the Torque developed by the armature.	[5]	CO3	L3
7(a)	Discuss the significance of Back emf in a DC Motor. Also derive the condition for maximum mechanical power developed.	[5]	CO3	L2
7(b)	Discuss the classification of different types of DC generators. What is the Relation between induced emf and terminal voltage?	[5]	CO3	L2

5(b)

3) A 4-pole short shunt compound generator has armature, shunt field and series field resistances of 0.4 Ω, 160 Ω and 0.2 Ω respectively. The armature is lap connected with 440 conductors and is driven at 600 rpm. Calculate the flux per pole when the machine is delivering 120A at 400V.



$P = 4$

$R_a = 0.4\,\Omega$

$R_{sh} = 160\,\Omega$

$R_{se} = 0.2\,\Omega$

$A = P$

$Z = 440$

$N = 600$ rpm

$I_L = 120$ A

$V = 400$ V.

$$E_g = \frac{\phi Z N}{60}\left(\frac{P}{A}\right)$$

$$V = E_g - I_a R_a - I_L [R_{se}]$$

$$= E_g - I_a R_a - I_L R_{se}$$

$$\therefore E_g = V + I_a R_a + I_L R_{se}$$

$$I_a = I_L + I_{sh}$$

$$I_{sh} = \frac{V + I_L R_{se}}{R_{sh}}$$

$$= \frac{400 + 120 \times 0.2}{160} = 2.65A$$

$$\therefore I_a = I_L + I_{sh} = 120 + 2.65 = 122.65A$$

$$\therefore E_g = V + I_a R_a + I_L R_{se}$$

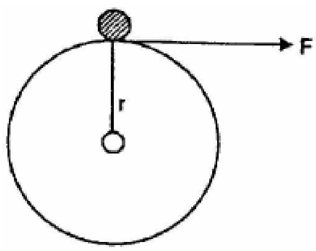
$$= 400 + 122.65 \times 0.4 + 120 \times 0.2$$

$$= 473.06V$$

6(a)Torque Equation of a DC Motor

Torque is the turning moment of a force about an axis. It is measured by the product of force (F) and radius (r) at right angle to which the force acts.

T = F x r



In dc motor, each conductor is acted upon by circumferential force, F at a distance r. Area, a = 2πrl/P

Let in a d.c. motor

r = average radius of armature in m

ℓ = effective length of each conductor in m

Z = total number of armature conductors

A = number of parallel paths

i = current in each conductor = I_a/A

B = average flux density in Wb/m2

ϕ = flux per pole in Wb

P = number of poles

Force on each conductor, $F = B\, i\, \ell$ newtons

Torque due to one conductor = $F \times r$ newton- metre

Total armature torque, $T_a = Z\, F\, r$ newton-metre

$$= Z\, B\, i\, \ell\, r$$

$i = I_a/A$, $B = \phi/a$

where a is the x-sectional area of flux path per pole

$$= Z \times \frac{\phi}{2\pi\, r \ell / P} \times \frac{I_a}{A} \times \ell \times r = \frac{Z \phi I_a P}{2\pi\, A} \;\; \text{N - m}$$

$$T_a = 0.159\, Z \phi I_a \left(\frac{P}{A} \right) \text{N - m}$$

Since Z, P and A are fixed for a given machine,

$$\therefore \qquad T_a \propto \phi I_a$$

6(b)

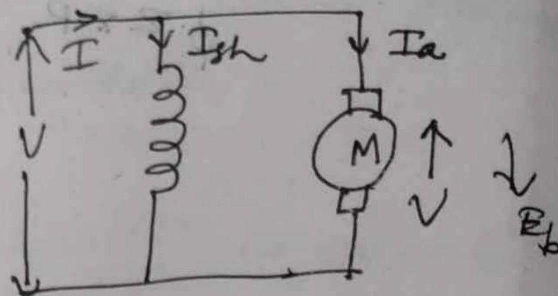
$V = 230V$

$I = 40A$

$N = 1100$ rpm

$R_a = 0.25\Omega$

$R_{sh} = 230\Omega$



$$T_a = 0.159 \frac{PZ}{A} \phi I_a$$

· Fx2πd

$\omega = 2\pi T_a$

$P = \frac{2\pi T_a}{60}$

$I_a = I - I_{sh}$

$$I_{sh} = \frac{V}{R_{sh}} = \frac{230}{230} = 1A$$

$\therefore I_a = 40 - 1 = 39A$

~~2πN~~

Power developed by the armature

$$= \frac{2\pi N T_a}{60} = E_b I_a$$

$V = E_b + I_a R_a$

$$\therefore E_b = V - I_a R_a = 230 - 39 \times 0.25 = 220.25\,V$$

$$\frac{2\pi N T_a}{60} = E_b I_a$$

$$\therefore T_a = \frac{E_b I_a \times 60}{2\pi N}$$ ~~= 220.25×~~

$$= \frac{220.25 \times 39 \times 60}{2\pi \times 1100}$$

$$= 74.61\,Nm$$

7(a) Significance of Back Emf

- The presence of back e.m.f. makes the d.c. motor a self-regulating machine.
- It makes the motor to draw as much armature current as is just sufficient to develop the torque required by the load.
- Back e.m.f. in a d.c. motor regulates the flow of armature current i.e., it automatically changes the armature current to meet the load requirement.
- As the armature rotates, back emf, Eb which opposes the applied voltage V is induced.
- The applied voltage has to force current through the armature against the back emf.

- The electric work done in overcoming the opposition is converted into mechanical energy developed in the armature.
- The energy conversion in a DC Motor is only possible due to the production of back emf.
- Net voltage across the armature circuit = V – Eb
- If Ra is the armature resistance, then Ia = (V – Eb)/Ra

Condition for Maximum Power

V Ia = Electrical input to the armature

Eb Ia = Mechanical Power developed in the armature

Ia^2 Ra = Armature copper loss

Out of the armature input, a small portion(about 5 %) is wasted as loss. The rest is converted into mechanical power within the armature.

The mechanical power developed by the motor is Pm = Eb Ia

Since, V and Ra are fixed, power developed by the motor depends upon armature current. For maximum power, should be dPm/dIa = 0

$$\therefore \quad \frac{dP_m}{dI_a} = V - 2I_aR_a = 0$$

$$\text{or} \quad I_aR_a = \frac{V}{2}$$

$$\text{Now,} \quad V = E_b + I_aR_a = E_b + \frac{V}{2}$$

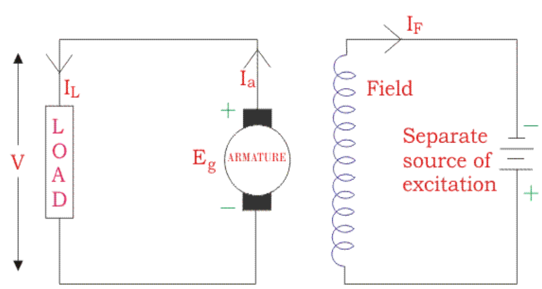
$$\therefore \quad E_b = \frac{V}{2}$$

- 7(b) Generally **DC Generators** are classified according to the ways of excitation of their fields.
- There are three methods of excitation. Field coils excited by permanent magnets – **Permanent magnet DC generators.**

- Field coils excited by some external source – **Separately excited DC generators.**
- Field coils excited by the generator itself – **Self excited DC generators.**

Separately Excited DC Generators

- These are the generators whose field magnets are energized by some external DC source such as battery.
  A circuit diagram of separately excited DC generator is shown in figure.
  I_a = Armature current
  I_L = Load current
  V = Terminal voltage
  E_g = Generated emf



Separately Excited DC Generator

Voltage drop in the armature = Ia Ra
Let Ia = IL = I
Voltage across the load, V = IRa
Power generated, Pg = Eg I
Power delivered to the external load,

PL = V I

According to the position of the field coils the self – excited DC Generators may be classified as :

- Series wound generators
- Shunt wound generators
- Compound wound generators

Series Wound Generator

Let R_{sc} = Series winding resistance

I_{sc} = Current flowing through the series field

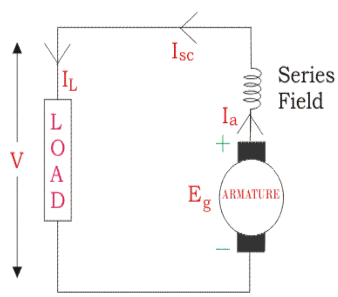
R_a = Armature resistance

I_a = Armature current

I_L = Load current

V = Terminal voltage

E_g = Generated emf



Series Wound Generator

- Here Ia = Isc = IL = I
- Voltage across the load, V = Eg – Ia(Ra + Rsc) – Brush drop
- Power generated, Pg = Eg Ia
- Power delivered, PL = V I

Shunt wound Generator

Let, R_{sh} = Shunt winding resistance

I_{sh} = Current flowing through the shunt field

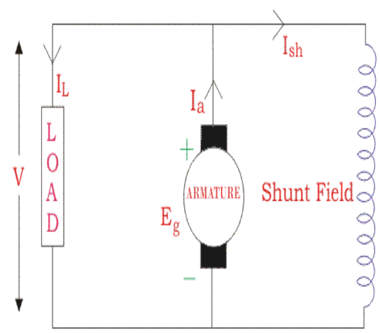
R_a = Armature resistance

I_a = Armature current

I_L = Load current

V = Terminal voltage

E_g = Generated emf



Shunt Wound Generator

Here Ia = Ish + IL

Ish = V / Rsh

Voltage across the load,

V= Eg – Ia Ra – Brush drop

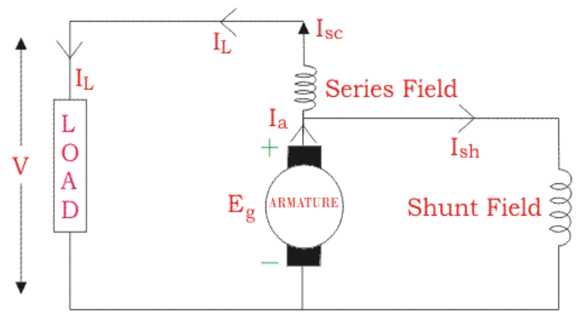
Power generated, Pg = Eg Ia

Power delivered to the load, PL = V I_L

Compound Wound Generators

Short Shunt Compound Wound DC Generators

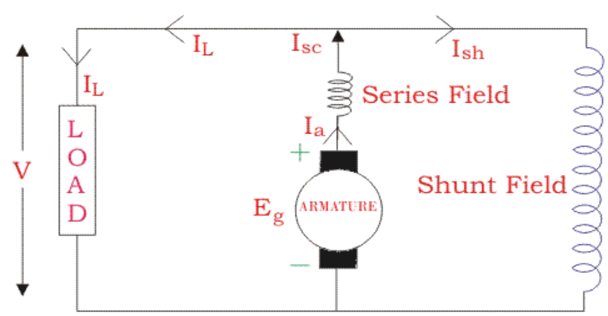
These are the generators in which only shunt field winding is in parallel with the armature winding



Short Shunt Compound Wound Generator

Isc = I_L
Ish = (V + Isc Rsc) / Rsh
Ia = Ish + I_L
V = Eg – Ia Ra – Isc Rsc – Brush drop
Pg = Eg Ia
PL = V I_L

Long Shunt Compound Wound DC Generator
The generators in which shunt field winding is in parallel with both series field and armature winding as shown in figure.



Long Shunt Compound Wound Generator

Ish = V / Rsh
Isc = I_L + Ish
V = Eg – Ia Ra – Isc Rsc – Brush drop
Pg = Eg Ia
PL = V I_L