Electrical Engineering

Engineering Drawing

Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur
Phone : 5639122/6634373/6635046/6630088
Website : www.moecdc.gov.np

10

Feedback Copy

Technical and Vocational Stream
Learning Resource Material

Engineering Drawing
(Grade 10)

Secondary Level
Electrical Engineering

Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur

Publisher : Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur

Layout by Khados Sunuwar

Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline and self-reliance, creativity and thoughtfulness. It is essential to develop in them the linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills. it is also necessary to bring in them the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values so as to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This Learning Resource Material for Electrical Engineering has been developed in line with the Secondary Level Electrical Engineering Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops and seminars, interaction programs attended by teachers, students and parents.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Dr. Lekhnath Poudel, Pro.Dr. Indraman Tamrakar, Dipak Shrestha, Akhileshwar Mishra, Jagdishraj Ghimire, Rupesh Maharjan, Sanju Shrestha, Rama shankar Shaha is highly acknowledged. The book is written by Abin Maharjan and the subject matter of the book was edited by Badrinath Timalsina and Khilanath Dhamala. CDC extends sincere thanks to all those who have contributed in developing this book in this form.

This book is a supplimentary learning resource material for students and teachrs. In addition they have to make use of other relevnt materials to ensure all the learning outcomes set in the curriculum. The teachers, students and all other stakeholders are expected to make constructive comments and suggestions to make it a more useful learning resource material.

2076 BS

Ministry of Education, Science and Technology
Curriculum Development Centre

Table of Contents

CHAPTER - 1
Power Supply

1. Objectives:

This chapter focuses on the constructional detail and working principle of DC power supply system. The main objectives are as follows:

- To make power supply
- ii. To be familiar with the construction and know operating principle of rectifiers

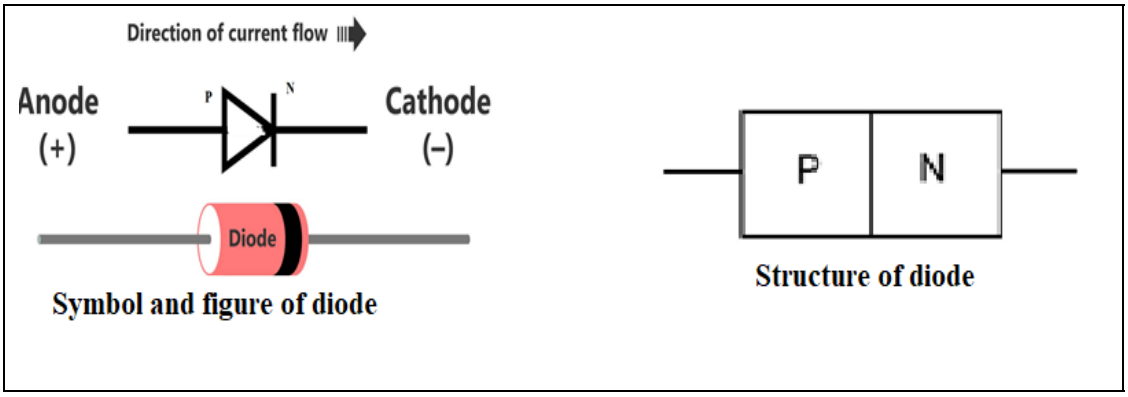
2. Learning materials:

- Electrical components like: transformer, diodes, capacitor, Zener diodes, resistors etc.
- DC power supply

3. Content:

Diode

Diode is a two terminal unidirectional device. The two terminals are P and N. The P-type region is called anode and N-type region is called cathode, It is a semi-conductor device. The main function of a diode is to pass the current in forward direction and block the current in reverse direction.



Symbol and figure of diode

Structure of diode

Rectifier

A rectifier is an electrical device which consists of one or more diodes. It converts alternating current (AC) into direct current (DC). It is just like a one way value as it allows the electrical current only in one direction to flow and the process is known as rectification. The rectifiers are used in various devices like:

a) DC power supply
b) Adapters
c) Radio signals and detectors
d) Video game system, laptop, television etc.

Rectifiers are of two types:

1) Half-wave rectifier 2) Full- wave rectifier

1 Half-wave Rectifier

Half-wave rectifier is such type of rectifier that converts only the positive half cycle of an alternating current (A.C) and blocked the negative half cycle of input signal.

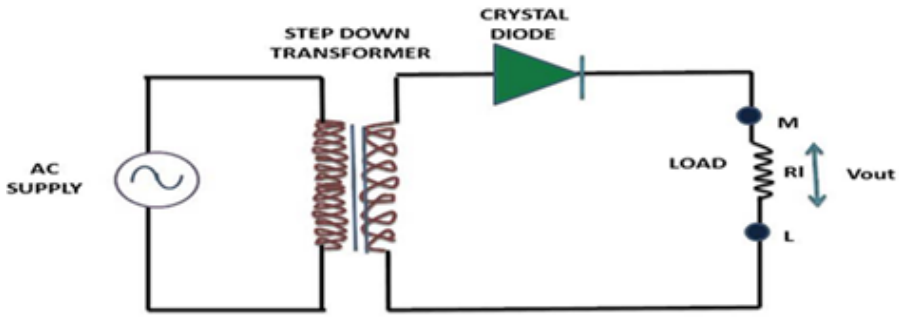


Figure: Half-wave rectifier

When an AC supply is given from the source, it is reduced to a low voltage by a step-down transformer and then fed to the diode. So, during the positive half cycle of the signal, the diode is forward biased and allows electric current and voltage is dropped across the load whereas during the negative half cycle, the diode is reverse biased and blocks electric current. The resistor placed at the output consumes the dc current generated by the diode. The wave-form of half wave rectifier is shown below:

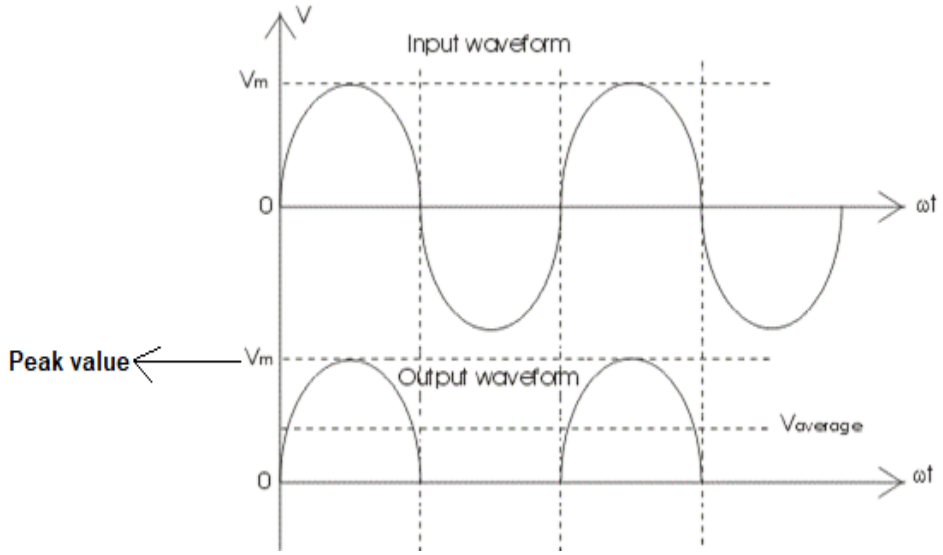


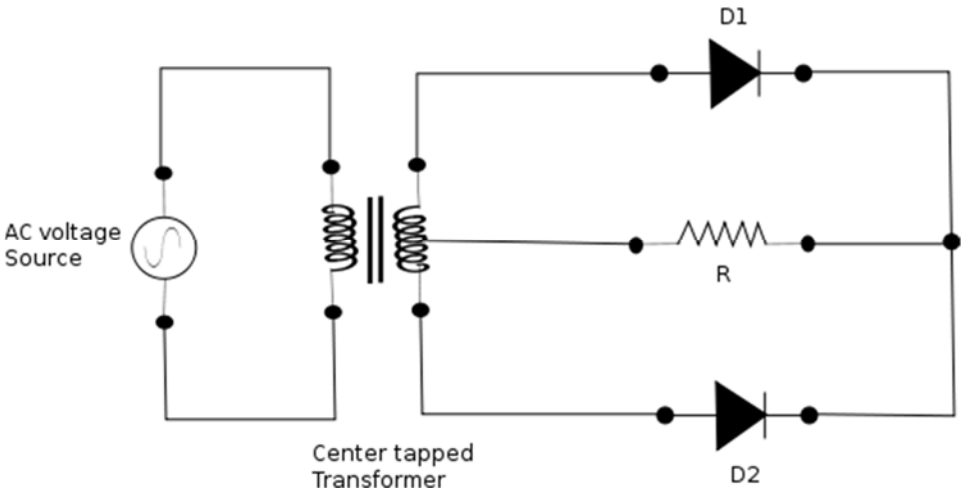
Figure: Waveform of half-wave rectifier

2. Full-wave Rectifier:

Full wave rectifier is that type of rectifier which converts or utilize both the half cycle(positive and negative) of ac input voltage. There are two types of full wave rectifier:

a) Center-tapped rectifier
b) Bridge type rectifier

a) Center tapped rectifier



The center-tapped full-wave rectifier circuit uses to diodes D_1 and D_2 which are connected to the center-tapped secondary winding of the transformer. The center-tapped on the secondary is taken at zero voltage reference point. If the secondary voltage is V_2 then the voltage between one end of secondary and center tapped is equal to $\frac{V_2}{2}$. According to the polarities of the secondary windings, for the positive cycle of the diode D_1 is forward biased and diode D_2 is reversed biased. Hence, D_1conducts a current "i_2" flows and D_2 is cut off while for the negative half cycle, the diode D_1 is reversed biased and the diode D_2 is forward biased hence D_1 is cut off and diode D_2 conducts the current.

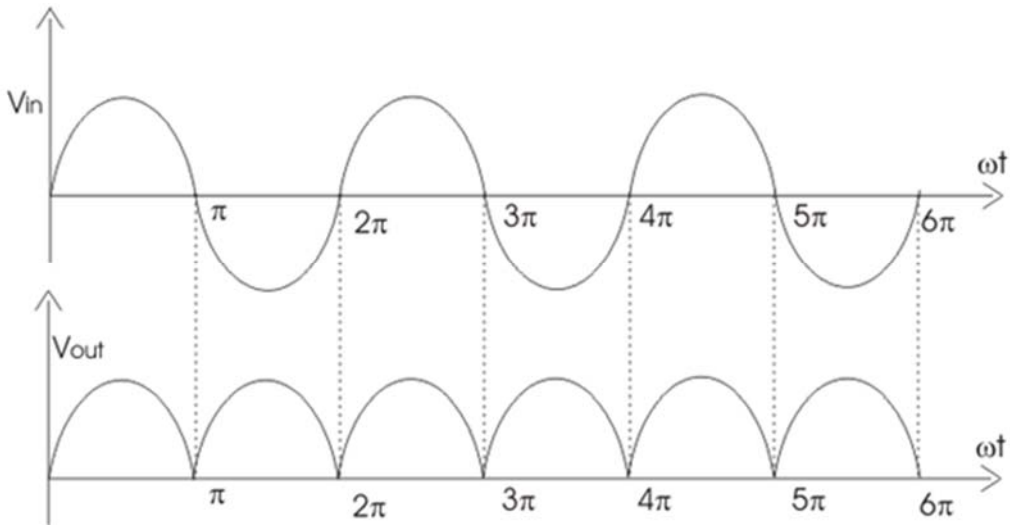


Figure: Waveform of center tapped full-wave rectifier

b). Bridge type full-wave rectifier

Bridge type full-wave rectifier uses four diodes which are connected across the secondary of the transformer. It avoids the needs of center-tapped transformer. The figure of bridge type is shown below:

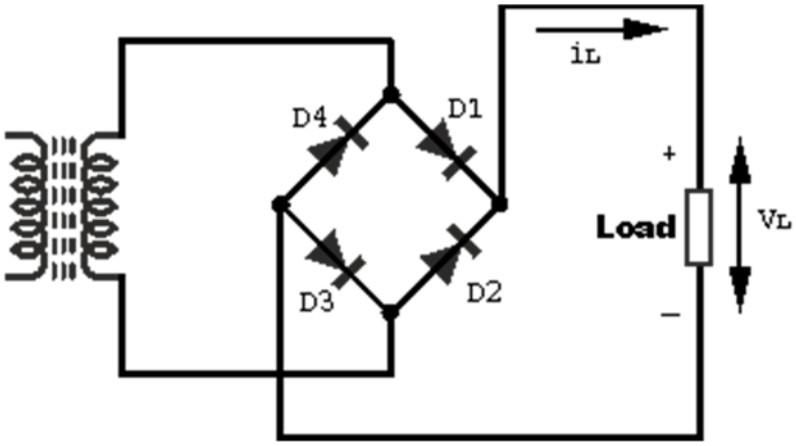


Figure: Bride type full-wave rectifier

During positive half-cycle, the diodes D_1 and D_3 are in forward biased (whereas the remaining two diodes are in reversed)so they conduct the current and the output voltage V_L is dropped across the the load resistance. Simillary, during the negative half-cycle, the diodes D_2 and D_4 are forward biased and they conduct (while the remaining two diodes are in reverse biased and they donot conduct) the current and voltage is dropped across the load resistance.Thus, full wave rectifier gives output in both positive and negative half cycle. The wave-form is shown below:

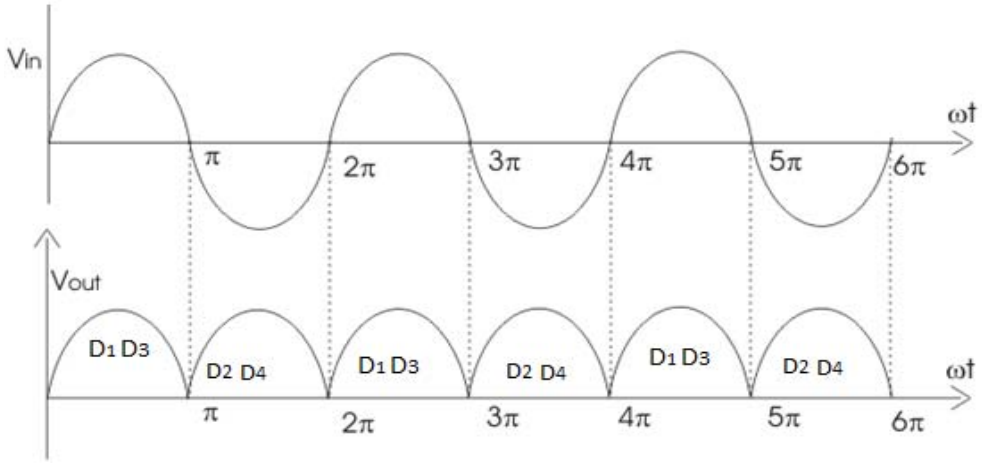


Figure: Input and output wave-form of bridge rectifier

Where, V_{in}= Input voltage, V_{out}= Output voltage

So, from the above waveform, it is clear that in full wave bridge rectifier, a fluctuating unidirectional output voltage is developed across the load continuously.

Power Supply

Power supply is an electrical device that provides electrical power to the load. It converts the input electrical power to the appropriate voltage current and frequency depending upon the load connected to it.

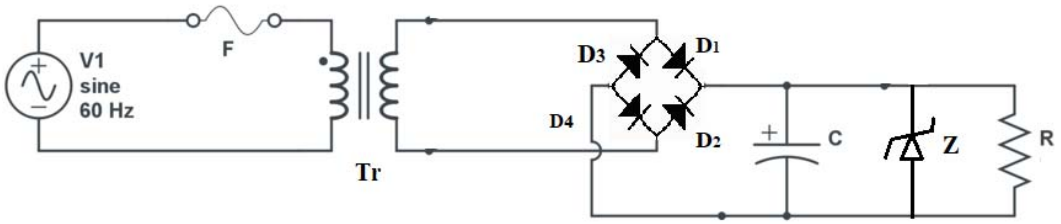


Figure: Power supply

Where; F= Fuse **;** Tr =Transformer; D = Diode;Z = Zener Diode **;** R = Resistor

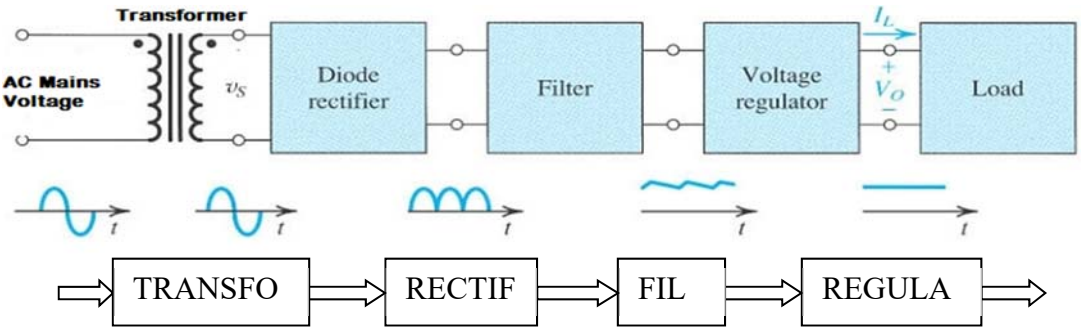


Fig:- Block diagram of a power supply

Different components of power supply:

AC source

Alternating current is supplied to the circuit by an A.C source which is usually represented by a sinusoidal waveform.

Transformer

Transformer is a static device which increases or reduces the AC voltage. In power supply, we generally use; step down transformer to get reduced voltage because the voltage needed for the diode is very small.

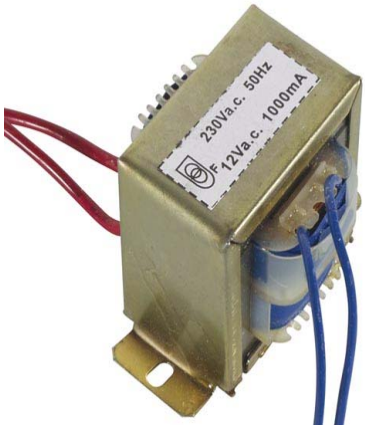


Fig:-230/12 Volts

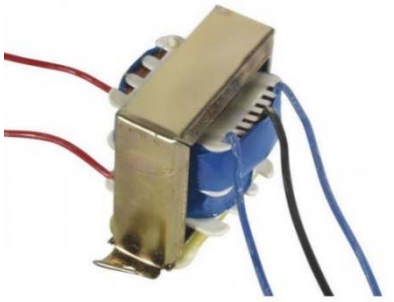


Fig:- Center tapped Transformer

Diode (Rectifying unit)

A diode is a two terminal device that allows the current to flow only in one direction (forward) and blocks current coming from another direction (reverse).In the above power supply, the no. of diodes used are four.

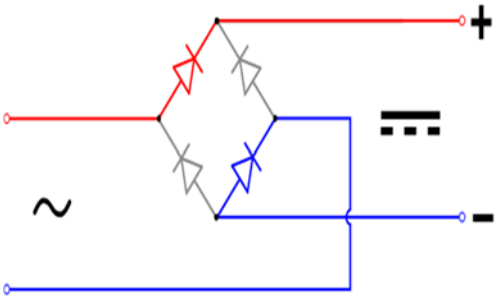


Fig:- Bridge type Rectifier

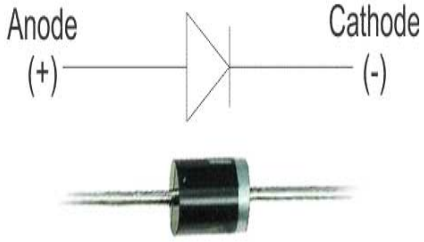


Fig:- PN Junction Diode

Capacitor (Filtering Unit)

The filter of filtering unit converts the pulsating direct current into pure direct current. The ripples from the output of a rectifier are removed with the help of a filter. A capacitor or an inductor is used as a filter to convert the pulsating DC to pure DC.

Fig:- Electrolytic capacitor

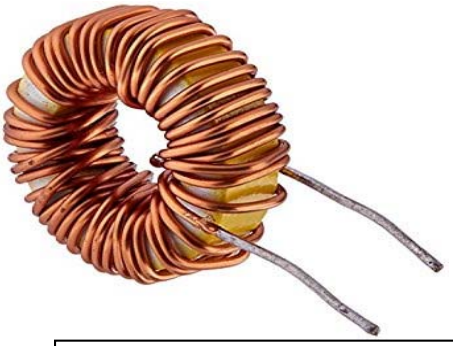


Fig:- Inductor

Zener diode (Regulating unit)

Zener diode is a special type of diode which allows current to flow from both directions (forward and reversed). It is used to regulate the voltage at constant level before passing to the load.

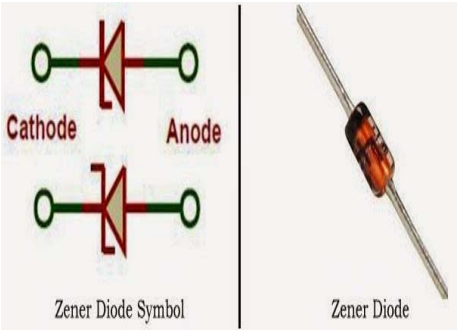


Fig:- Zener diode

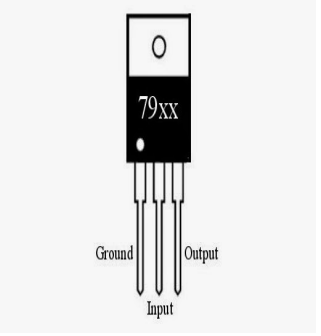


Fig: Voltage

Resistor

A resistor is passive component that restricts the flow of current and the voltage is dropped across it and the output is taken from it.

V-I characteristics of P-N junction diode or practical diode

The V-I characteristics of a diode is simply a curve or graph between voltage applied across its terminals and the current that flows through the diode due to this applied voltage. The entire V-I characteristics may be divided into 2 parts:

a) Forward characteristics
b) Reverse characteristics

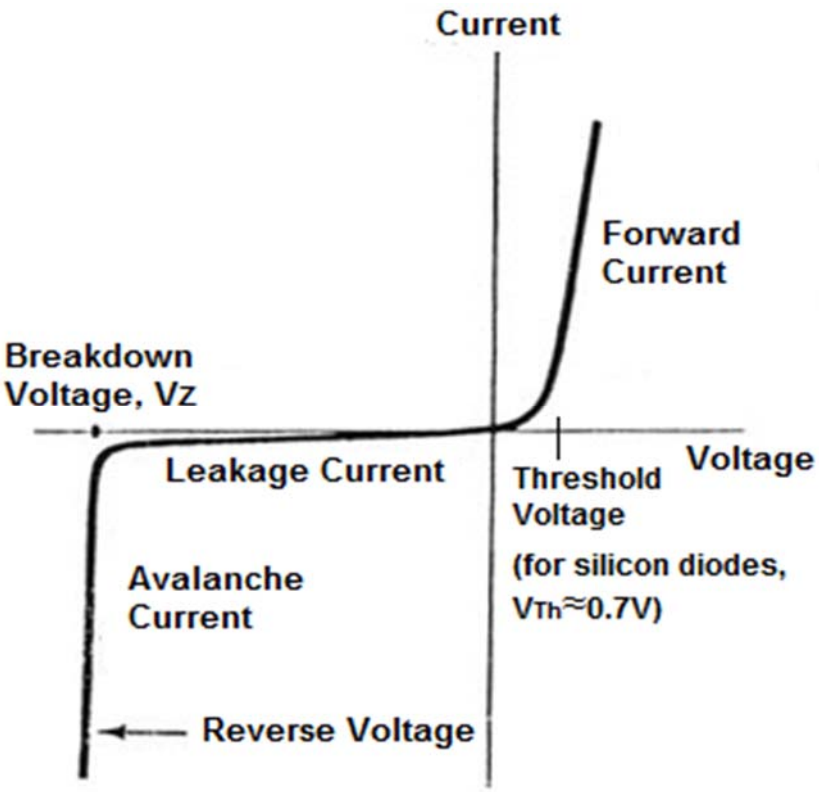


Figure: V-I characteristics of P-N junction diode

a) Forward characteristics

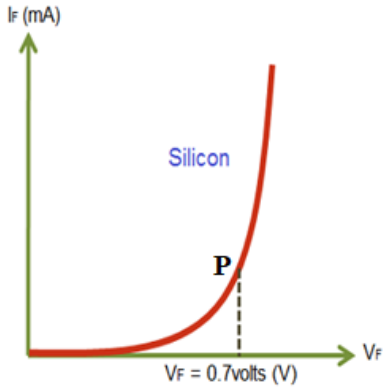


Figure: Forward characteristics of silicon diode

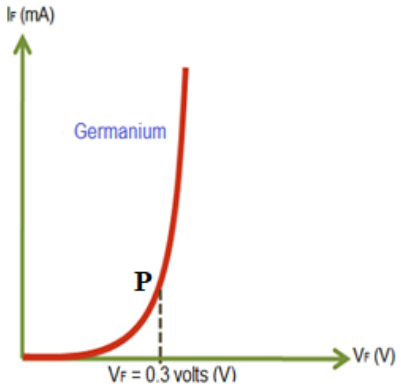


Figure:Forward characteristics of germanium diode

In order the characteristic of a diode, the voltage across the diode is gradually increased and the corresponding increase in current is noted. Then after, the graph is plotted taking the voltage in the horizontal axis whereas current in the vertical axis.

As seen on the graph, there is only slight increase in current till the point 'P' is reached. This is because the applied voltage has to overcome the barrier potential. Further increase of voltage beyond the point "P", current increases rapidly and diode conducts heavily. The voltage at which current starts increasing is called knee voltage which is 0.7V for silicon and 0.3V for germanium. The applied voltage across the diode should not increase beyond a specified safe value otherwise the diode will burn due to heat.

b) Reverse characteristics

If the negative terminal of the battery is connected to the p-type semi-conductor and the positive terminal of the battery is connected to the n-type semi-conductor, the diode is said to be in reverse bias. In the above figure, V_R represents the reverse voltage and I_R represents the reverse current.

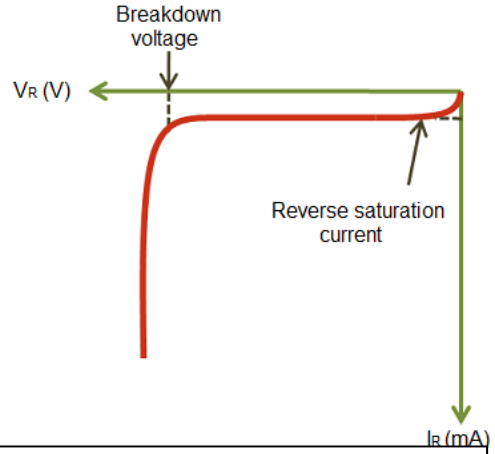


Figure: Reverse characteristics of diode

When the reverse voltage on the p-n junction diode is increased, the free electrons from the n-type semi-conductor and the holes from the p-type semi-conductor are moved away from p-n junction, thus the width of depletion region is increased. This depletion layer completely block the majority charge carrier current. The free electrons(majority carrier) in the p-type semi-conductor and the hole(minority) in n-type semi-conductor carry the electric current. The electric current which is carried by the majority charge carriers in the p-n junction diode is called reverse current. The point or voltage at which the electric current reaches it's maximum level and further increase in the voltage does not increase the electric current is called reverse saturation current.

Transformer:

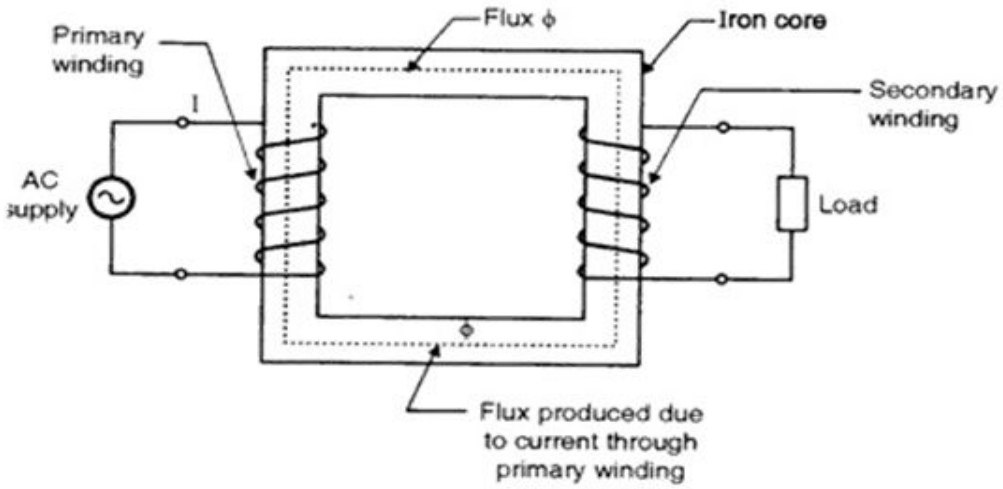


Figure: Transformer

Transformer is a static device that consists of electrically isolated two coils which operates on the principle of Faraday's law of mutual induction. In transformer, an emf is induced in the secondary coil due to the magnetic flux generated by current and voltage in the primary coil.

Transistor:

Transistor is a three terminal semi-conductor device in which a layer of n-type semi-conductor is sandwiched between two layers of p-type semi-conductor or vice-versa.

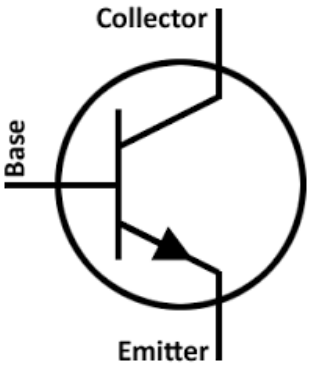
It can be used to amplify the signal also can be used as a switch. The types of transistor are: BJT and FET.

The types of Bi-Junction Transistor (BJT) are:

a. NPN transistor
b. PNP transistor

a). NPN transistor

It is the type of transistor in which two n-type regions is separated by p-type region. It consists of emitter, base and collector.



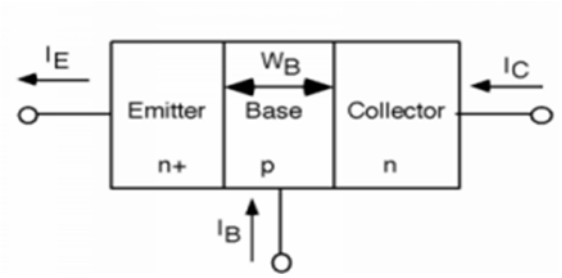
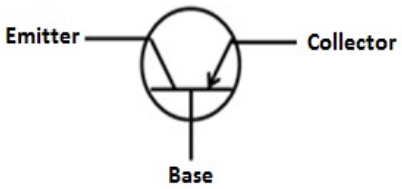


Figure: Symbol of NPN transistor **Figure:** Structure of NPN trasistor

In this of trasnsistor, emitter is heavily doped, collector is moderately doped and base is lightly doped.

b) PNP transistor

It is the type of transistor in which two p-type regions is separated by -type region. It consists of emitter, base and collector.



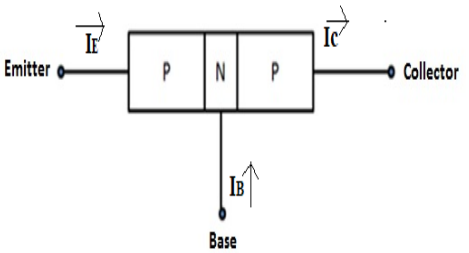


Figure: Symbol of PNP transistor **Figure:** Structure of PNP transistor

In this of trasnsistor, emitter is heavily doped, collector is moderately doped and base is lightly doped.

Capacitor:

Capacitor is a passive component that store electric charge. It helps in smoothing the output voltage from the rectifier in-case of power supply.

4. Assessments

A. Very short answer questions.

1. What is diode?
2. What is capacitor?
3. What is transformer?
4. What is the function of diode?
5. Define V-I curve of a diode.
6. How many diodes are used in half-wave rectifier?
7. Draw the symbol of diode.
8. Draw the symbol of capacitor.

B. Short answer questions.

1. Write short notes on power supply.
2. Draw the circuit diagram of half wave rectifier.
3. Draw the circuit diagram of full wave rectifier.
4. Draw the waveform of half wave rectifier.
5. Draw the waveform of full wave rectifier.

C. Long answer questions.

1. Describe the units of power supply with diagram.
2. Explain the working principle of half wave rectifier with diagram and waveform.
3. Explain the working principle of half wave rectifier with diagram and waveform.
4. Differentiate between half and full wave rectifier.

Glossary:

doped: to add

multi-range: having wide ranges

waveform: graphical representation that shows changes in amplitude over time

References:

1. www.electricaleasy.com

2. http://electricalengineeringtutorials.com

3. www.electrical4u.com

4. www.electricalengineeringtoolbox.com

5. Basic electronics, Dr. Sanjay Sharma

6. Electronic Circuit, Sedra and Smith

CHAPTER - 2
DC Motor

1. Objectives:

The main objectives of this chapter are:

i. To construct dc motor and know operation of it
ii. To be familiar with the types of motor and its circuit diagram

2. Learning Materials:

Different types of dc motor are required:

a. shunt
b. series
c. compound

3. Content:

Concept and definition:

DC machines are the rotating electrical machines which can be used as either motors or generators. DC machine is a device which converts mechanical energy into electrical energy and vice-versa. When the device acts as a generator (or dynamo), mechanical energy is converted into electrical energy. On the other hand, when the device acts as the motor, the electrical energy is converted into mechanical energy. The process of the interconversion is reversible. However, during the conversion process, a part of energy is transformed into heat, which is lost, and can't be reversible. Therefore, this type of machine can work either as" motor" or "generator". Almost, generator and motor are very much similar to each other in essential parts and construction. But slight modification is done for their operation.

Main parts of DC motor:

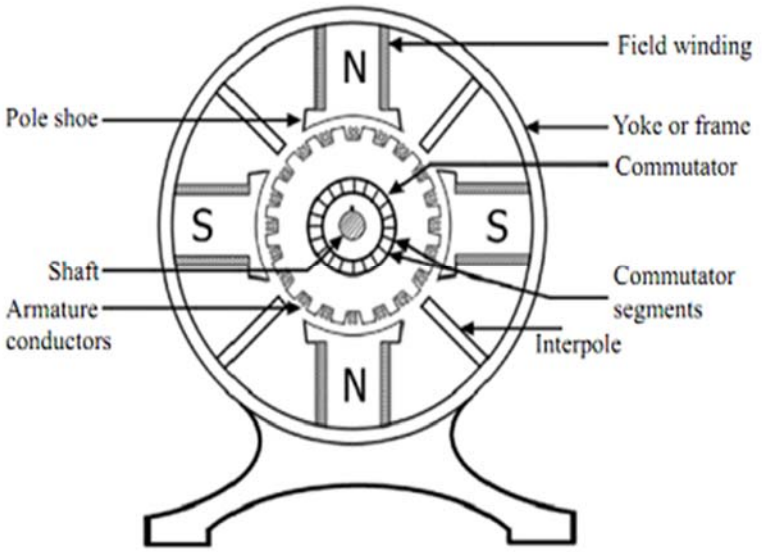


Figure: Dc motor

The different parts of dc machines are as follows:

i) Yoke

It is the outermost frame of the machine. It provides mechanical support for the field pole and acts a protecting cover for the whole machine and also carries the magnetic flux produced by the field poles. In small machines, cast iron yokes are used because of cheapness but yoke of large machine is invariably made of fabricated steel due to its high permeability.

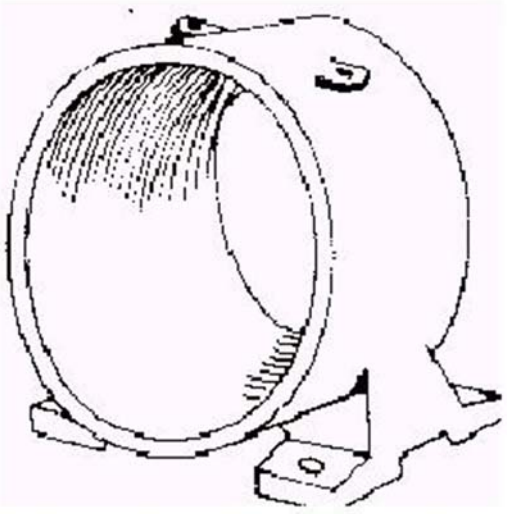


Figure: Yoke

ii) Field poles

They are the iron core projected from yoke. The upper part of the pole, which is connected to the yoke, is known as pole -core. The lower and wider part is known as pole-shoe. The field poles are generally made from the laminated annealed steel sheet. The field poles are usually formed of laminations (thin sheet of steel) and are bolted to the frame or yoke to which are also fastened the end bells with their bearings and the brush rigging. The pole shoe serves two purposes:

a) It spreads out the magnetic flux in the air gap and also being larger cross section reduces the reluctance of the magnetic path.
b) It supports the field winding.

Field winding

It is the copper wire or strip wound on the field pole. The windings are insulated from the pole core and each turns of windings are also insulated from each other to protect from turn to turn short circuit. When DC current is passed through these coils, they will magnetize the pole core and produce magnetic field in the central space of the machine.

i) Armature

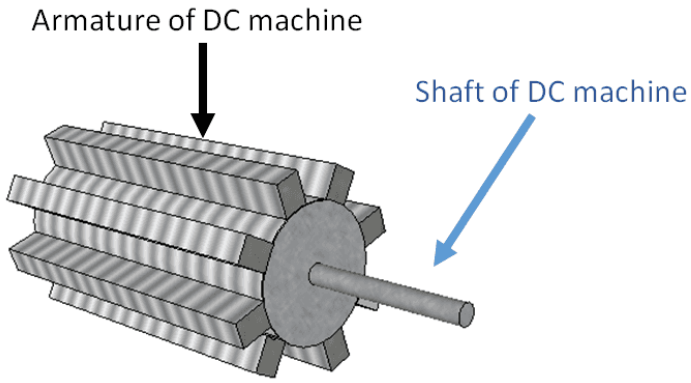


Figure: Armature

It is rotating part of the machine and is built up in a cylindrical or drum shape. The various parts of an armature are shaft, armature core, commutator and armature winding. The bearing holds the shaft on the central empty space of the machine in

such way that there is a small air gap few mm between armature and the pole- shoes the armature core is made from laminated silicon steel sheet insulated with varnish. The purpose of armature is to rotate the conductors in the uniform magnetic field. It consists of coils of insulated wires wound around an iron and so arranged that electric currents are induced in these wires when the armature is rotated in a magnetic field. In addition, its most important function is to provide a path of very low reluctance to the magnetic flux. The armature core is made from high permeability silicon-steel stampings, each stamping, being separated from its neighboring one by thin paper or thin coating of varnish as insulation.

ii) Commutator

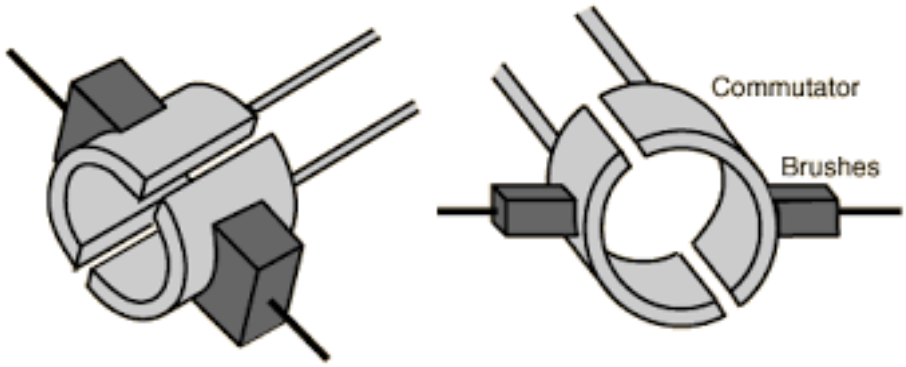


Figure: Commutator and brushes

The commutator is a form of rotating switch placed between the armature and the external circuit and so arranged that it will reverse the connections to the external circuit at the instant of each reversal of current in the armature coil. It is made of number of copper segments insulated from each other and from the shaft. It is also known as mechanical rectifier as it coverts ac into dc. It is very important part of a dc machine and serves the following purposes:

1) It provides the electrical connections between the rotating armature coils and the stationary external circuit.
2) As the armature rotates, it performs a switching action reversing the electrical

connections between the external circuit and each armature coil in turn so that the armature coil voltages add together and result in a dc output voltage.

3) It also keeps the rotor or armature mmf stationary in space

i) Armature winding

Armature winding is an arrangement of conductors to develop desired emf by relative motion in a magnetic field. In winding, conductor or group of conductors are distributed in different ways in slots all over the periphery of the armature. The conductors may be connected in series and parallel combinations depending upon the current and voltage rating of the machine. It is the enamel insulated copper wire wound on the slots of the armature core.

ii. Carbon Brush

Carbon brush is rectangular in shape which rest on the commutator. The main function of the carbon brush is to collect the current from the commutator and supply it to the external load circuit. The brushes are held under pressure over the commutator by the combination of brush holders and springs whose tension may be adjusted.

Operation of dc motor

The operation of dc motor is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force. The direction of this force is given by Fleming's left hand rule and magnitude is given by; F= BIL Newtons

When the dc source is applied to the carbon brush of the dc motor, the current flows through the positive brush, commutator, armature winding and finally goes out through the negative brush. The current flows through the field winding represents magnetic field while current flowing through the conductor of the armature winding represents mechanical force.

Types of DC motor along with their characteristics and uses

There are three types of DC motor based upon the method of excitation;

a) DC shunt motor
b) DC series motor
c) DC compound motor

1. DC shunt motor

If the field winding is connected in parallel to the armature of DC motor then such a motor is called DC shunt motor. The field winding consists of a large number of turns of comparatively fine wire so as to provide large resistance. The field current is much less than the armature current, sometimes as low as 5%. The circuit diagram is shown in figure 2.6 (a).

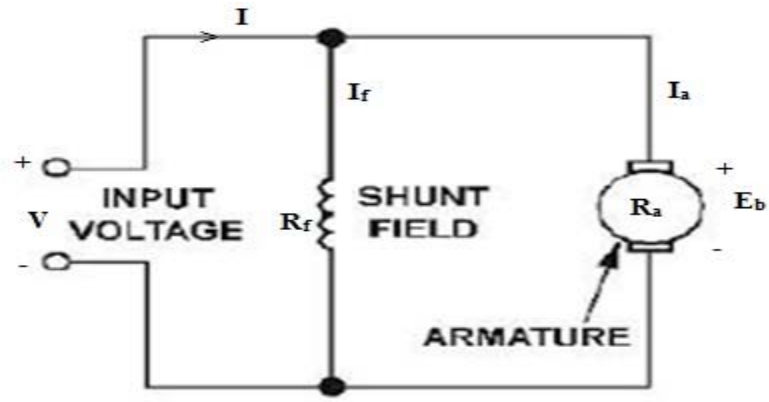


Figure: Dc shunt motor

Let;

E_b = back emf on armature
V =input voltage applied
R_a = armature resistance
I_a= armature current
I = input current
I_f = field current
R_f = field resistance

Applying KVL,

$V - E_b - I_aR_a = 0$

$V = E_b + I_aR_a$..... (i)

The above equation (i) shows relationship between applied voltage and back emf.

2. DC series motor

The field winding is connected in series with the armature winding in-case of DC series motor. In this motor the field coils consists few numbers of thick turns. The cross-sectional area of the wire used for the field coils has to be fairly large to carry the armature current, but owing to the higher current, the number of turns of wire in them needs not to be large.

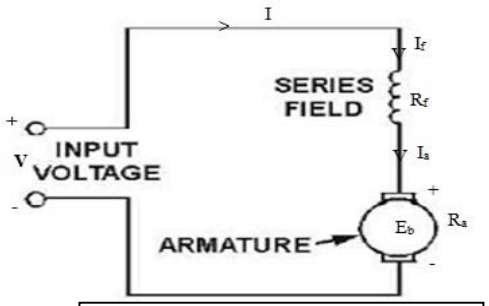


Figure: DC series motor

Let ;

E_b = back emf on armature

R_a = armature resistance

I_a = armature current

V =input voltage applied

R_f = field resistance

I_f = field current

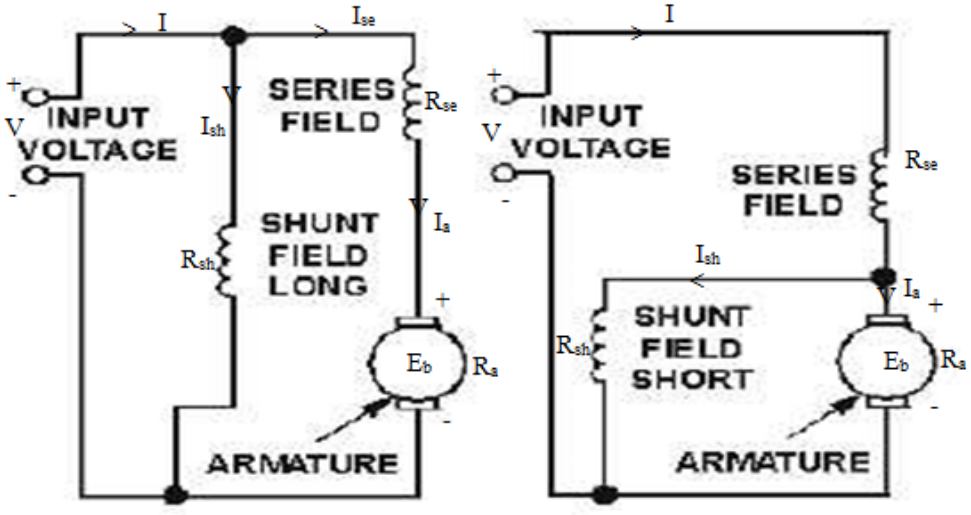
Applying KVL, ($I=I_a=I_f$)

$V - E_b - I_aR_a - I_fR_f = 0$

$V = E_b + I_a(R_a + R_f)$……(ii)

This is required relationship between applied voltage and back emf.

3. DC compound motor



A. Long shunt compound motor

B. Short shunt compound motor

It has two field winding: series and shunt winding. When shunt field winding is connected parallel to armature and series field winding is connected series to the load then such motor is short shunt compound motor (figure 2.6(B)). When shunt field winding is connected parallel to both armature and series field winding is called long-shunt dc compound motor (figure 2.6 (A)). In long shunt compound motor, the input current is equal to the sum of armature current and the shunt field current i.e $I = I_{Sh} + I_a$ where series field current is equal to armature current i.e $I_{se} = I_a$. Similarly, in short shunt compound motor, the input current is equal to field series current which is equal to the sum of armature current and shun field current. i.e $I = I_{se} = I_{sh} + I_a$.

Uses of dc machine as motor

a. DC shunt motor: They are used where the machines need to run at constant speed in different load condition such as in driving pumps, drills, printing press, lathes.

b. DC series motor: They are used where load needs high starting torque such as in cranes, pumps, trains, trolley etc.

c. Compound motor: They are used for drives requiring high starting torque and only fairly constant speed such as in rolling mills, crushers, cutting coals, punch presser, printing press etc.

Some differences between AC motor and DC motor:

Basis	AC motor	DC motor
1.Type	1. It can be classified into induction, rotor wound and synchronous	1. It can be classified as separately excited and self-excited.
2. Nature of input	2. Alternating current is used as input supply.	2. Direct current is used as input supply.
3. Source	3. Single or three phase supply	3. Dc source or battery
4.Commutation process	4. Absent	4. Present
5.Carbon brush	5. Absent	5. Present
6. Position of armature	6. Armature is stationary whereas magnetic field rotates.	6. Armature rotates while magnetic field remains stationary.
7. Application	7. In large and industrial application	7.In small and domestic application
8.Maintenance	8. Low maintenance cost	8. High maintenance cost

Assessments:

A. Very short answer questions:

1. What is dc motor?
2. Write down the applications of dc series motor.
3. Write down the applications of dc shunt motor.
4. Write down the applications of dc compound motor.
5. What is the function of pole shoe?

B. Short answer questions.

1. Differentiate between AC and DC motor.
2. Draw the circuit diagram of dc series motor.
3. Draw the circuit diagram of dc compound motor.
4. Draw the circuit diagram of dc shunt motor.

C. Long answer questions.

1. Explain the types of dc motor.
2. Explain the working principle of dc motor with figure.
3. Differentiate between dc shunt and series motor.
4. Differentiate between DC and AC motor.

Glossary:

Application: use

Stamping: method of manufacturing using dies at extreme pressure Slot: Channel opening in stator or rotor of a rotating machine for ventilation and insertion of windings

References:

www.electricaleasy.com
www.electrical4u.com
Jupta Gupta, "Electrical Machine"
S. Chand, "Principle of Electrical Machine"
Jain and Jain. "ABC of Electrical Engineering"

CHAPTER - 3
Single Phase Motor

1. Objectives:

The main objectives of this chapter are:

i. To construct and know the operation of different types of single phase motor
ii. Familiar with the circuit diagram of different types of induction motor
iii. To test the use-ability of capacitor

2. Learning materials:

1. Split phase induction motor
2. Capacitor start motor
3. Capacitor start/run motor
4. Universal motor
5. Capacitor
6. Multi-meter

3. Content:

Introduction of single phase induction motor

This type of motor is used on single-phase supply. It is most familiar motors that are used in our home, shop, office etc. The construction of single phase induction motor is similar to that of three phase induction motor, except that the stator is provided with a single phase supply between poles. It has stator with slots and the squirrel cage rotor with a small air-gap in between. Generally, the single phase induction motor is not self- starting and requires some starting means to get started.

Constructional detail of single phase induction motor

Different parts of single phase motor are as follows:

1. Stator
2. Rotor
3. Fan cover
4. End shield
5. Bearing
6. Centrifugal

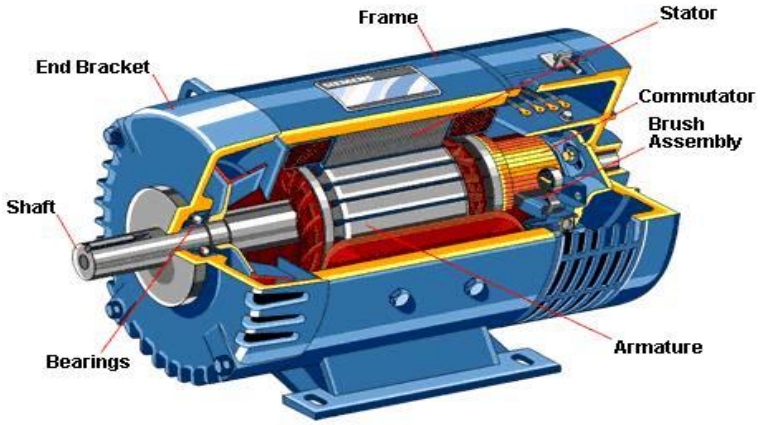


Figure: Single phase induction motor

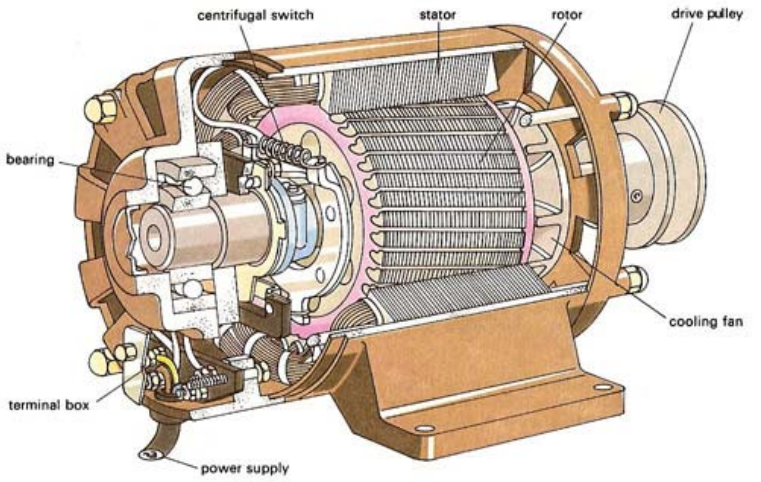


Figure: Single phase induction motor

1. **Stator:** It is stationary part of the machine. It is made up of stampings. The stampings are slotted on its periphery to carry the winding called stator winding or min winding.
2. **Rotor:** Rotor is same as squirrel cage rotor. It consists of uninsulated copper or aluminum bars placed in the slots. The copper or aluminum bars are slotted by ring known as end ring.
3. **Fan cover:** Generally, the fan cover used in the single phase motor is of metal.

4. **End shield:** An end shield for mounting on a stack of laminations forming the stator of an electric motor. The motor incorporates at least one end shield .
5. **Bearing:** Bearing is a element that constrains relative motion to only the desired motion, and reduces friction between moving parts. Rotary bearings hold rotating components such as shafts or axles within mechanical systems, and transfer axial and radial loads from the source of the load to the structure supporting it.
6. **Centrifugal:** A centrifugal switch is an electric switch that operates using the centrifugal force . The centrifugal switch consists of weights mounted to the shaft of the motor and held near the shaft by spring force. The switch is used to disconnect the starting winding of the motor once the motor approaches its normal operating speed.

Operating principle of single phase motor

When single phase supply is given to stator winding of single phase induction motor, the alternating current starts flowing through the stator or main winding. This alternating current produces alternating flux called main flux. This main flux also link with the rotor conductors and hence cut the rotor conductor. According to Faraday's law of electromagnetic induction, emf will be induced in the rotor. As rotor circuit is closed ones o, the current starts flowing in the rotor. Then, this rotor current produces it own flux called rotor flux. Now there are two fluxes. These two fluxes produce the desired torque which is required by the motor to rotate.

Method of making Single Phase Induction Motor self-startin

The single phase induction motor is not self-starting. To make it self-started, we need to produce a revolving stator magnetic field. This may be achieved by converting a single – phase supply into two phase- supply through the use of an additional winding. As soon as the motor attains sufficient speed, the starting means (which is additional winding) can be removed depending upon the type of motor used. By the help of following methods, single phase induction motor is made self-started:

1) Split phase method
2) Capacitor start and induction run method
3) Capacitor start and run method

1.Split Phase Induction Motor

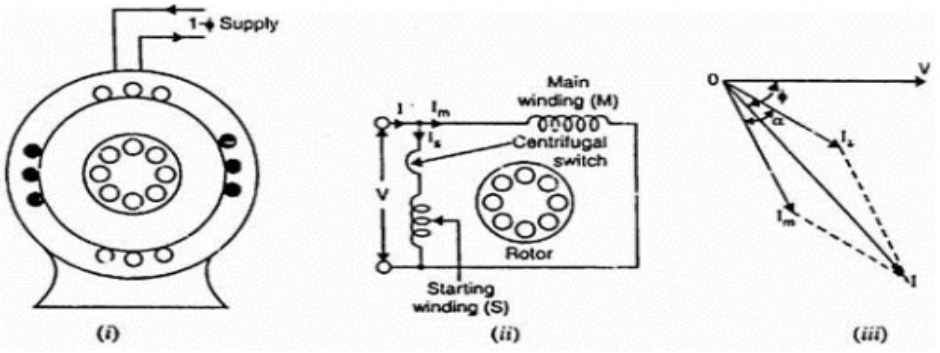


Figure: Split phase induction motor

This motor is started by two phase motor action by using auxiliary or starting winding. The stator of split phase induction motor is provided with on auxiliary (main) or starting winding in addition to the main or running winding.

The starting winding has high resistance and small reactance and in the main winding has low resistance and large reactance.

Operation:

When single phase supply is given to the stator winding of single phase motor, then main winding carries current I_m and starting winding carries current Is.

Since main winding is highly inductive and starting winding have highly resistive, the current I_m and Is have a phase difference (20^0 to 30^0). Due to this phase difference, the starting torque will be developed which expression is given below:

$T_s = k\ I_m I_s \sin \prec$ where;

k = constant value whose magnitude depends upon the design of th motor

I_m = current flowing to the main winding

I_s = current flowing to the starting winding

When the motor reaches about 75% of full speed, the centrifugal switch opens and circuit gets opened.

Applications:

This type of motor has low starting torque and are cheap. They are used for drives requiring less than 1kw. The various applications are as follows:

- Used in the washing machine and air conditioning fans.
- The motors are used in mixer grinder, floor polishers.
- Blowers, Centrifugal pumps
- Drilling and lathe machine.

2. Capacitor Start Induction Motor

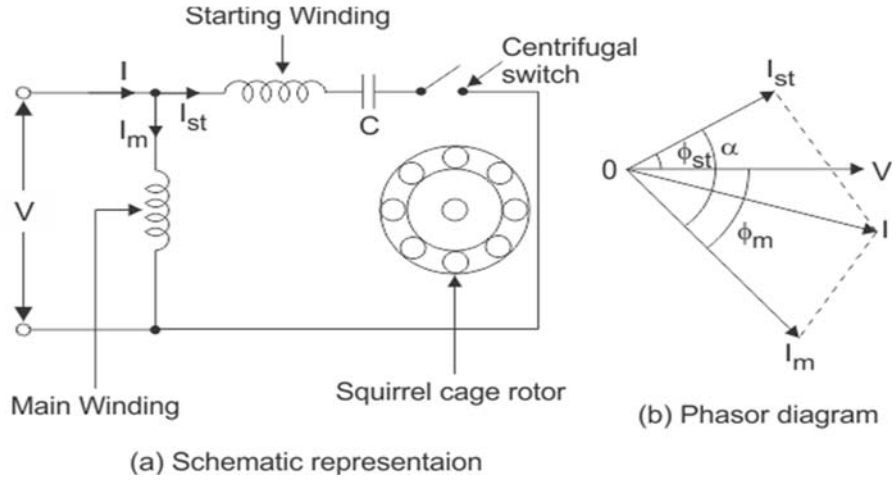


Figure: Capacitor start induction motor

This motor is same as split phase except that stator winding has many turns as the main winding. A capacitor 'C' is connected in series with the starting winding.

The main winding has high reactance whereas the starting winding has high resistance

When the single phase supply is given to the stator. Current "I_m" flows in the main winding and the current "I_s" flows on the starting winding.

The value of capacitor is so choose that I_s lead I_m by about 80^0.). Due to this phase difference, the starting torque will be developed which expression is given below:

$T_s = k\ I_m I_s \sin \prec$ where;

k = constant value whose magnitude depends upon the design of th motor

I_m = current flowing to the main winding

I_s = current flowing to the starting winding

The starting winding is opened by the centrifugal switch when the motor attains about 75% of synchronous speed.

Applications:

- Used for the loads of higher inertia where frequent starting is required.
- Used in pumps and compressors
- Used in the refrigerator and air conditioner compressors.
- Used for conveyors and machine tools.

3. Capacitor Start Capacitor Run Motor

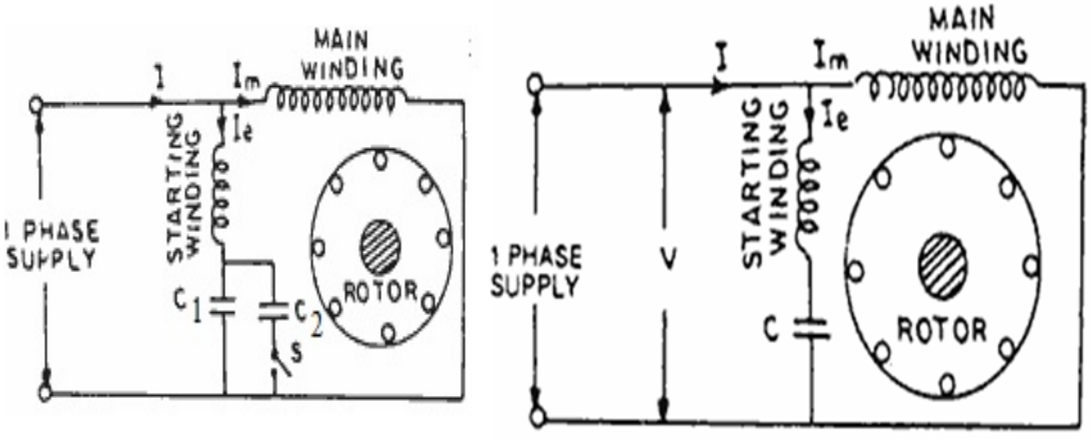


Figure: Capacitor start/capacitor run motor

The stator of this motor contains two winding i.e stating and main winding. When single phase current "I" is given to the stator "I_s" flows in the starting winding and "I_m" flows in the main winding.

In this type of starting of motor are described as the two methods.

In fig 1) Single capacitor C is used for both starting and running. This design eliminates the need of a centrifuged switch and at the same time improves the power, factors and efficiency of motor.

The capacitor used here produces the required amount of starting torque and also helps in self-starting.

In other design, two capacitors C_1 and C_2 are used in the starting winding. The smaller capacitor C_1 required for optimum running condition is permanently connected in parallel with C_2 for optimum starting required in the circuit during starting. The starting capacitor C_2 is disconnected when the motor approaches about 75% synchronous speed. Due to the presence of C_1 in the circuit, it helps to improve the power factor and the running conditions of the single phase induction motor. This type of motor has high starting torque.

Applications:

- Larger single phase compressors
- Pumps
- Grinders
- Conveyors
- Larger single-phase air conditioning compressors

Single phase series motor and universal motor

Introduction to single phase series motor and universal motor

A universal motor is such a motor which works on both ac and dc supply at almost same speed and output. Since the performance remains same for the supply. Hence, the name universal is therefore given to it.In it, both armature and field winding ae in series. Since the armature current and flux reverse simultaneously, the torque always acts in the same direction regardless of the polarity of the supply.

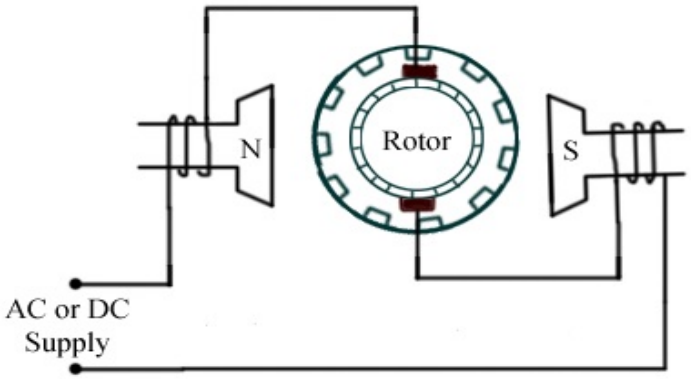


Figure: Universal motor

Operation:

Since field winding and armature winding are connected in series, the same current passes through both when motor is connected to either ac or dc supply. The field winding produces an alternating flux (ϕ) that reacts with current flowing in the armature to produce a torque. The magnetic flux of the series field and armature produces by this current reverses at the same time, the torque always acts in the same direction. Since universal motors are series wound, they have high starting torque and high speed.

It is noted that in this type of motor, no rotating flux is produced and the principle of operation is same as that of d.c series motor

Advantages and application of single phase series and universal motor

Advantages of universal motor:

1) Universal motor has high starting torque so can run at high speed.
2) It has high weight and compact.
3) Universal motors are easy to control.

Application of universal motor:

1) Vacuum cleaner
2) Projectors
3) Sewing machine
4) Food mixture
5) hair dryer
6) drill machine

Checklist of single phase motor:

The most important factor to be considered while selecting the motor are the supply sources (single or three phase if AC) and type of housing or enclosure.

Type of Electric Motor Enclosure

There are two basic enclosure options available: drip proof in steel or totally enclosed, in aluminum, steel and cast iron.

The totally enclosed fan cooled (TEFC) motor is the predominant standard for industrial applications, today. The versatile TEFC is fully enclosed within the motor frame, with cooling air directed over it by an externally mounted fan.

Other Key Factors Required for Motor Selection

Loading (KW)

Loading is determined by the equipment to be driven, and the torque available at the shaft. Electric motors have standard outputs per frame size from which any KW loading required can be selected from.

Speed

Choose the required speed of the motor. The induction motor is a fixed single speed machine. Its speed is dependent on the frequency of the electricity supply and the stator winding design. The no load speed of an induction motor is slightly lower than synchronous speed due to the no load losses in the machine. Full load speed is typically a further 3-4 per cent lower than no load speed.

Mounting

The mounting position must always be given when a motor is to be selected. Improper motor mounting can affect performance.

Power Supply

The supply voltage and frequency must be given when selecting an Electric motor

Operating Environment

This is one of the major factors that affect motor performance. The environment in which the motor is to operate is an important factor to consider when selecting a motor, as the ambient temperature, humidity and altitude can all affect performance

Checklist for Ordering a Fixed Speed TEFC Motor:

1. Power Supply	Voltage (Volts)	No. of Phases	Frequency (Hertz)
2. Power Rating	KW		
3. Speed	Rev/min	No. of Poles	
4. Duty	Type	Mounting IM	
5. Motor Drive	Direct	Belt	
6. Insulation Class/Temperature Rise	Insulation Class	Temperature Rise (oC)	
7. Torque Type	Quadratic	Constant	
8. Environmental Conditions	IP Rating	Ambient Temperature (oC)	Relative Humidity

Functions and advantages of using capacitor in single phase motor:

The functions of capacitor that is used in the single phase induction motor are as follows:

1. Improve power factor
2. Increases efficiency of a motor
3. Helps in self- starting
4. Provides required amount of torque to rotate.

Testing procedure of a capacitor:

The following procedure should be followed in order to test the capacitor:

1. Take out the capacitor from the given circuit
2. Charge the capacitor by providing the supply
3. Take out the multi-meter.
4. Indicate the point of multi-meter to the symbol of capacitor
5. Connect the capacitor to the multi-meter wire to the proper polarity.
6. Note the reading of capacitor.
7. If the shown value is nearly equal to the rated value of the capacitor then the capacitor is in normal condition and if shown value is way below the rated value then the capacitor is said to be in dead condition.

Types of capacitor:

The different types of capacitor are as follows:

1. Mica capacitor

A capacitor in which di-electric is sheet mica which is splinted into layers (0.1mm) and the electrodes are of foil of metal that is deposited directly on the mica. It is used for the frequencies up-to several mega-hertz.

2. Ceramics capacitor

A capacitor whose di-electric is a ceramic material such as steatite or barium titanate, the composition of which can be varied to give a wide range of temperature coefficient is called ceramics capacitor.

3. Paper capacitor

A capacitor whose di-electric material consists of coiled sandwiched between two layers of material foil is said to be paper capacitor.

4. Electrolytic capacitor

A type of capacitor used to conduct current in a single direction, which one oxide coated plate serves as the di-electric while the other is replaced by an electrolyte called and electrolytic capacitor.

Assessments

A. Very short answer questions.

1. What is induction machine?
2. What is capacitor?
3. What is universal motor?
4. List out the types of single phase induction motor.
5. What is the function of capacitor in single phase induction motor?

B. Short answer questions.

1. Draw the circuit diagram of split phase induction motor.
2. Draw the circuit diagram of capacitor start induction motor.
3. Draw the circuit diagram of capacitor start/run induction motor.
4. Draw the circuit diagram of universal motor.
5. What are the advantages of using capacitor in single phase induction motor?
6. List out the procedure to test the capacitor.

C. Long answer questions.

1. Explain the parts of single phase induction motor.
2. Explain the construction and operation of split phase motor.
3. Explain the construction and operation of capacitor start motor.
4. Explain the construction and operation of capacitor start/run motor.

Glossary:

Procedure: Process to follow

Test : To check

Sandwich: Any combination formed by layering one type of material between two layers of some other materials

References:

www.electricaleasy.com

http://electricalengineeringtutorials.com

www.electrical4u.com

www.electricalengineeringtoolbox.com

Jupta Gupta, “Electrical Machine”

S. Chand, “Principle of Electrical Machine”

Jain and Jain. “ABC of Electrical Engineering”

CHAPTER - 4
Three Phase Motors

1. Objectives:

The main objectives of this chapter are:

- To construct and be familiar with operation of induction motor
- To know the types of motor and its circuit diagram

2. Learning materials:

1. Squirrel cage induction motor
2. Double cage induction motor
3. Slip ring induction motor
4. Delta connected induction motor
5. Star connected induction motor

3. Content:

Concept on 3 phase induction motor

Three phase Induction motors are the most widely used electric motor in the industry.

Normally, they run at constant speed from no load to full load. The speed is frequency dependent. The speed control of three phase induction machine is difficult. These motors are simple, low price, easy to maintain. Generally, three phase induction motors are self-started.

Regarding the construction, it is very simple. The essential features of induction motor are: laminated stator core carrying a poly-phase winding, a laminate rotor core carrying a cage or poly-phase winding, the latter with mounted slip rings, a stiff shaft to preserve the very short air gap.

Function and Applications

When three phase supply is given to the stator of the induction machine hen emf is induced in the rotor from the electromagnetic induction.

It is used in different types of industries where speed control is not required. Such as: printing machines, flour mills and other shaft drives of small power.

TYPES OF INDUCTION MOTOR

Based on the types of rotor, three phase induction motor are of two types:

I. Squirrel cage rotor
II. Phase wound rotor(slip ring rotor)

i. Squirrel cage rotor

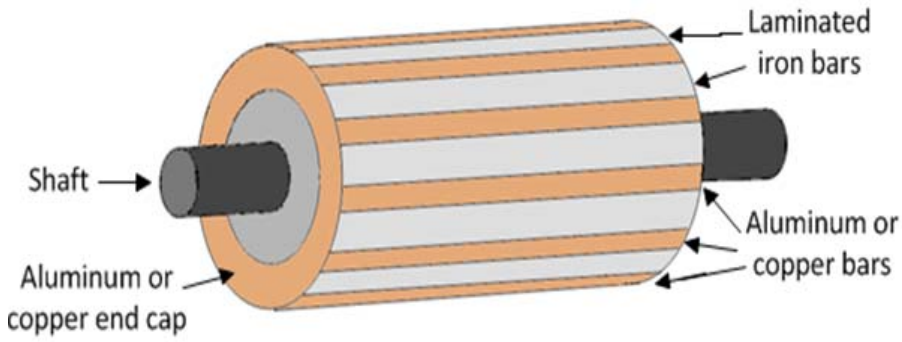


Figure: Squirrel cage induction motor

Squirrel cage rotor is made of laminated cylindrical core with parallel slots. These parallel slots carry rotor conductor. A squirrel cage rotor is the rotating part used in most common form of A.C induction motor. It consists of a cylinder of steel with aluminum or copper conductors embedded in its surface.

Squirrel cage motors are generally used induction motors. But it has a major drawback which is poor starting torque due to low rotor resistance (as Starting torque is directly proportional to the rotor resistance). But increasing the rotor resistance for improving starting torque reduces the efficiency of the motor (due to more copper loss). One cannot even add external resistance for starting of purposes, as the rotor bars are permanently short circuited. Hence, these drawbacks are removed by a double squirrel cage motor, which has high starting torque with the greater amount of efficiency (without the lost of any efficiency in the motor).

Construction Of Double Squirrel Cage Rotor

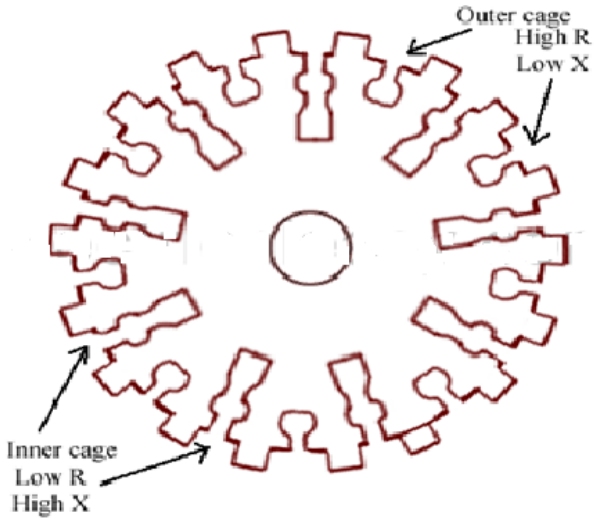


Figure: Double cage rotor (Cross-sectional view)

Double cage induction motor is a special type of squirrel cage motor in which its rotor has two independent cages on the same rotor. Bars of high resistance and low reactance are placed in the outer cage, and bars of low resistance and high reactance are placed in the inner cage. The outer cage has high 'reactance to resistance ratio' whereas, the inner cage has low 'reactance to resistance ratio'.

ii. Phase wound rotor:

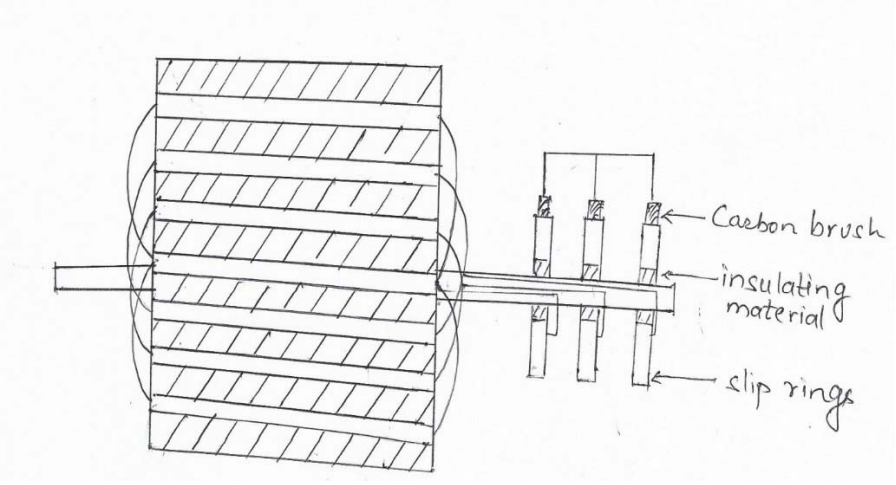


Figure : Phase wound rotor

This type of rotor is also made of cylindrical laminated core. It has open slots along the outer circumference. Three ends of rotor winding are connected to three separated slip-rings and the slip rings are short circuited by the carbon brush. As the name implies, such a rotor is wound with an insulated windings similar to that of the stator except that the number of slots is smaller and fewer turns per phase of a heavier conductor are used. Since the connection of the wound secondary to the external terminals is made through slip rings and brushes, so wound secondary motors are often called slip-ring induction motors.

Differences between single and three phase motor:

Basis	Single phase	Three phase
1.Supply 2. Starting torque 3.Repair and maintenance 4.Features 5. Efficiency 6. Power factor 7. Applications	1.Single phase supply 2. Low 3. Easy 4.Simple and reliable 5. Less 6. Low 7. Domestic applications like grinder, compressor.	1.Three phase supply 2. High 3. Difficult 4. Complex and costly 5. High 6. High 7. Mostly used in industries

Star connected three phase induction motor

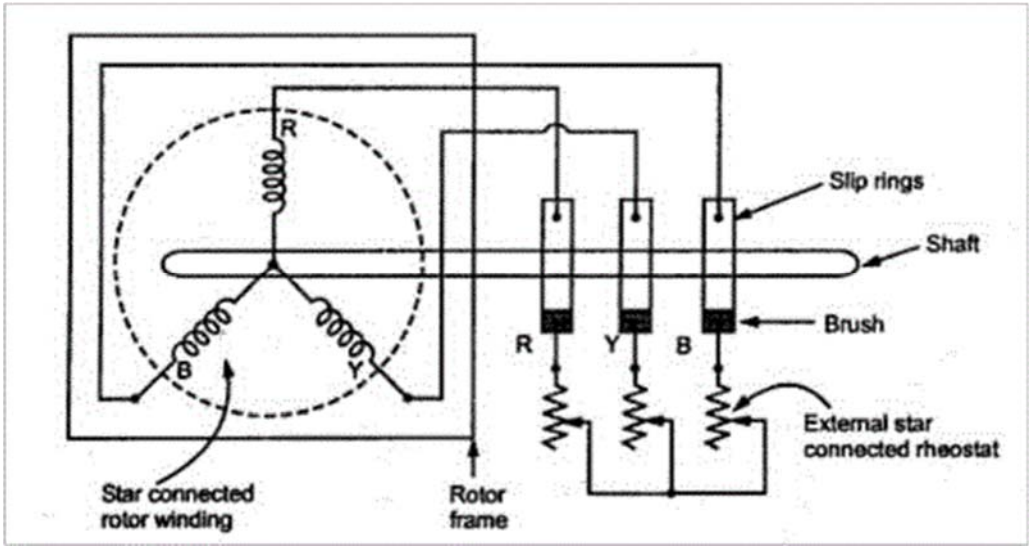


Figure: Star Connected System.

Star connection is used where we require Neutral terminal to obtain Phase voltage like above image.

in a star connected system VL=√3Vph, i.e Line Phase voltage is equal to root 3 times phase voltage.

Star connected system requires less insulation level.

Star Connected system is used where low starting current is required.

Star connected motor only run at one third of the motor rated torque and power

Delta connected three phase induction motor

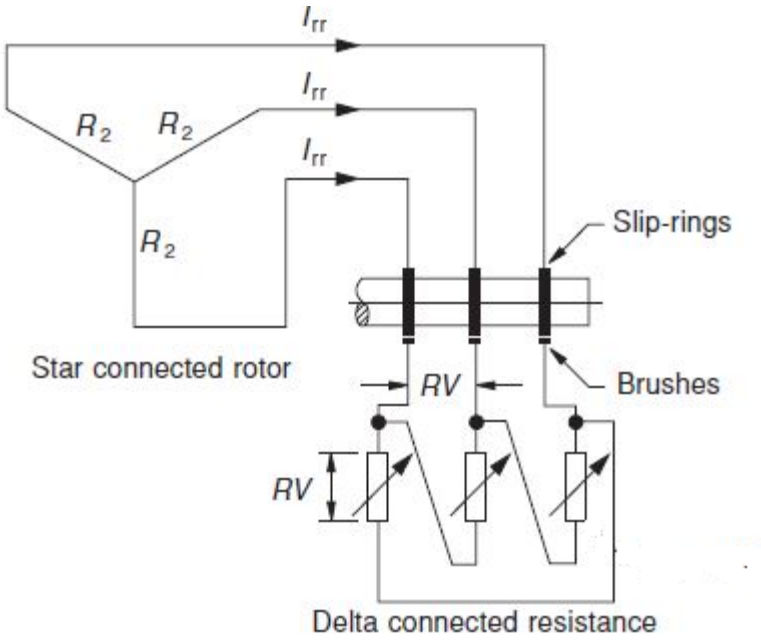


Figure: Internal connection of delta connected three phase motor

Delta Connected System.

- In a Delta Connected system Line Voltage is equal to Phase Voltage.
- While phase current is √3 times less than Line current.
- Insulation level is high because line voltage = Phase Voltage.
- Generally used where high starting Torque is required.
- Delta connected motor operates at full torque and power

4. Assessments

A. Very short answer questions.

1. What is three phase induction machine?
2. List out the types of induction machine.
3. Write down the applications of induction machine.
4. List any two features of star connected 3 phase induction machine.
5. List any two features of delta connected 3 phase induction machine.

B. Short answer questions.

1. Differtiate between three phase and single phase motor.
2. Draw the diagram of squirrel cage rotor.
3. Draw the diagram of slip ring rotor.
4. List out the advantage of three phase motor over single phase.
5. Why cannot three phase induction motor run at synchronous speed?

C. Long answer questions.

1. Explain the internal connection diagram of 3 phase star connected motor.
2. Explain the internal connection diagram of 3 phase delta connected motor.
3. Differtiate between three phase and single phase motor.
4. Explain the types of induction motor.

References:

www.electricaleasy.com

http://electricalengineeringtutorials.com

www.electrical4u.com

www.electricalengineeringtoolbox.com

Jupta Gupta, “Electrical Machine”

S. Chand, “Principle of Electrical Machine”

Jain and Jain. “ABC of Electrical Engineering”

CHAPTER - 5

Electrical motor, bell and lamp control circuit

1. Objectives:

The main objectives of this chapter are:

- To recognize different electrical symbols.
- To deal with different motor control systems

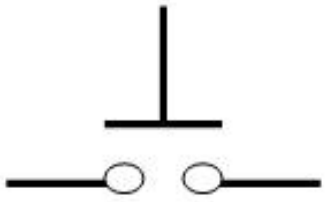
2. Learning material:

- Different types of drum switch
- Push button switch
- Different types of contactor (simple, forward/reverse, star/delta)
- Burglar alarm
- DOL switch

Content:

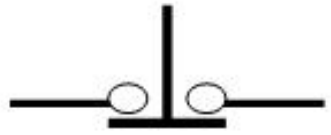
Electrical Symbols :

1. Push button switch



Normally Open (NO)

(i)

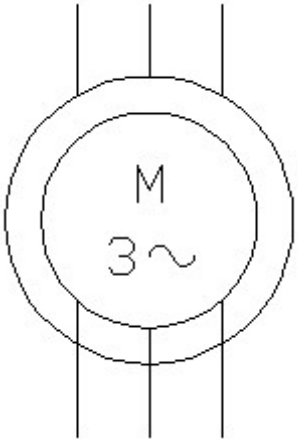


Normally Closed (NC)

(ii)

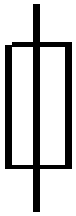
2. Three phase induction motor

i. Squirrel cage



ii. Slip ring

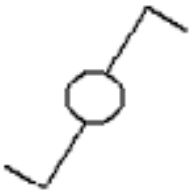
3. Power fuse

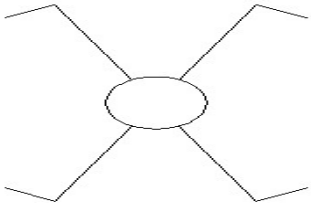


i. Single pole switch

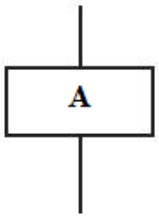
ii. Two pole switch

iii. Two way switch

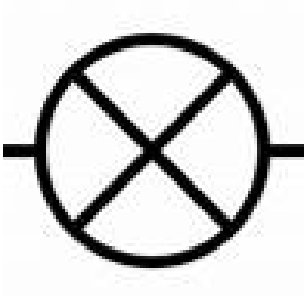




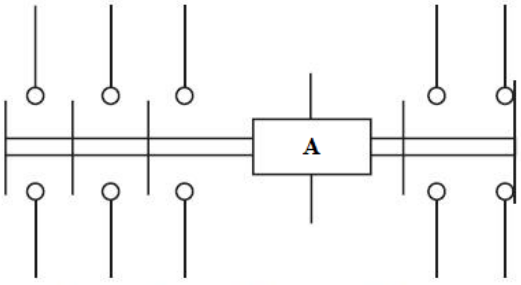
iv. Intermidiate switch



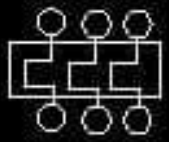
v.Auxillary contactor

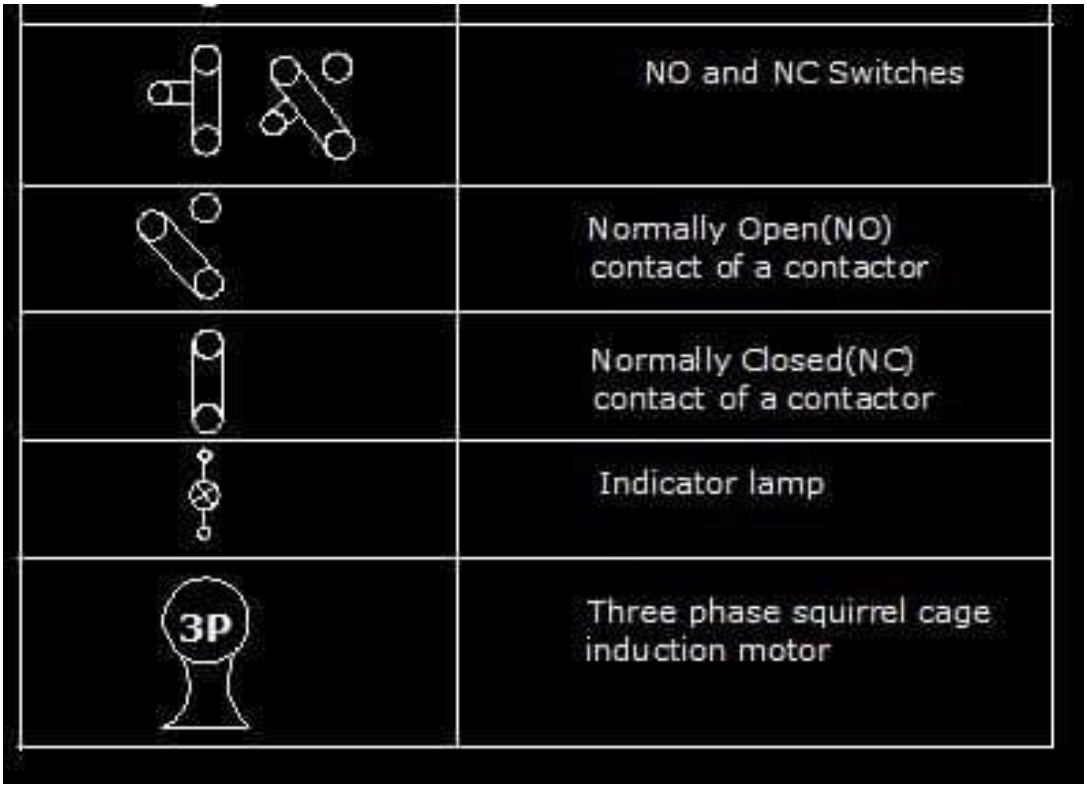


vi. Signal lamp



vii. Auxiliary contactor with normally open and close contact

INDEX	
Symbols	**Description**
	Triple Pole MCB
	Triple Pole Contactor
	Triple Pole OLR
	Contactor Coil
	Winding of a motor
	Single Pole MCB
	Normally Open(NO) contact of a relay
	Normally Closed(NC) contact of a relay



Concept of motor control system

In motor control system, there are two major parts:

a. Power diagram (circuit)
b. Control diagram (circuit)

a) Power diagram

The diagram in which main parts of the circuit are included is called power diagram. There are some basic electrical accessories which is included in power diagram.

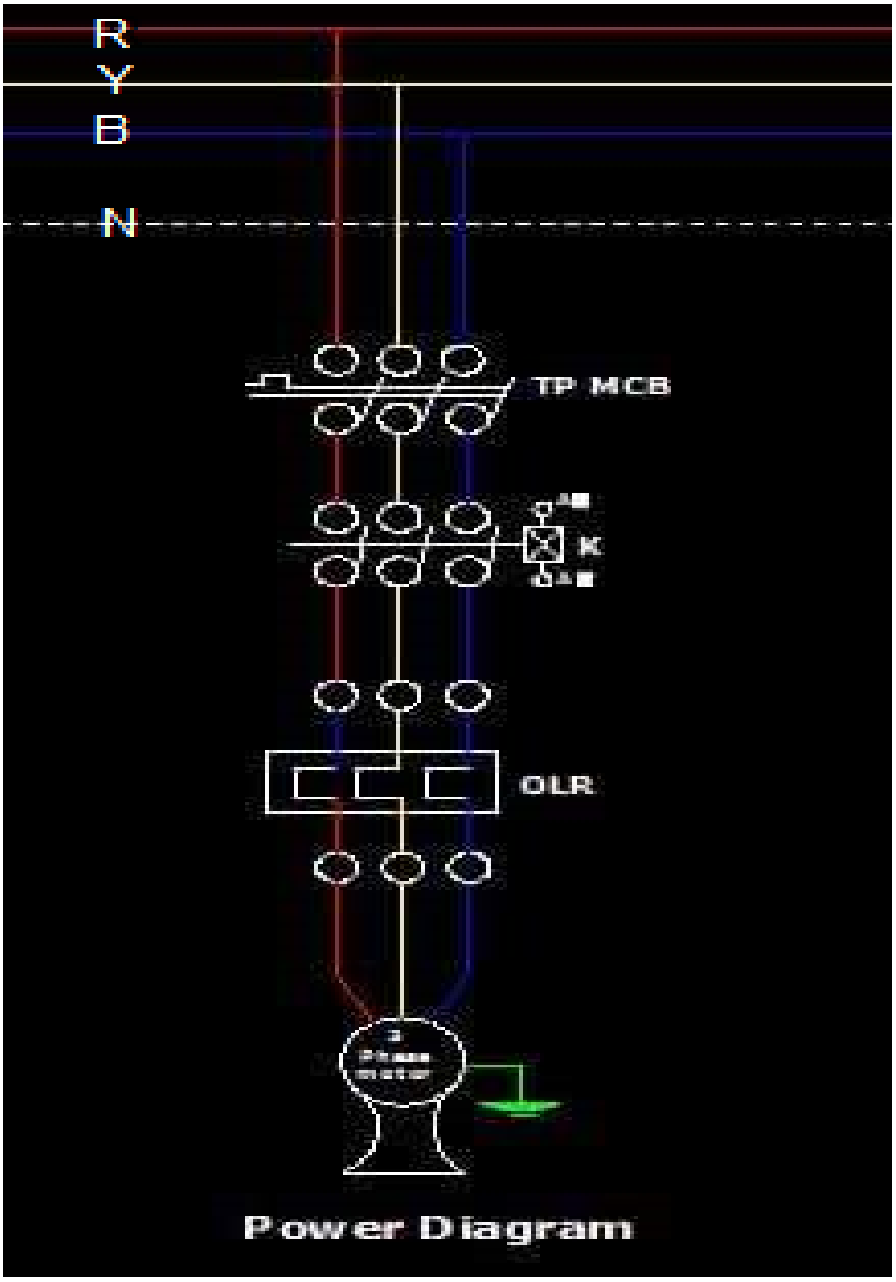


Figure: Power Diagram

b) Control circuit:

Those diagrams in which auxiliary parts are included in a circuit is called control circuit. There are some basic electrical accessories which are included in this circuit.

1. Light fuse or SPMCB 2. OLR(Over Load Relay)
3. Stop push button switch 4. Start push button switch
5. Contactor coil 6. Neutral

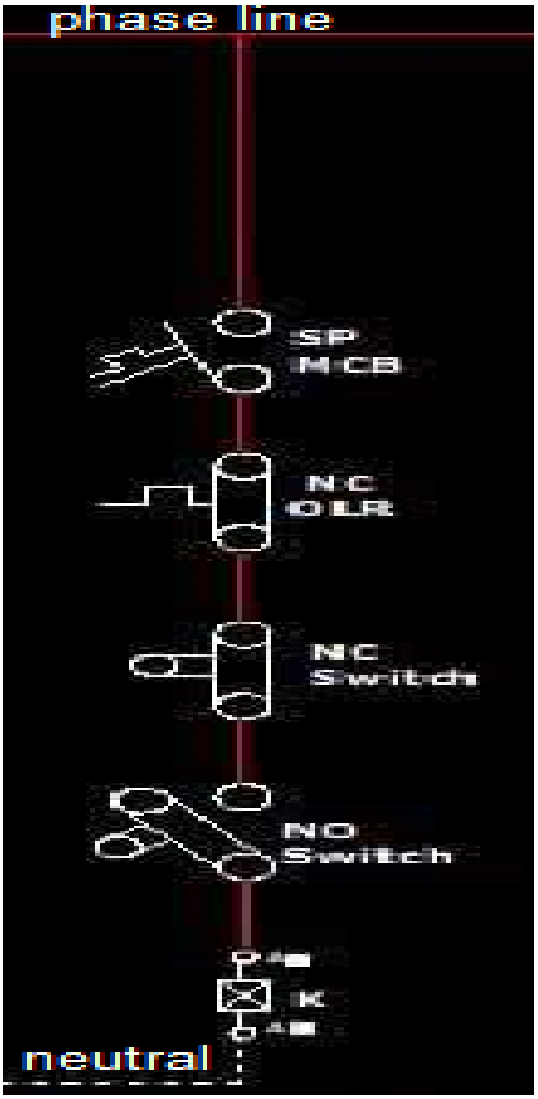


Figure: Control Diagram

Direct On Line system (DOL)

1) Simple DOL switch system
2) Simple drum type switch
3) Contactor system
4) Holding type
5) Impulse type

1) Simple DOL switch system

An electrical motor is to be started and stopped by direct on line with the help of two push button switch.

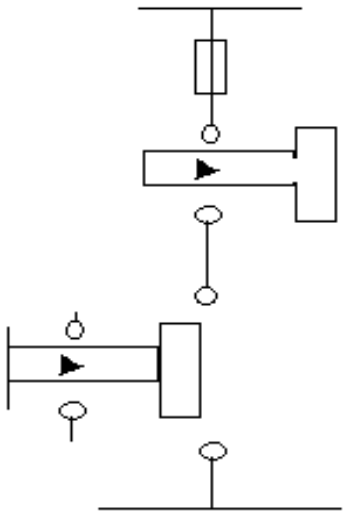


Figure: Control diagram

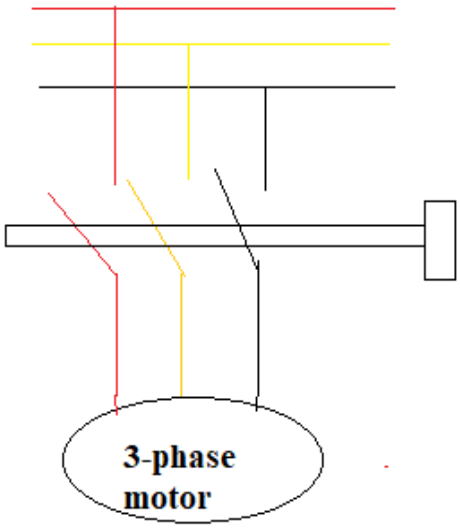


Figure: Power diagram

2. Simple drum type switch:

An electrical motor is started and stopped usually with the help of simple drum type switch. If the position of L_1 and V, L_2 and U, L_3 and W (as shown in figure below) are disconnected electrically with the help of drum type switch, the motor become stop(off).

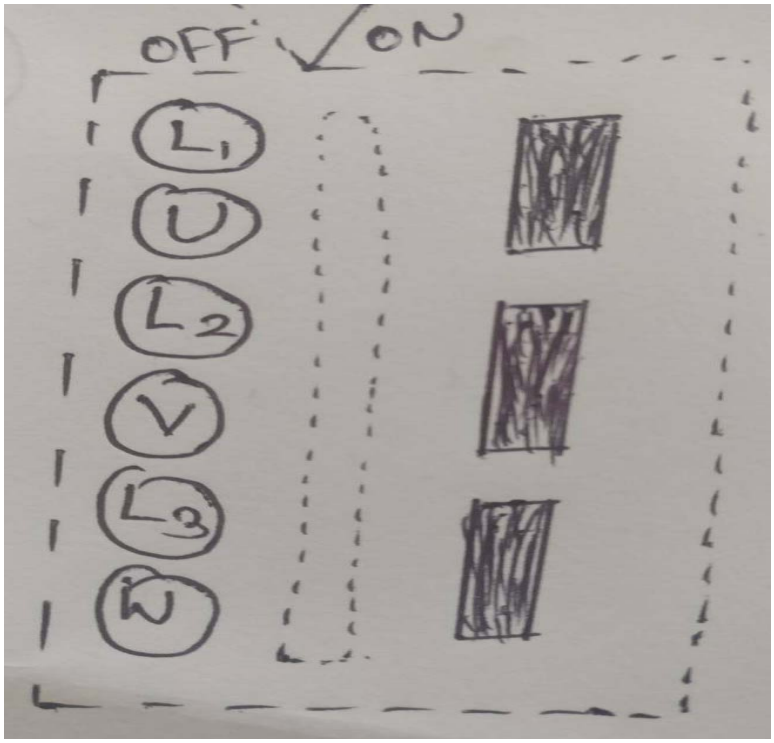


Figure: Drum switch

3.Contactor system:

An electrical motor can be started and stopped with the help of contactor system

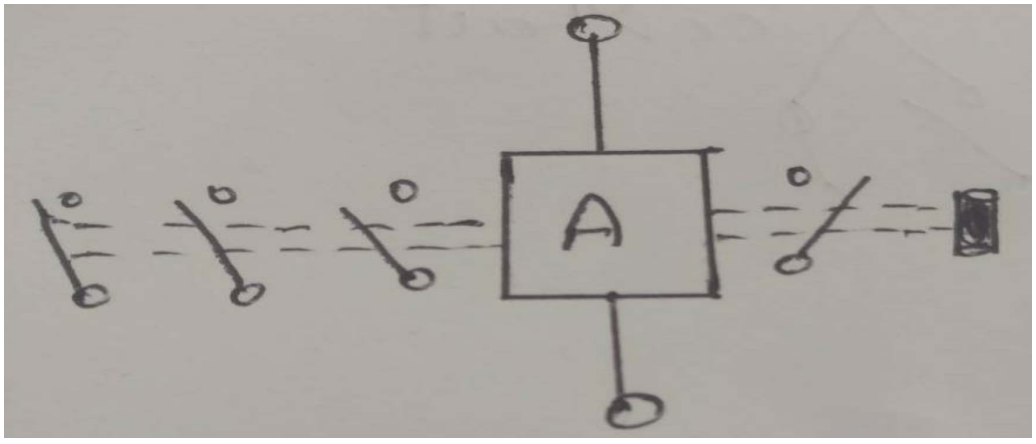
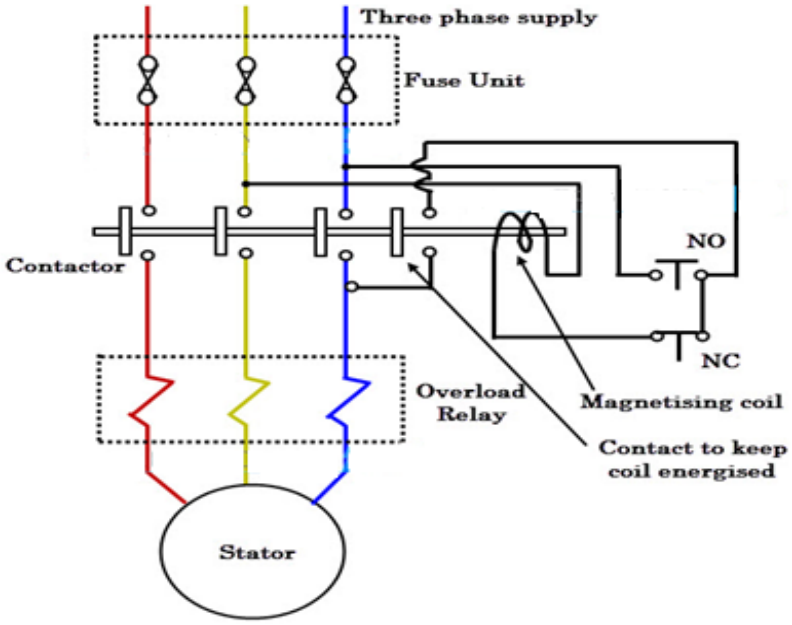


Figure: Contactor

Working of contactor



When NC button is pressed, the relay coil is energized and the magnetic action of iron piece lying in the relay will pull auxiliary contact inward. Since, the three power contactor are interlocked and counted on insulating link, all the four contactors will be moved towards their terminal. The supply to the motor will start instantly when the supply to relay is given. The contactors will move back to their original (off) position only of the supply to relay is cut only by pressing stop or NC push button.

4. Holding type

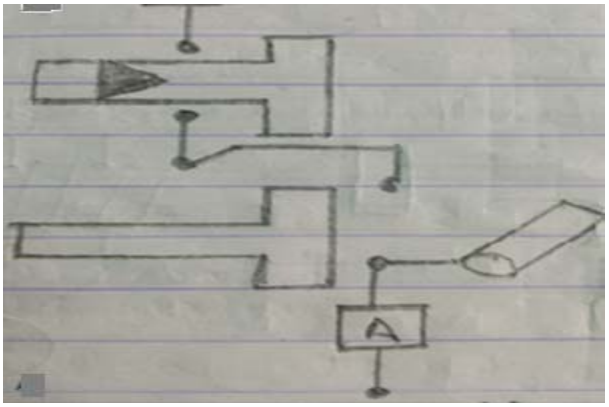
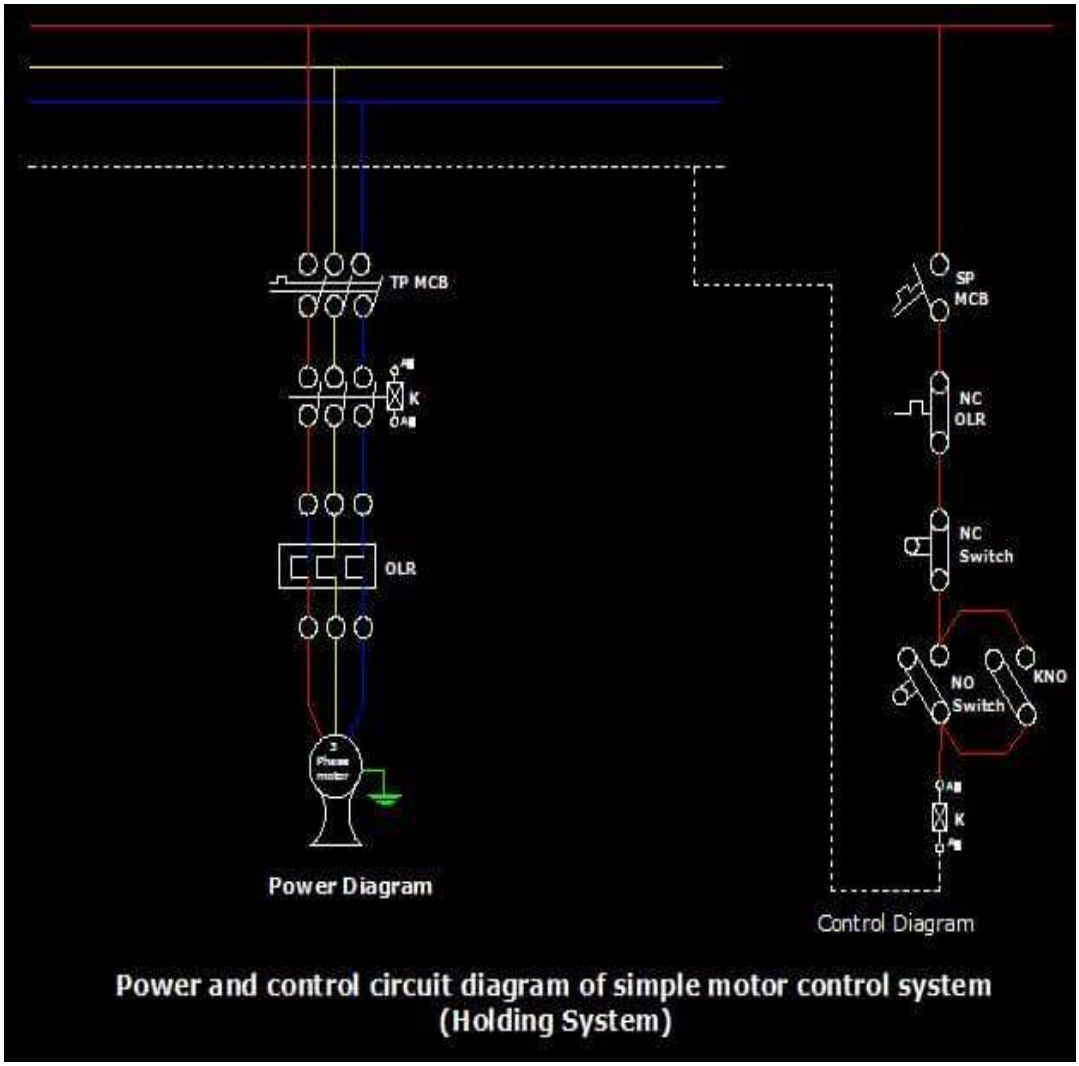
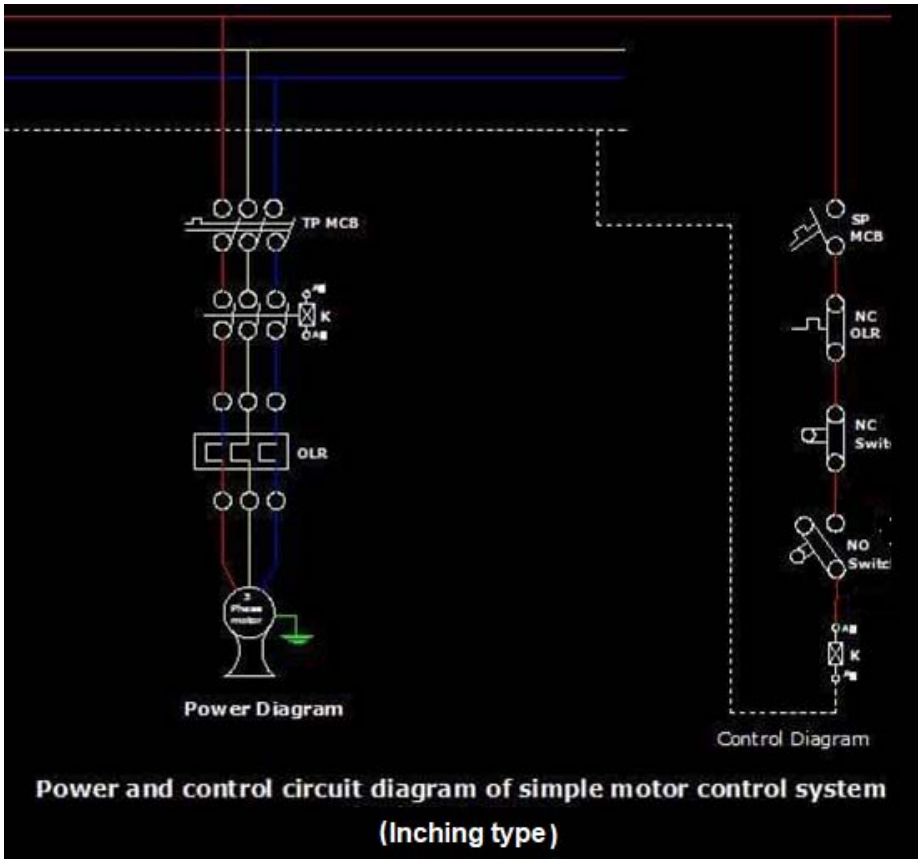


Figure: Holding type switch



Power and control circuit diagram of simple motor control system (Holding System)



1.Drum type switch:

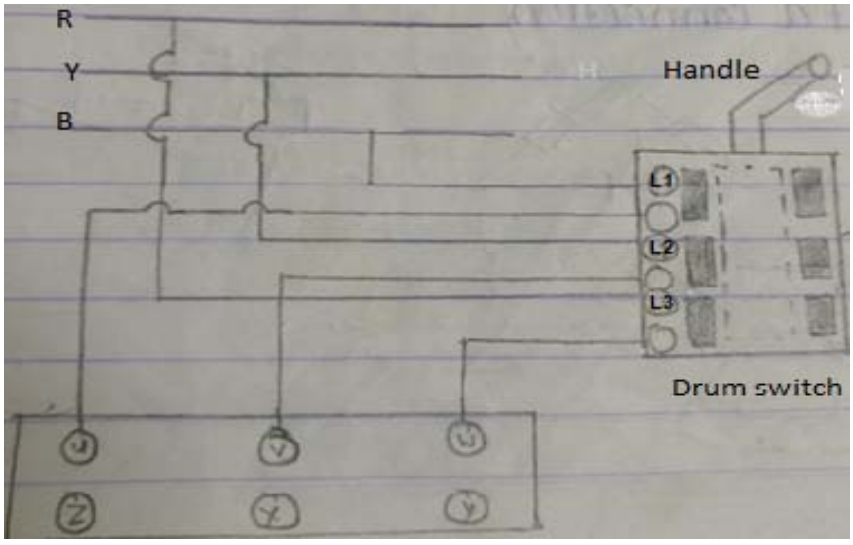


Figure: Drum type switch

Drum switch is an electrical switch in which the connecting parts are held by spring pressure against contact surfaces in a revolving cylinder or sector.

An electric motor is to be forward/ reversed and off with the help of drum type switch. When the handle of drum type switch is moved in forward then motor turns in forward direction connecting L1 and U, L2 and V, L3 and W respectively. When the handle of drum type switch is moved in "ON" position then motor becomes stop disconnecting L1 and U, L2 and V, L3 and W respectively. Again, when handle is moved in "R" position then it runs in reverse direction connecting L1and U, L2 and V, L3 and W respectively.

2. Contactor interlock system

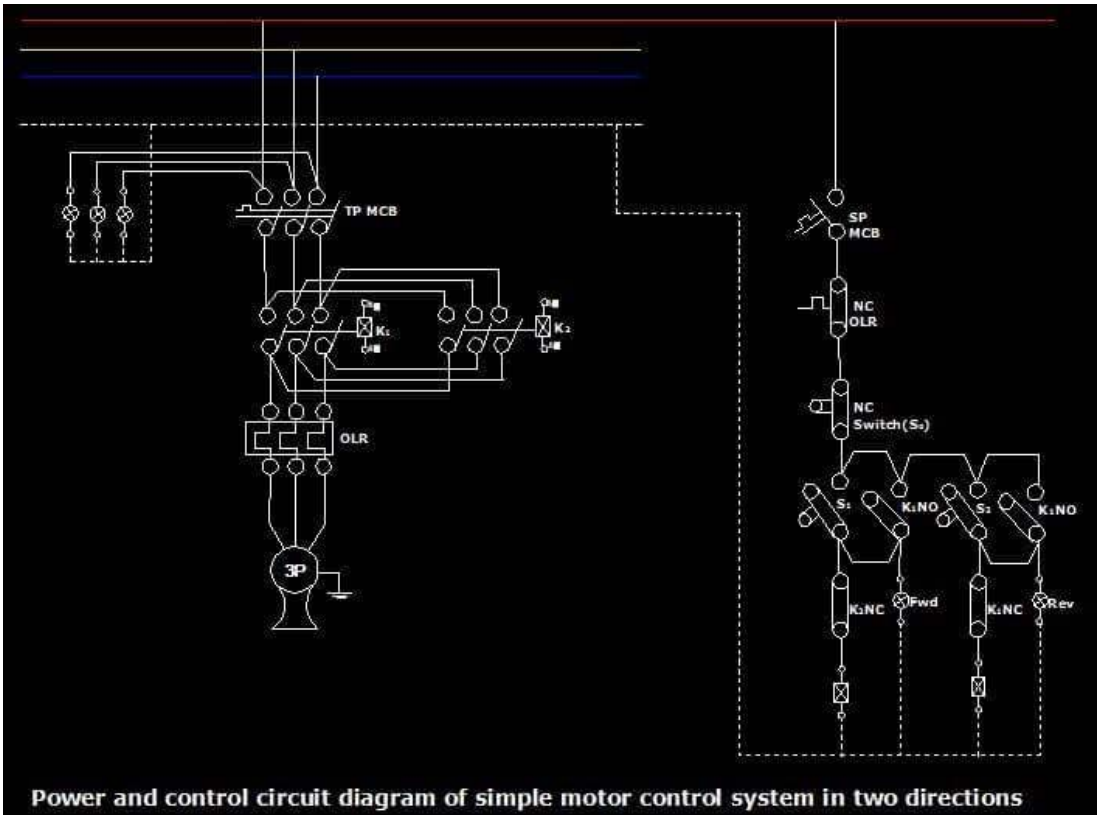


Figure: Contactor interlocked system forward/reversed

When start push button of forward switch is pressed, the relay coil of forward contactor is energized which attract the auxiliary and main contact (N0 and NC) and connect and disconnect them there by completing the circuit to relay of forward contactor through N0 of auxiliary contact and same time NC of auxiliary is opened which is kept in the way of reversed relay coil because when motor is running in forward direction then reverse direction is interlocked/closed. After closing the motor by stop push button and same process repeat when start switch of reverse is pressed.

3. Reversed/Forward switch interlock system

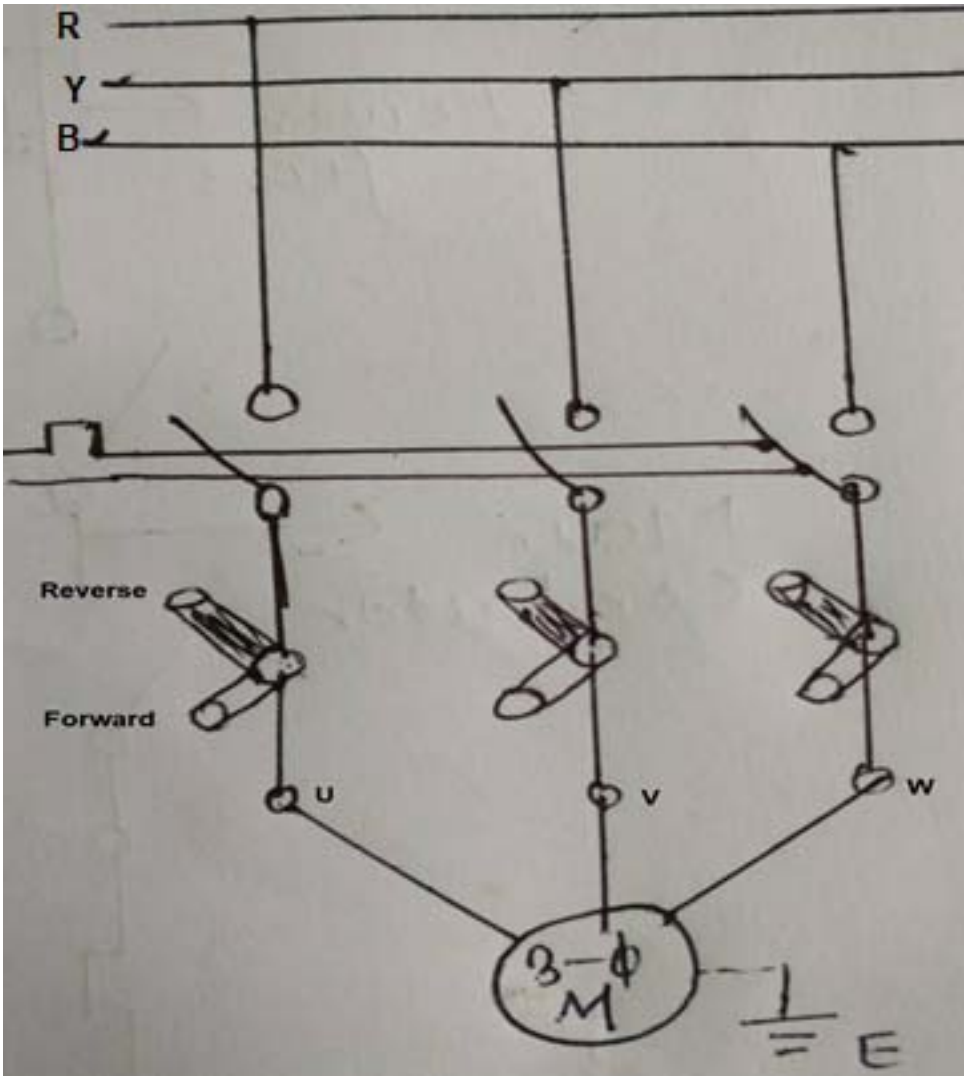


Figure: Switch interlock system forward/reversed

Motor control by star/delta system:

a) Drum type switch

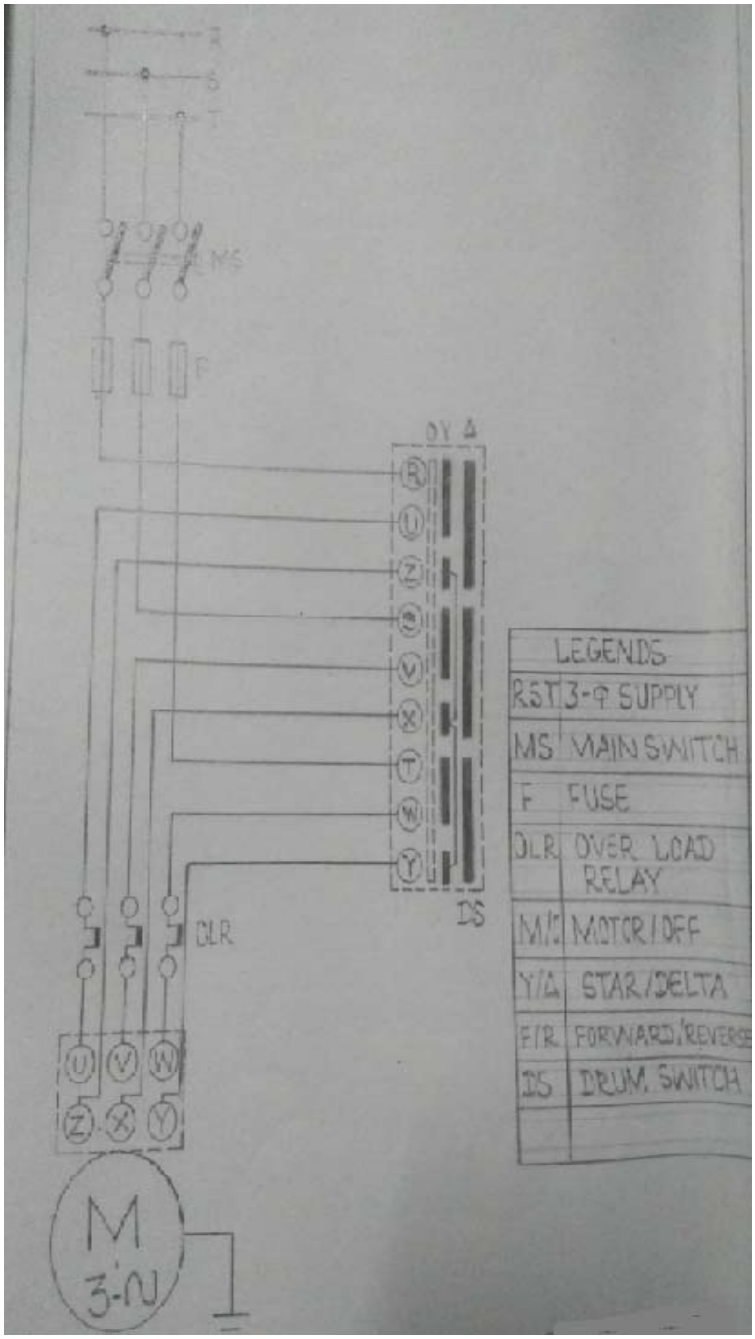


Figure: Star/Delta drum type switch

Contactor interlock system by three ways:

1. Semi-automatic contactor interlocked system.
2. Manually contactor interlocked system
3. Fully automatic contactor interlocked system.

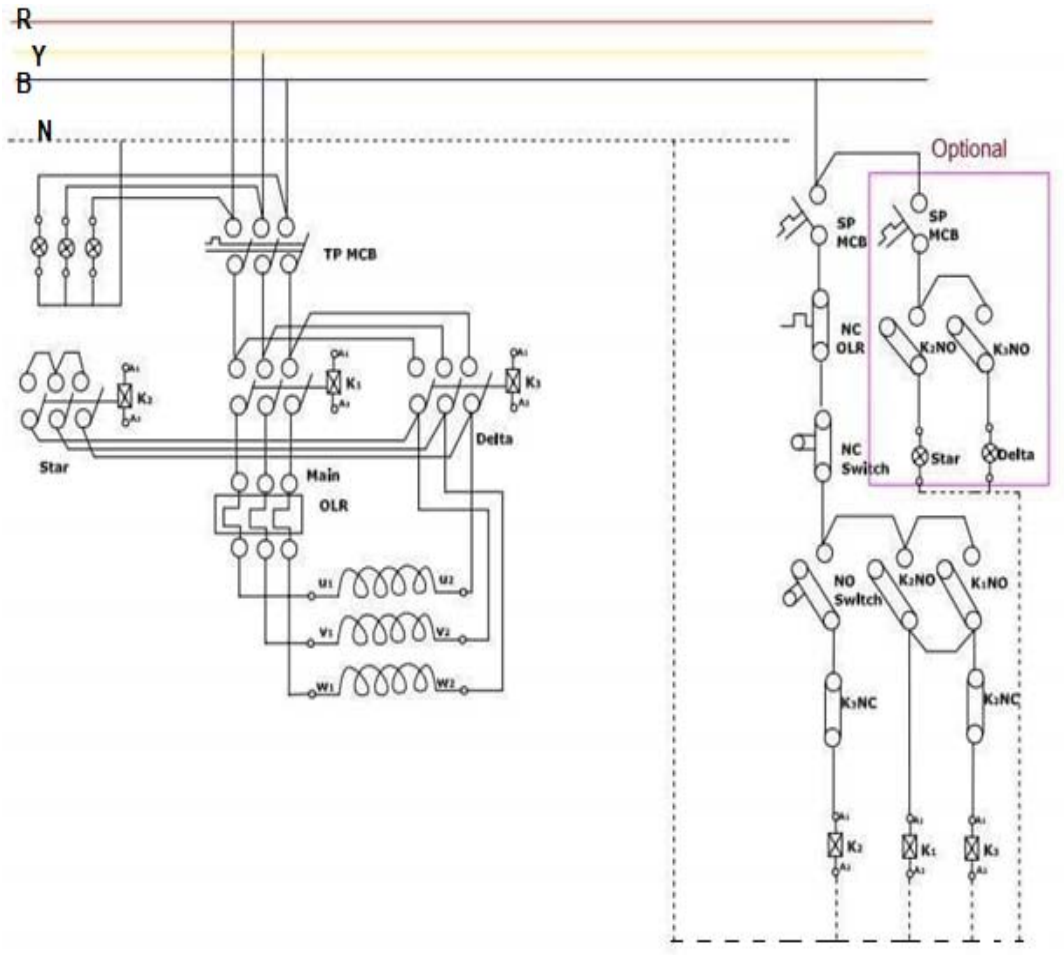


Figure: Star/Delta connected contactor interlocked system

1) Semi-Automatic contactor interlocked system:

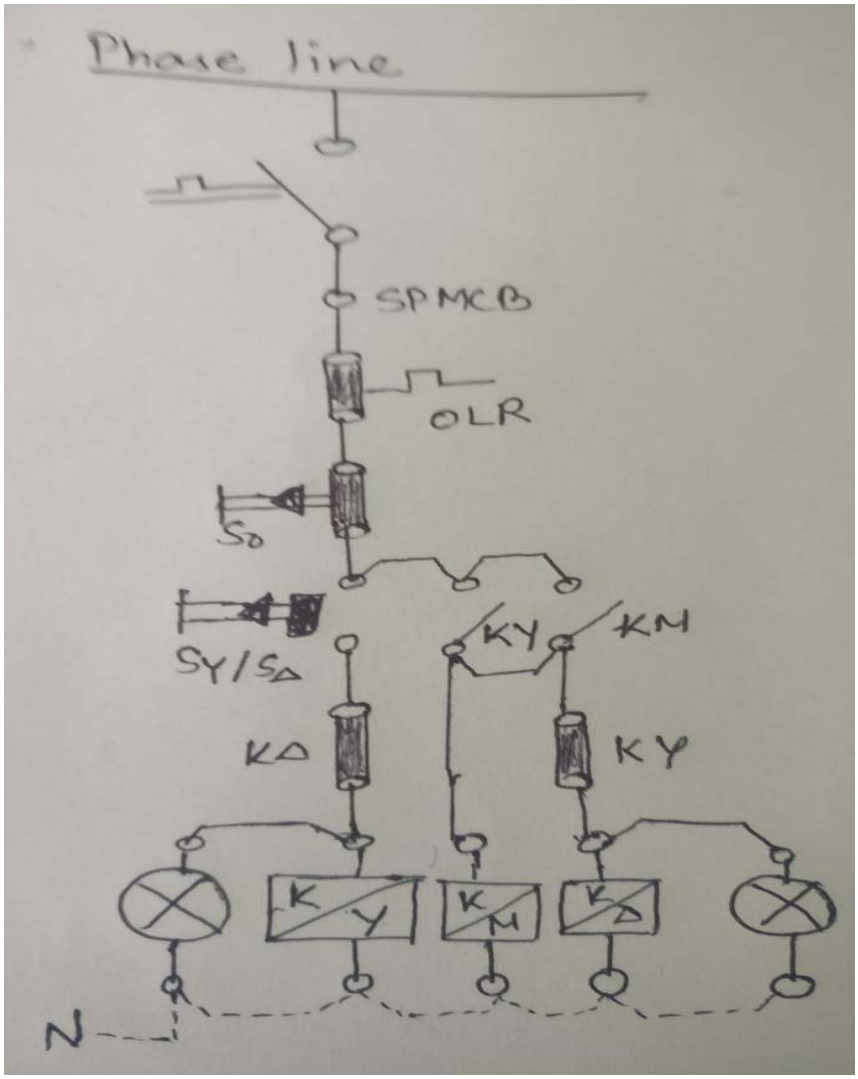


Figure: Semi-Automatic contactor interlocked system

In the above figure, control circuit of semi-automatic contactor interlocked system have SPMCB, control fuse, overload relay contact, stop push button switch, start push button switch, delta contactor, star contactor and main contactor are connected in series connection whereas N_0 of star contactor (KY), N_o of main contactor(KM), star indicator(IY) with star contactor (KY) and delta indicator (IΔ) with delta contactor(KΔ) are connected in parallel connection.

When start push button is pressed then auxiliary contact of star contactor and main contactor (KM) are activated (energized). Now, motor is running in star connection. When star push button is released (leave) then auxiliary contact become in normal condition. So, through normally loaded of the main (KM) and normally closed of star (KY) delta contactor (KΔ) and the main contactor (KM) are energized so motor running will be in delta connection. If we want to stop the motor, the stop switch (S_0) is pressed.

2. Manually contactor interlocked system

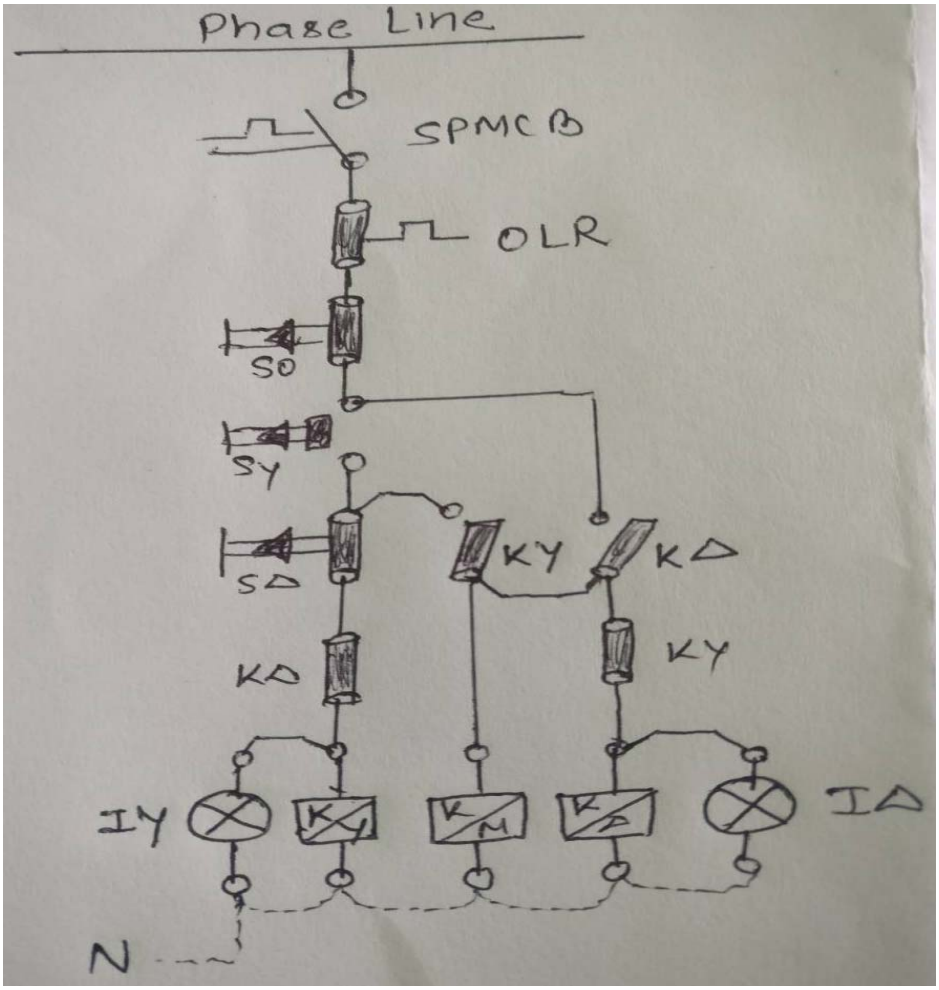


Figure: Manually contactor interlocked system

3. Fully automatic contactor interlocked system.

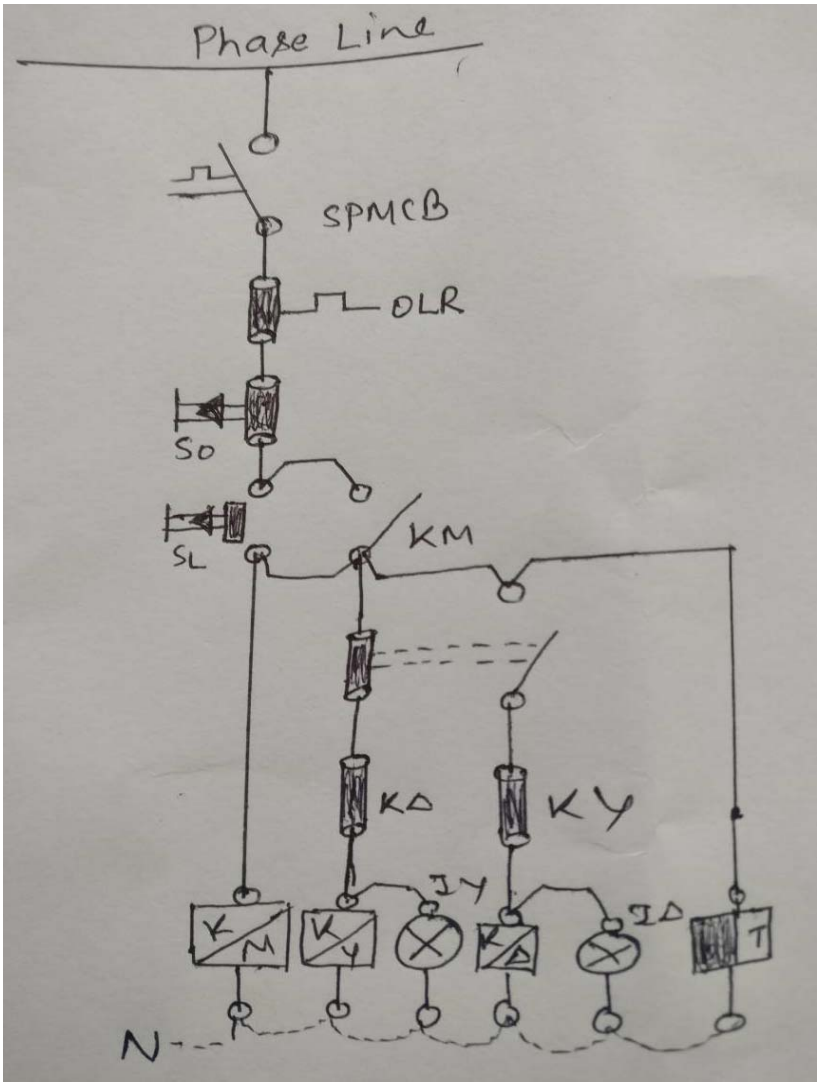


Figure: Fully automatic contactor interlocked system.

Control Device:

A component or any kind of input device which controls the flow of current in a circuit is called control device.There are two classification of control device:

1. Primary Control Device

Primary control device used to connect or disconnect the load to the line directly, such as a motor starter, motor contactor, and controller. Whether it is manual or automatic.In case of Direct ON Line (DOL) starters, main contactors and triple pole switch which connects the motor to the line will be classified as primary control devices.

2. Pilot Control Device

Pilot control device used to control or modulate the primary control devices. Pilot Control Devices control the primary control devices and do not control the load directlyFor example such as push buttons, float switches, pressure switches, and thermostats. Also a relay or contactor that activates a power circuit and directs the operation of another device.

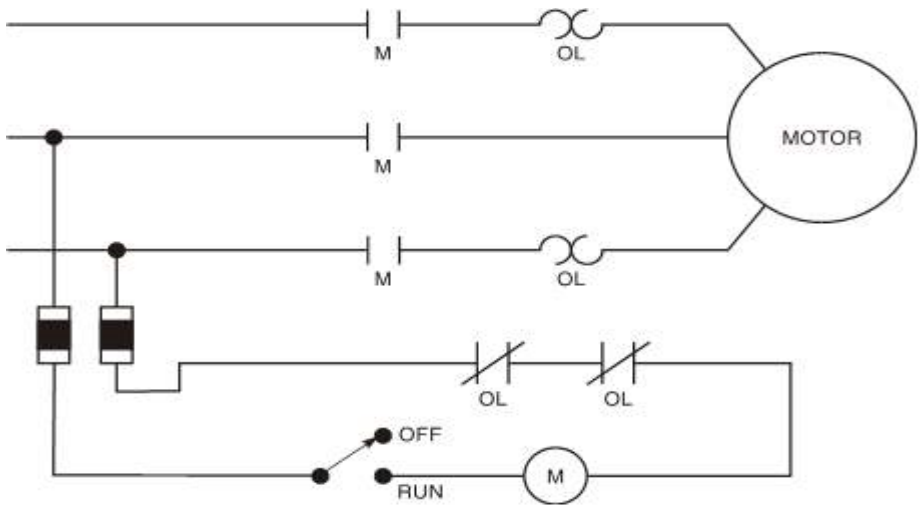


Figure: Basic Motor Control Circuit

In the picture above, the contactor, in that it connects the motor or load to the line, would be classed as a primary control device. The switch does not connect the load to the line, but is used to energize and de-energize the coil of the starter. So, it would be classed as a pilot control device.

Push Buttons:

Push button is a device that provides control of an equipment by pressing a button.Push buttons is the most simple of all the pilot control devices. Push buttons is most commonly used for starting or stopping electrical motors by remote control. Push buttons are of generally two types:

1. The maintained contact type
2. Momentary contact type.

1.The maintained contact type

In maintained contact type, the contacts are closed and will be closed until stop button is pushed whenever the push button is pushed,

2.Momentary contact type.

In momentary contact type push buttons, contact remains closed until the push button is held down. The contacts of the push buttons are usually double break type. Two types of contacts are usually provided namely normally open (NO) and normally closed contacts (NC). When the push button is pressed its NO contacts closes and NC contacts opens. Since the equipment is not to be used in power circuits but is to be used in control circuits, current rating of the push button circuits is usually small. By pressing the push button, contactor control is energized. This closes the main contactors in the circuit. The operation of the contactors is not affected by the length of the wires leading from the contactor to the remote control push button stations.

Limit Switches:

Limit switches are the switches which are required to perform the functions such as slow down, stop or reverse the drive at the end of the travel. The main function of a limit switch is to open or close a contact in a circuit when a certain limit has been reached. Limit switches can also be used to provide control impulses to initiate the control sequence as a function of the position of the driven machinery. Limit switches are available with different kinds of actuators, cams, levers and push rods. Limit switches have usually one NO and one NC contacts. Limit switches find numerous applications such as in opening and closing of curtains, lifts and elevators, water level control of tanks etc.

Contactors:

Contactors are mechanical switching devices. They are capable of making and breaking over load conditions. The speed of make and break is independent of the operator.

Electromagnetic Contactor: In this type of contactor moving elements leave the position of the rest when the electromagnet is energized and acts directly on the mechanism of the contactor

Pneumatic Contactor: In this type of contactor the moving element leaves the position of rest when compressed air is fed without the use of electrical means, to a device which acts on the mechanism of the contactor

Electro pneumatic Contactor: This is similar to pneumatic contactor except that the compressed air is fed by means of electrical controlled device,

Burglar Alarm

Burglar alarm is a device that monitors the designated area or areas to detect the presence of suspicious elements. The system takes the help of the sensor to detect such element and if found then it sends emergency signals to the user. The burglar alarm is one of the most reliable means to secure a house or a work place. The burglar alarm is one of the most reliable means to secure a house or a work place.

The basic components of a burglar alarm system are:

- Control panel
- Keypad
- Sensor
- Siren
- Flashing light
- Motion detector

Operation and function:

The work of this system begins with the sensors and motion detectors. They send emergency signals to the control panel once they detect something that surpasses their

tolerance level. The control panel of the system works like the brain and decide the next step of action. There are different things that the control panel can performs. Generally, it is set off with an alarm located near the house to alert the homeowner and the neighbors.

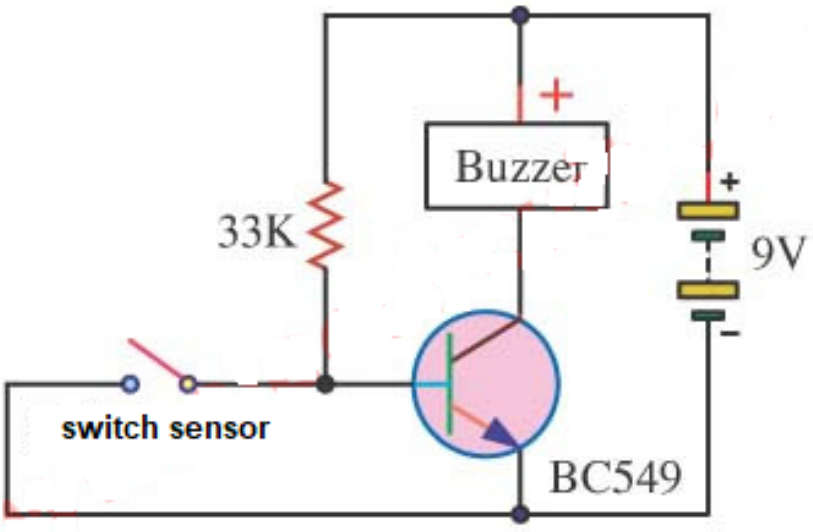


Figure: Simple burglar alarm circuit

Assessments

A. Very short answer questions.

1) Draw the symbol of two way switch.
2) Draw the symbol of intermediate switch.
3) Draw the symbol of push button switch normally closed.
4) Draw the symbol of push button switch normally opened.

B. Short answers question:

1) Draw the figure of drum type switch.
2) Write short note on
   i. Contactor
   ii. Drum switch
   iii. Pilot control device

iv. Burglar control system
v. Push button switch
vi. Limit switch

1) Draw the diagram of control system.
2) Draw the power diagram of motor control system

C. Long answers questions:

1) Draw the control and power diagram of contactor interlocked system.
2) Draw the forward and reverse of contactor interlocked system.
3) Draw the forward and reverse of switch interlocked system
4) Draw the star and delta of contactor interlocked system.

Glossary:

Suspicious: doubtful, questionable

Surpasses: to exceed

References:

www.electricaleasy.com

http://electricalengineeringtutorials.com

www.electrical4u.com

www.electricalengineeringtoolbox.com