Department of Mechanical Engineering

ME1030-Basic Workshop Practice Lab[1 0 0 2]

LIST OF EXPERIMENTS

1. Study of parts of lathe machine and lathe operations
2. Perform different operations on lathe machine like Facing, Turning, Taper Turning and knurling on MS cylindrical work piece
3. Study of types of welding process and perform welding of different types of joint on MS plate with arc welding process
4. Study of two stroke and four stroke engines.
5. Layout of a small building plan on ground.
6. Levelling around Academic block.
7. Measurement of tensile strength of reinforcement bar using UTM.
8. Measurement of compressive strength of Brick/Cement by CTM.
9. Designing of residential wiring and study of three phase induction motor.
10. Study of the working of fluorescent lamp and ceiling fan.
11. Use of electronic Instruments and tools.
12. Building DC Regulated Power Supply.

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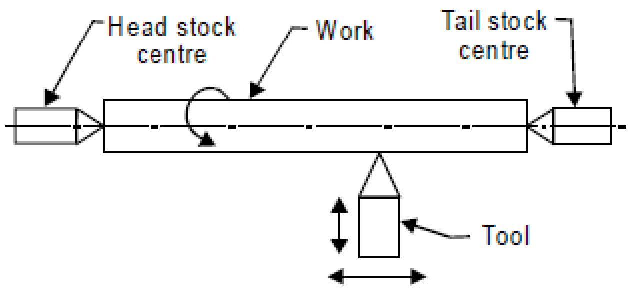
Experiment No 1

Aim: Study of parts of lathe machine and lathe operations

Introduction:

The main function of a lathe is to remove metal from a job to give it the required shape and size. The job is secure1y and rigid1y held in the chuck or in between centers on the lathe machine and then turn it against a single point cutting tool which wi1l remove meta1 from the job in the form of chips.



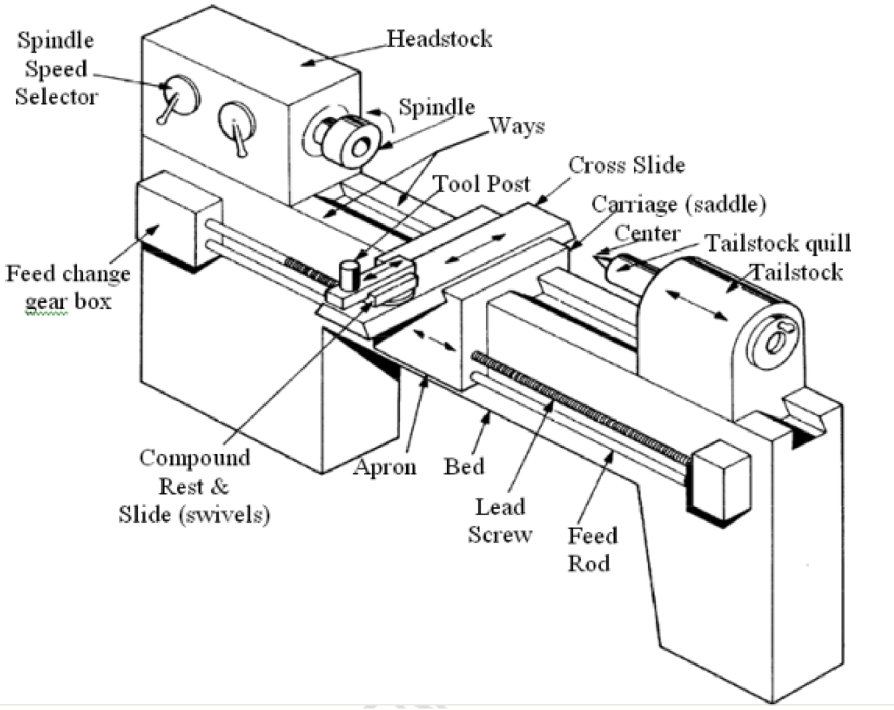
Speed Lathe: Speed lathe is simplest of all types of lathes in construction and operation. The important parts of speed lathe are following-

1. Bed
2. Headstock
3. Tailstock, and
4. Tool post mounted on an adjustable slide.

It has no feed box, 1eadscrew or conventional type of carriage. The tool is mounted on the adjustable slide and is fed into the work by hand contro1. The speed lathe finds applications where cutting force is least such as in wood working, spinning, centering, polishing, winding, buffing etc. This lathe has been so named because of the very high speed of the headstock spindle.

Centre Lathe or Engine Lathe: The term “engine” is associated with this lathe due to the fact that in the very early days of its development it was driven by steam engine. This lathe is the important member of the lathe family and is the most widely used. Similar to the speed lathe, the engine lathe has all the basic parts, e.g., bed, headstock, and tailstock. But its headstock is much more robust in construction and contains additional mechanism for driving the lathe spindle at multiple speeds. Unlike the speed lathe, the engine lathe can feed the cutting tool both in cross and longitudinal direction with reference to the lathe axis with the help of a carriage, feed rod

and lead screw. Centre lathes or engine lathes are classified according to methods of transmitting power to the machine. The power may be transmitted by means of belt, electric motor or through gears.



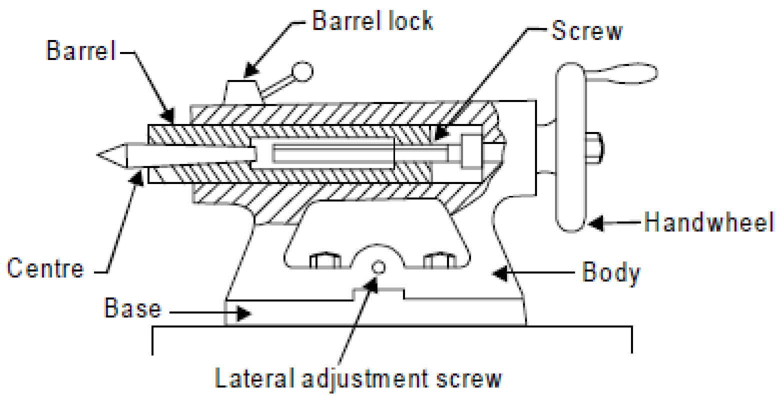
Engine Lathe

<u>Engine Lathe Machine Parts</u>

Bed: The bed of a lathe machine is the base on which all other parts of lathe are mounted. It is massive and rigid single piece casting made to support other active parts of lathe. On left end of the bed, headstock of lathe machine is located while on right side tailstock is located. The carriage of the machine rests over the bed and slides on it. On the top of the bed there are two sets of guide ways-inner ways and outer ways. The inner ways provide sliding surfaces for the tailstock and the outer ways for the carriage. The guide ways of the lathe bed may be flat and inverted V shape. Generally cast iron alloyed with nickel and chromium material is used for manufacturing of the lathe bed.

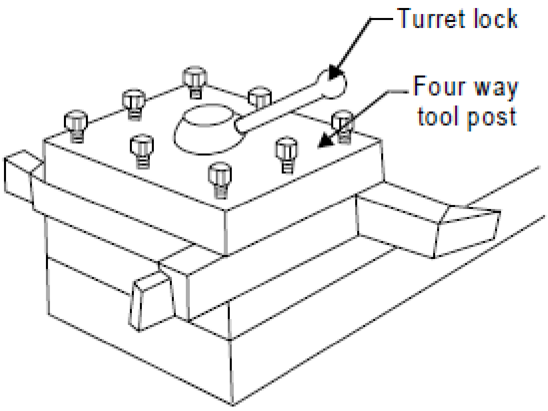
Head Stock: The main function of headstock is to transmit power to the different parts of a lathe. It comprises of the headstock casting to accommodate all the parts within it including gear train arrangement. The main spindle is adjusted in it, which possesses live centre to which the work can be attached. It supports the work and revolves with the work, fitted into the main spindle of the headstock. The cone pulley is also attached with this arrangement, which is used to get various spindle speed through electric motor. The back gear arrangement is used for obtaining a wide range of slower speeds. Some gears called change wheels are used to produce different velocity ratio required for thread cutting.

Tail Stock: The tail stock of central lathe, is commonly used for the objective of primarily giving an outer bearing and support the circular job being turned on centers. Tail stock can be easily set or adjusted for alignment or non-alignment with respect to the spindle centre and carries a centre called dead centre for supporting one end of the work. Both live and dead centers have 60° conical points to fit centre holes in the circular job, the other end tapering to allow for good fitting into the spindles. The dead centre can be mounted in ball bearing so that it rotates with the job avoiding friction of the job with dead centre as it important to hold heavy jobs.



Tail Stock

Carriage: Carriage is mounted on the outer guide ways of lathe bed and it can move in a direction parallel to the spindle axis. It comprises of important parts such as apron, cross-slide, saddle, compound rest, and tool post. The lower part of the carriage is termed the apron in which there are gears to constitute apron mechanism for adjusting the direction of the feed using clutch mechanism and the split half nut for automatic feed. The cross-slide is basically mounted on the carriage, which generally travels at right angles to the spindle axis. On the cross-slide, a saddle is mounted in which the compound rest is adjusted which can rotate and fix to any desired angle. The compound rest slide is actuated by a screw, which rotates in a nut fixed to the saddle. The tool post is an important part of carriage, which fits in a tee-slot in the compound rest and holds the tool holder in place by the tool post screw.



Carriage

Feed Mechanism: Feed mechanism is the combination of different units through which motion of headstock spindle is transmitted to the carriage of lathe machine. Following units play role in feed mechanism of a lathe machine-

1. End of bed gearing
2. Feed gear box
3. Lead screw and feed rod
4. Apron mechanism

The gearing at the end of bed transmits the rotary motion of headstock spindle to the feed gear box. Through the feed gear box the motion is further transmitted either to the feed shaft or lead screw, depending on whether the lathe machine is being used for plain turning or screw cutting. The feed gear box contains a number of different sizes of gears. The feed gear box provides a means to alter the rate of feed, and the ration between revolutions of the headstock spindle and the movement of carriage for thread cutting by changing the speed of rotation of the feed rod or lead screw. The apron is fitted to the saddle. It contains gears and clutches to transmit motion from the feed rod to the carriage, and the half nut which engages with the lead screw during cutting threads.

Thread Cutting Mechanism: The half nut or split nut is used for thread cutting in a lathe. It engages or disengages the carriage with the lead screw so that the rotation of the leadscrew is used to traverse the tool along the workpiece to cut screw threads. The direction in which the carriage moves depends upon the position of the feed reverse lever on the headstock.

Cross slide: Cross-slide is situated on the saddle and slides on the dovetail guideways at right angles to the bed guideways. It carries compound rest, compound slide and tool post. Cross slide handwheel is rotated to move it at right angles to the lathe axis. It can also be power driven. The cross slide hand wheel is graduated on its rim to enable to give known amount of feed as accurate as 0.05mm.

Chucks: Chuck is one of the most important devices for holding and rotating a job in a lathe. It is basically attached to the headstock spindle of the lathe. The internal threads in the chuck fit on to the external threads on the spindle nose. Short, cylindrical, hol1ow objects or those of irregular shapes, which cannot be conveniently mounted between centers, are easily and rigidly held in a chuck. Jobs of short length and large diameter or of irregular shape, which cannot be conveniently mounted between centers, are held quickly and rigidly in a chuck.

There are a number of types of lathe chucks, e.g.

(1) Three jaws or universal

(2) Four jaw independent chuck

(3) Magnetic chuck

(4) Collet chuck

(5) Air or hydraulic chuck operated chuck

(6) Combination chuck

(7) Drill chuck.

Specification of lathe:

The size of a lathe is generally specified by the following means:

(*a*) Swing or maximum diameter that can be rotated over the bed ways

(*b*) Maximum length of the job that can be held between head stock and tail stock centres

(*c*) Bed length, which may include head stock length also

(*d*) Maximum diameter of the bar that can pass through spindle or collect chuck of lathe.

Lathe operations:

For performing the various machining operations in a lathe, the job is being supported and driven by anyone of the following methods.

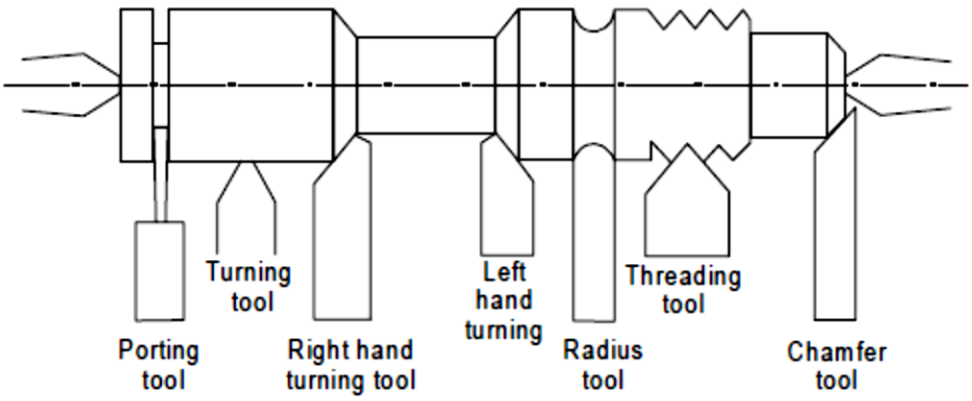
1. Job is held and driven by chuck with the other end supported on the tail stock centre.

2. Job is held between centers and driven by carriers and catch plates.

3. Job is held on a mandrel, which is supported between centers and driven by carriers and catch plates.

4. Job is held and driven by a chuck or a faceplate or an angle plate.

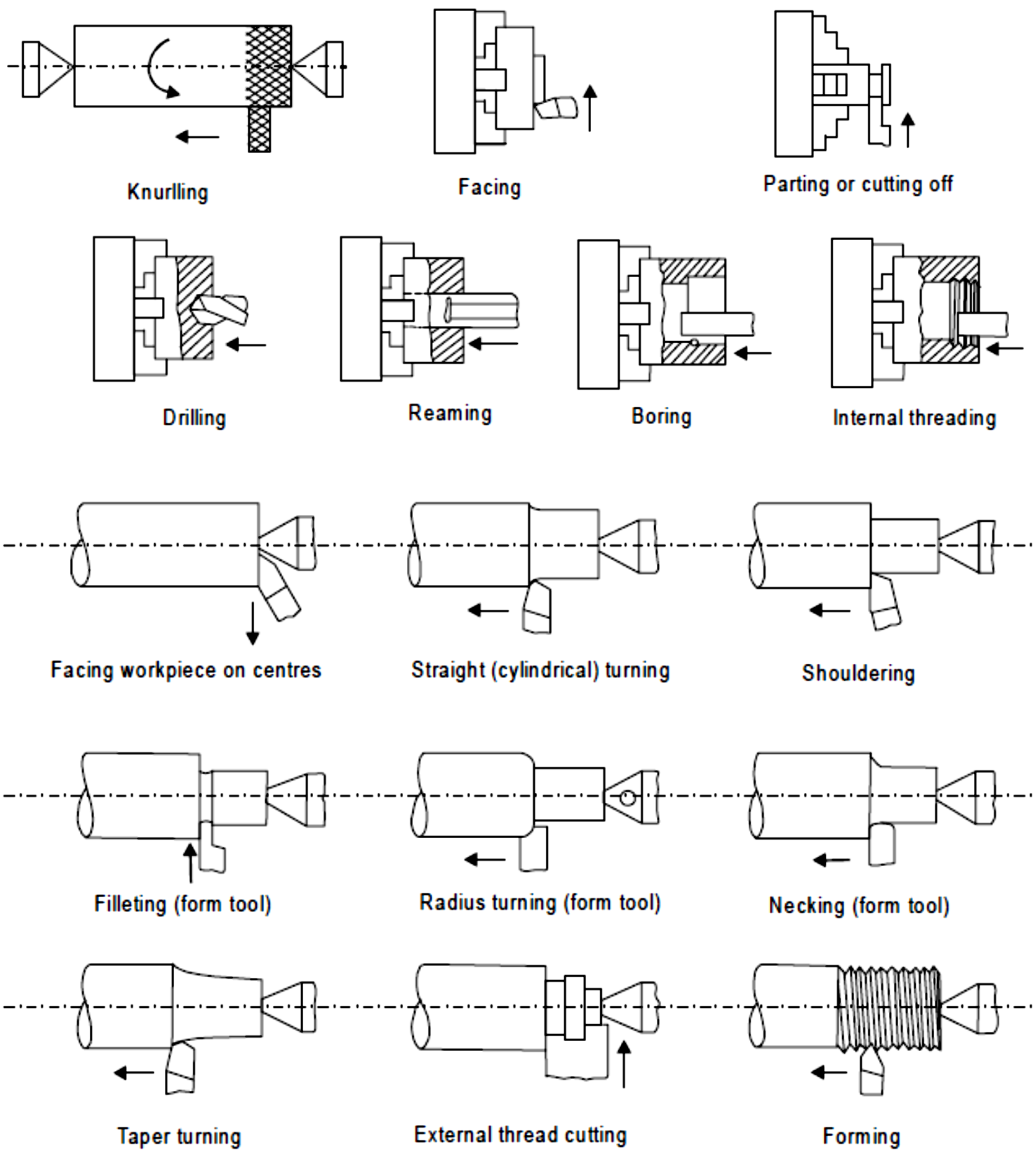
The above methods for holding the job can be classified under two headings namely job held between centers and job held by a chuck or any other fixture.



Operations, which can be performed in a lathe either by holding the work piece between centers or by a chuck, are:

- Straight turning
- Shoulder turning
- Taper turning
- Chamfering
- Thread cutting
- Facing
- Forming
- Grooving
- Knurling
- Operations which are performed by holding the work by a chuck or a faceplate or an angle plate are:
- Undercutting
- Parting-off
- Internal thread cutting

- Drilling
- Reaming
- Boring
- Counter boring
- Taper boring
- Tapping



Experiment no: 2

AIM: Perform different operations on lathe machine like Facing, Turning, Taper Turning and knurling on MS cylindrical work piece

Tools required: Single point cutting tool, parting tool, knurling tool.

Material required: Mild steel rod (Diameter 32mm)

Instruments required: Steel rule, vernier caliper, outside caliper.

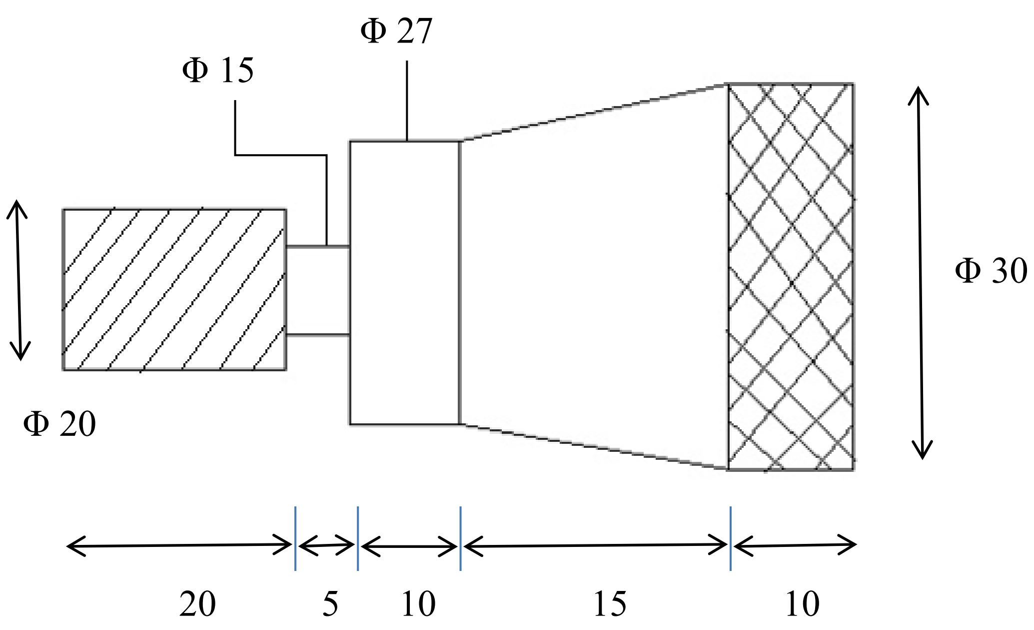
Procedure:

1. Job is fixed in three jaw chuck for proper alignment.
2. Single point cutting tool is fixed in the tool post and facing operation is completed.
3. A rough cut is used to turn the outer periphery.
4. Final turning and step turning operation are completed in sequence.
5. The compound slide is set at the taper angle as per calculation with the center line and tapering operation is completed through different cuts.
6. Knurling tool is fixed in tool post for knurling operation.
7. For maintaining the proper length of the job parting off tool is used and parting operation is completed.

Precautions:

1. Work piece should be firmly gripped in the three jaw chuck.
2. Coolant is to be used.
3. Hand gloves and apron must be used while working.
4. Proper rpm should be selected before the operation.

Drawing:



Dimensions are in mm

Conclusion:

Experiment no 3

Aim:

To make Butt and Lap joint on given MS plate piece with arc welding process.

Material Required: Mild steel plate of size 30X50X6 mm – 2 No's

Welding Electrodes: M.S electrodes 3.1 mm X350 mm

Welding Equipment: Air cooled transformer Voltage-80 to 600 V 3 phase supply, amps up to 350

Tools and Accessories required:

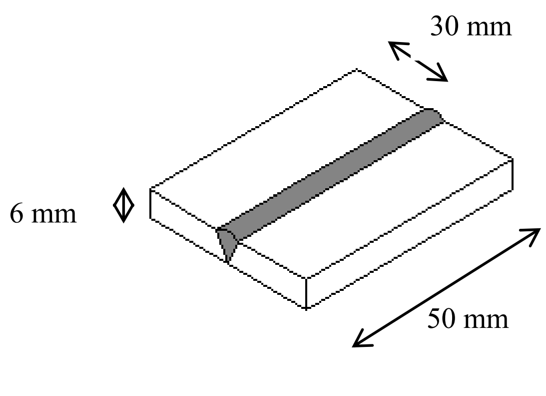
1. Rough and smooth files.
2. Protractor
3. Arc welding machine (transformer type)
4. Mild steel electrode and electrode holder
5. Ground clamp
6. Tongs
7. Face shield
8. Apron
9. Chipping hammer.

Sequence of operations:

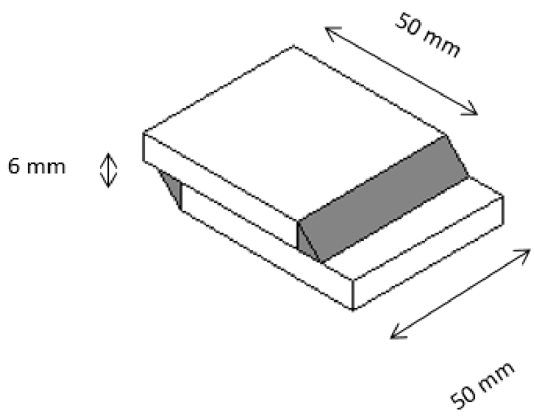
1. Marking
2. Cutting
3. Edge preparation (Removal of rust, scale etc.) by filling
4. Try square leveling
5. Tacking
6. Welding
7. Cooling 8. Chipping
9. Cleaning

Procedure:

1. The given M.S pieces are thoroughly cleaned of rust and scale.
2. One edge of each piece is believed, to an angle of 300 , leaving nearly ¼ th of the flat thickness, at one end.
3. The two pieces are positioned on the welding table such that, they are separated slightly for better penetration of the weld. (For Butt Joint)
4. The two pieces are positioned on the welding table such that, the two pieces overlapped one over the other as shown in drawing. (For Lap Joint)
5. The electrode is fitted in the electrode holder and the welding current is ser to be a proper value.
6. The ground clamp is fastened to the welding table.
7. Wearing the apron and using the face shield, the arc is struck and holding the two pieces together; first run of the weld is done to fill the root gap.
8. Second run of the weld is done with proper weaving and with uniform movement. During the process of welding, the electrode is kept at 150 to 250 from vertical and in the direction of welding.
9. The scale formation on the welds is removed by using the chipping hammer.
10. Filling is done to remove any spanner around the weld.



Butt Joint



Lap Joint

Experiment no 4

Aim: To study two stroke and four stroke petrol engines.

Apparatus: Model of two stroke and four stroke petrol engine.

Theory: The engine which converts the heat energy into mechanical energy is known as heat engine.

1. WORKING PRINCIPLE OF FOUR STROKE PETROL ENGINES

There are four strokes which are as follows:

i) Suction stroke

ii) Compression stroke

iii) Expansion or working or power stroke

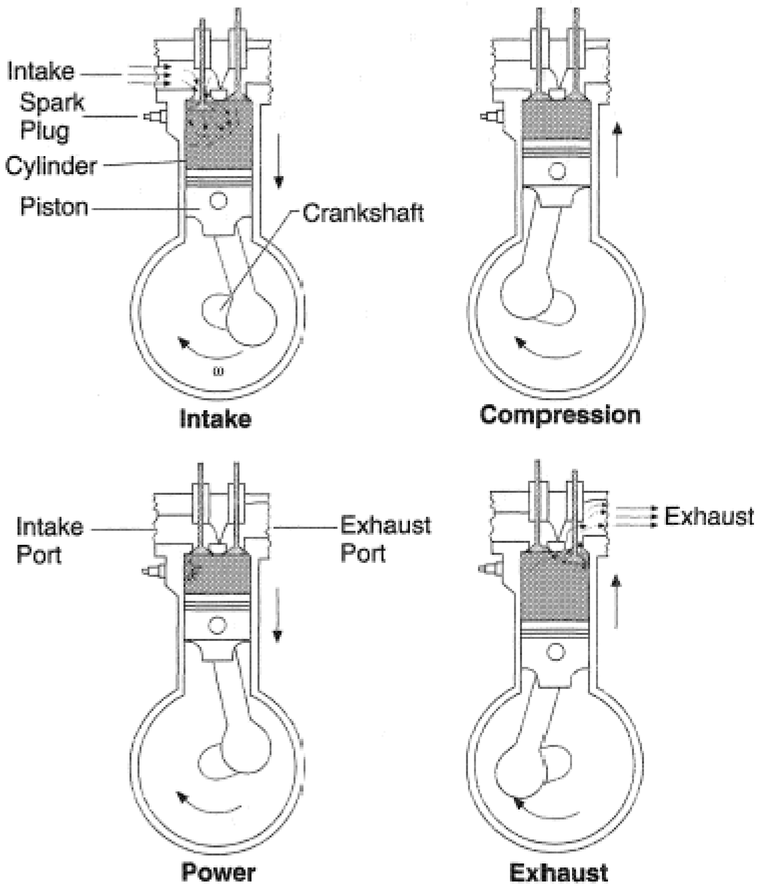
iv) Exhaust stroke

i) SUCTION STROKE: The suction stroke starts with the piston at top dead centre position. During this stroke, the piston moves downwards by means of crank shaft. The inlet valve is opened and the exhaust valve is closed. The partial vacuum created by the downward movement of the piston sucks in the fresh charge (mixture of air and petrol) from the carburettor through the inlet value. The stroke is completed during the half revolution (180^O) of the crank shaft, which means at the end of the suction stroke, piston reaches the bottom head centre position.

ii) COMPRESSION STROKE: During this stroke the inlet and exhaust valves are closed and the piston returns from bottom dead centre position. As the piston moves up, the charge is compressed. During compression the pressure and temperature rises. This rise in temperature and pressure depends upon the compression ratio (in petrol engines the compression ratio generally varies between 6:1 and 9:1). Just before the completion of the compression stroke, the charge is ignited by means of an electric spark, produced at the spark plug.

iii) WORKING OR EXPANSION STROKE: The ignition of the compressed charge. Just before the completion of compression stroke, causes a rapid rise of temperature and pressure in the cylinder. During this stroke the inlet and exhaust values remain closed. The expansion of gases due to the heat of combustion exerts pressure on the piston due to which the piston moves downward, doing some useful work.

iv) EXHAUST STROKE: The exhaust value is opened and the inlet valve remain closed. The piston moves upward (from its BDC position) with the help of energy stored in the flywheel during the working stroke. The upward movement of the piston discharges the burnt gases through the exhaust value.



At the end of exhaust stroke, piston reaches its TDC position and the next cycle starts

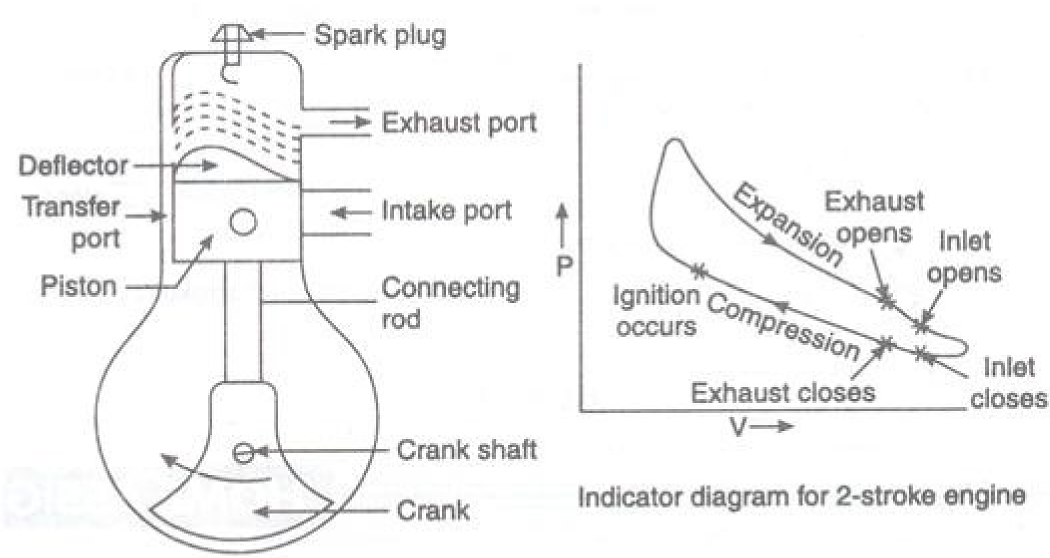
Working Principles of 2-Stroke petrol engine

The working principle of 2-Stroke petrol engine is discussed below: -

1) 1st Stroke: To start with let us assume the piston to be at its B.D.C. position. The arrangement of the ports is such that the piston performs two jobs simultaneously.

As the piston starts rising from its B.D.C. position it closes the transfer port and the exhaust port. The charge (mixture, of the air and petrol) which is already there in the cylinder, as the result of the previous running of the engine is compressed at the same time with the upward movement of the piston vacuum is created in the crank case (which is gas tight). As soon as the inlet port is uncovered; the fresh change in sucked in the crank case. The charging is continued until the crank case and the space in the cylinder beneath the piston is filled with the charge. As the end of third stroke, the piston reached the T.D.C. position.

2) 2nd Stroke: Slightly before the completion of the compression stroke, the compressed charge is ignited by means of a spark produced at the spark plug.



Indicator diagram for 2-stroke engine

Pressure is exerted on the crank of the piston due to the combustion of the piston is pushed in the downward direction producing some useful power. The downward movement of the will first close the inlet port and then it will compress the charge already sucked in the crank case.

Just the end of power stroke, the piston uncovered the exhaust port and the transfer port simultaneously the expanded gases start escaping through the exhaust port and the same time the fresh charge which is already compressed in the crank case, rushed into the cylinder through the transfer port and thus the cycle is repeated again.

The fresh charge coming into the cylinder also helps in exhausting the burnt gases out of the cylinder through the exhaust port. This is known as scavenging.

Diesel Engine:

1. Suction stroke: This stroke starts with the piston at top dead centre position. The inlet value is opened and the exhaust value is closed. The downward movement of the piston creates vacuum in the cylinder due to which air is drawn into the cylinder. The movement of the piston is obtained either by the starter motor or by the momentum of the fly wheel.

2. Compression stroke: This stroke starts with the piston at B.D.C. position. Both the inlet and exhaust values are closed.

The air sucked during the suction stroke is compressed as the piston moves in the upward direction. A few degree before the completion of compression stroke, a very fine spray of diesel is injected into the compressed air. The fuel ignites spontaneously.

3. Expansion stroke: Both the inlet and exhaust valves remain closed. The heat energy released by the combustion of the fuel, results in the rise in pressure of the gases. This high pressure rise drives the piston in the downward direction, thereby producing some useful work. This stroke is called as power stroke.

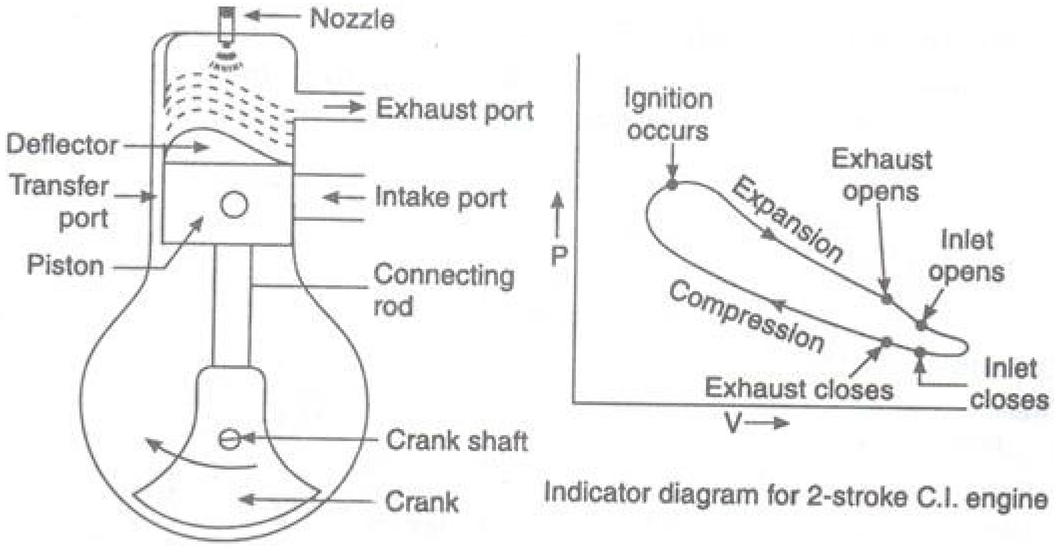
4. Exhaust stroke: This stroke starts with the piston at the B.D.C. position. The inlet value remains closed whereas the exhaust value is opened. The upward movement of the piston pushes the burnt gases out of the cylinder through the exhaust valve. At the end of exhaust stroke, the exhaust valve is also closed.

The four-strokes complete one cycle which may repeat again to produce power.

WORKING PRINCIPLE OF 2 STROKE DIESEL ENGINE

1. 1st Stroke – As the piston starts rising from its B.D.C. position, it closes the transfer and the exhaust port. The air which is already there in the cylinder is compressed. At the same time with the upward movement of the piston, vacuum is created in the crank case. As soon as the inlet port is uncovered the fresh air is sucked in the crank case. The charging is continued until the crank case and the space in the cylinder beneath the piston in filled with the air.

2. 2nd Stroke – Slightly before the completion of the compression stroke a very fine spray of diesel is injected into the compressed air (which is at a very high temperature). The fuel ignites spontaneously.



Indicator diagram for 2-stroke C.I. engine

Pressure is exerted on the crown of the piston due to the combustion of the air and the piston is pushed in the downward direction producing some useful power. The downward movement of the piston will first close the inlet port and then it will compress the air already sucked in the crank case.

Just at the end of power stroke, the piston uncovers the exhaust port and the transfer port simultaneously. The expanded gases start escaping through the exhaust port and at the same time the fresh air which is already compressed in the crank case, rushes into the cylinder through the transfer port and thus the cycle is repeated again.

Experiment no 5

Aim: Procedure for setting out a building plan on ground

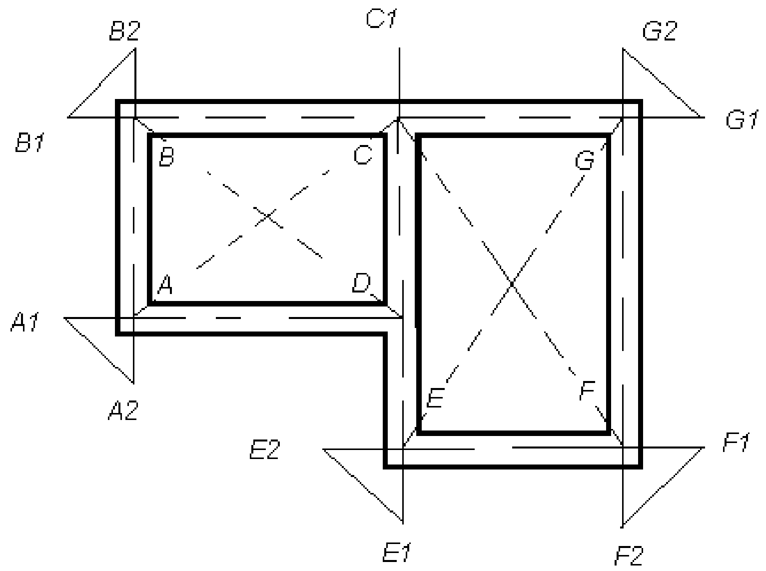


Fig.1: Example plan to be set out on the ground

1. From the Example plan (fig 1), the centre line of the walls is determined first. Then the centre lines of the rooms are set out by setting perpendiculars in the ratio 3:4:5 as explained below.
2. For this first mark point A then on the ground then mark point A1 and A2 at a distance of 3 ft and 4 ft then check the distance between them it should be 5 ft. This will give the perpendicular line towards point B and point D, mark point B and D using the distance from the given plan.
3. Follow the same process at all the points on the corner B, C, D, E, F and G and mark them with the help of a pegs and complete the traverse on the ground as given in the plan fig (3)
4. After setting the corner points A, B, C, D, E, F and G, check the distances between points AC, BD, CF, EG according to the distance between the diagonals which are calculated from the given plan in fig (2).
5. Now mark the excavation width at equal distance from the central line with arrow and lime at appropriate positions as mentioned in the plan fig (3).

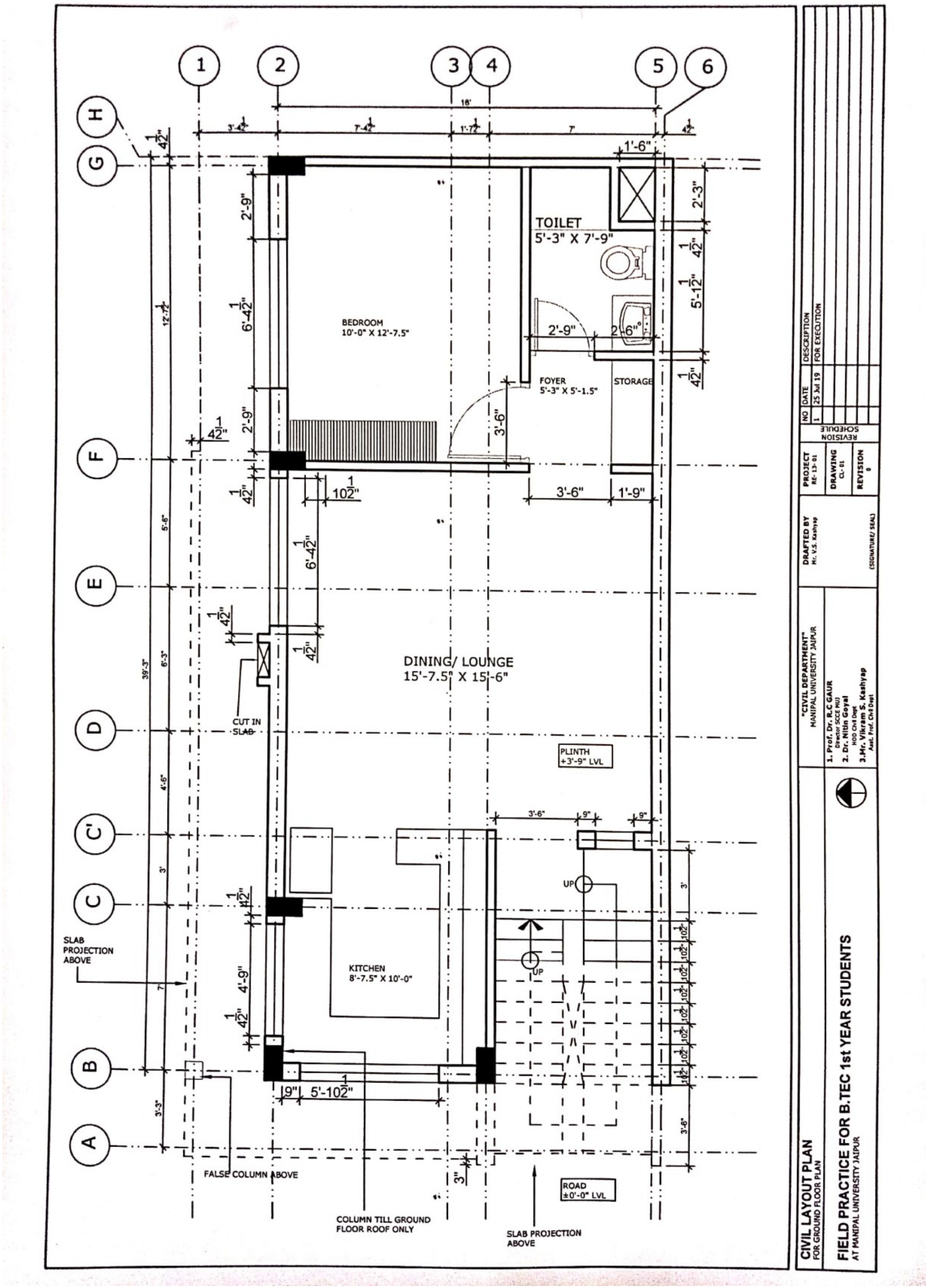


Fig (2) Building Layout Plan to be plotted on the Ground

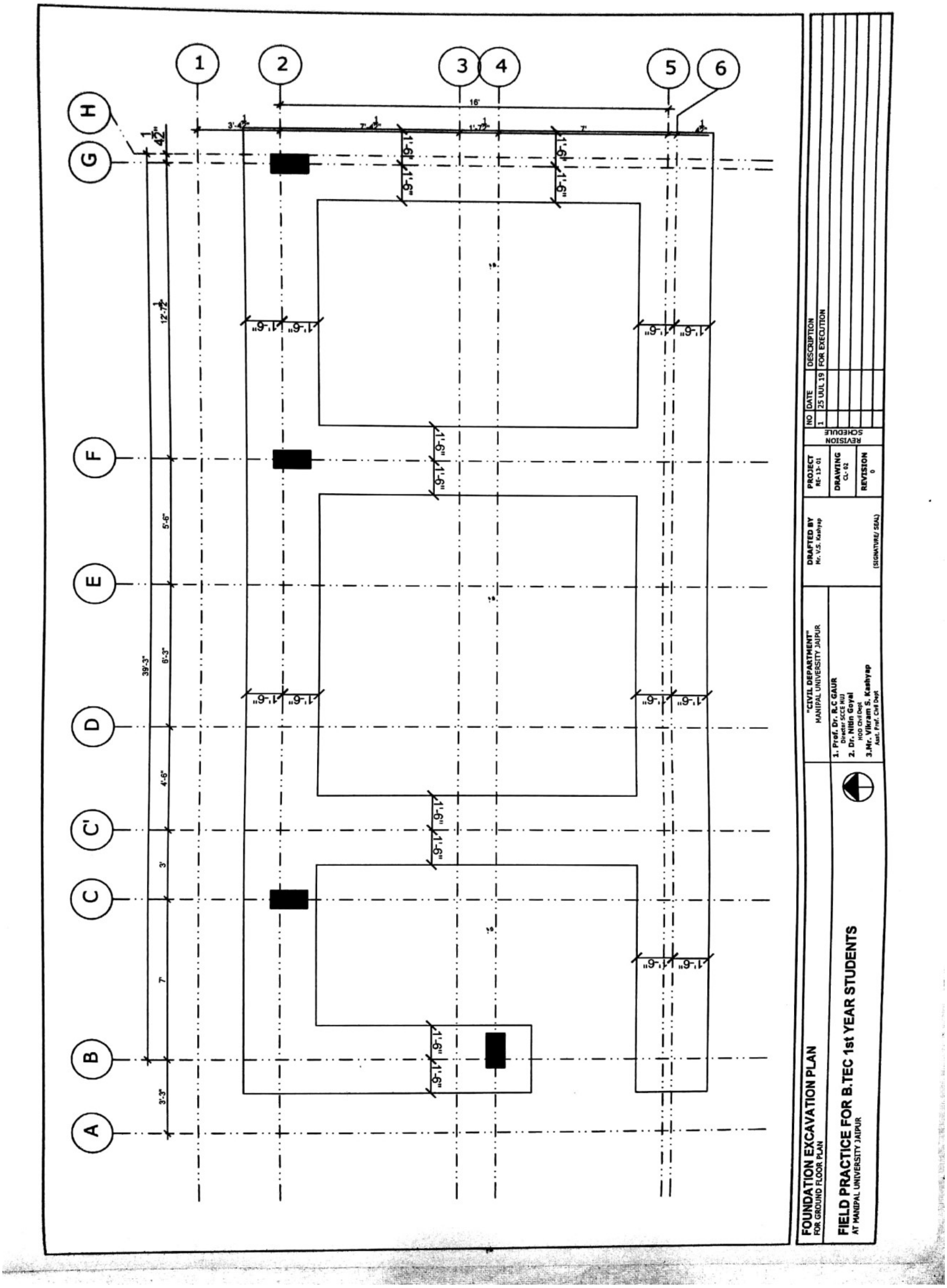
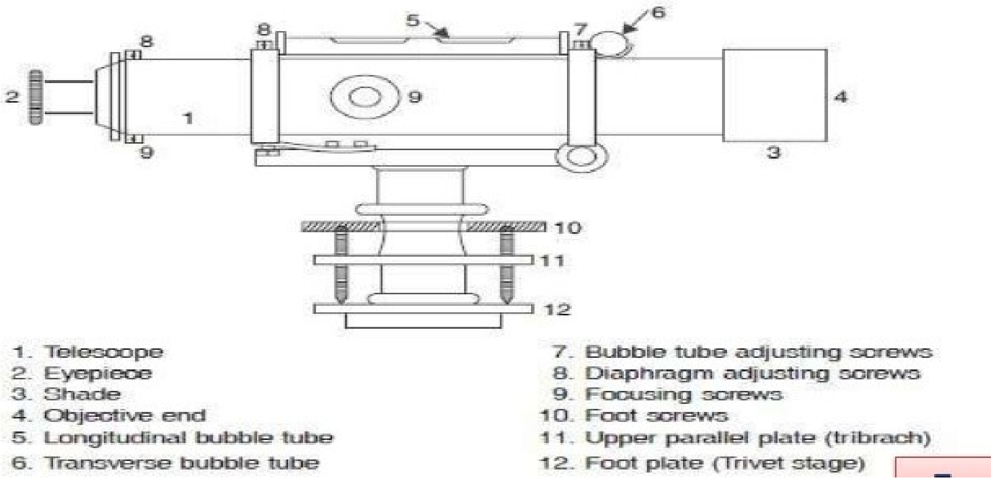


Fig (3) Excavation Plan for the Building

Experiment no 6

<u>Aim</u>: Determination of elevation of various points with Auto level by Height of instrument method to generate the ground profile

<u>Apparatus</u>: Auto level, Levelling staff



<u>Theory:</u>

Levelling: The art of determining and representing the relative height or elevation of different object/points on the surface of earth is called levelling. It deals with measurement in vertical plane. By leveling operation, the relative position of two points is known whether the points are near or far off. Similarly, the point at different elevation with respect to a given datum can be established by leveling.

Levelling Instruments: - The instrument which are directly used for leveling operation are: - level, levelling staff

Level: - An instrument which is used for observing staff reading on leveling staff kept over different points after creating a line of sight is called a level. The difference in elevation between the point then can worked out. A level essentially consists of the following points: 1) Levelling Heads 2) Limb plate 3) Telescope

Auto level: The Auto level is simple, compact and stable instrument. The telescope is rigidly fixed to its supports. Hence it cannot be rotated about its longitudinal axis or cannot be removed from its support. The name Auto is because of its compact and stable construction. The axis of telescope is perpendicular to the vertical axis of the level. The level tube is permanently placed so that its axis lies in the same vertical plane of the telescope but it is adjustable by means of captain head not at one end. The ray shade is provided to protect the object glass. A clamp and slow motion screw are provided in modern level to control the movement of spindle, about the vertical axis. The telescope has magnifying power of about thirty diameters. The level tube is graduated to 2mm divisions and it has normally a sensitiveness of 20 seconds of are per graduation. The telescope may be internally focusing or external focusing type.

Adjustment of the level

The level needs two type of adjustment

1) Temporary adjustment and

2) Permanent adjustment

Temporary adjustments of Auto level

These adjustments are performed at each set-up the level before taking any observation.

A) **Setting up the level**: -

1) Fixing the instrument in the tripod: - The tripod legs are well spread on the ground with tripod head nearly level and at convenient height. Fix up the level on the tripod.

2) Leg adjustment: - Bring all the foot screws of the level in the center of their run. Fix any two legs firmly into the ground by pressing them with hand and move the third leg to leg to right or left until the main bubble is roughly in the center. Finally, the leg is fixed after centering approximately both bubbles. This operation will save the time required for leveling.

B) **Levelling**: - Levelling is done with the help of foot screws and bubbles. The purpose of levelling is to make the vertical axis truly vertical. The method of leveling the instrument depends upon whether there are three foot screws or four foot screws. In all modern instruments three foot screws are provided and this method only is described.

1) Place the telescope parallel to pair of foot screws.

2) Hold these two foot screw between the thumb and first finger of each hand and turn them uniformly so that the thumbs move either toward each other until the bubble is in center.

3) Turn the telescope through 90°so that it lies over the third foot screw.

4) Turn this foot screw only until the bubble is centered.

5) Bring the telescope back to its original position without reversing the eye piece and object glass ends.

6) Again bring the bubble to the center of its run and repeat these operations until the bubble remains in the center of its run in both position which are at right angle to each other.

7) Now rotate the instrument through 180°, the bubble should remain in center provided the instrument is in adjustment: if not, it needs permanent adjustment.

C) **Focusing the eye piece**: - To focus the eye piece, hold a white paper in front of the object glass, and move the eye piece in or out till the cross hairs are distinctly seen. Care should be taken that the eye piece is not wholly taken out, sometimes graduation is provided at the eye piece and that one can always remember the particular graduation position to suit his eyes, this will save much time of focusing the eye piece.

D) **Focusing the object glass**: - Direct the telescope to the leveling staff and on looking through the telescope, turn the focusing screw until the image appears clears and sharp. The image is thus formed inside the plane of cross hairs, Parallax, if any is removed by exact focusing.

It may be noted that parallax is completely eliminated when there is no change in staff reading after moving the eye up and down. Reduced Levels The system of working out the reduced level of the points from staff reading taken in the field is called as reduced level (R.L) of a points is the elevation of the point with reference to the same datum.

There are two systems of reduced levels

1) The plane of collimation system (H.I. method)

2) The Rise and fall system

The plane of collimation system (H.I. method): - In this system, the R.L. of plane of collimation (H.I) is found out for every set-up of the level and then the reduced levels of the points are worked out with the respective plane of collimation as described below.

1) Determine the R.L. of plane of collimation for the first set up of the level by adding B.S. to the R.L. of B.M. i.e.

(R. L of plane of collimation= R.L. of B.M.+B.S.)

2) Obtain the R.L. of the intermediate points and first change point by subtracting the staff readings (I.S. and F.S. from the R.L. of plane of collimation (H.I)).
(R.L. of a point=R.L of plane of collimation H.I.-I. S or F.S)

3) When the instrument is shifted and set up at new position a new plane of collimation is determined by addition of B.S. to the R.L of change point. Thus the levels from two set-ups of the instruments can be correlated by means of B.S. and F.S. taken on C.P.

4) Find out the R.L.s of the successive points and the second C.P. by subtracting their staff readings from this plane of collimation R.L.

5) Repeat the procedure until all the R. Ls are worked out.

OBSERVATION TABLE: -

Station	**Readings**			**Height of Instrument**	**Reduced level (R.L)**	**Remarks**
	B.S	**I.S**	**F.S**			

Experiment no. 7

TENSION TEST ON MILD STEEL

Aim: (i) To study the behaviour of mild steel specimen under the action of gradually increasing load tested up to failure.

(ii) To determine yield stress, ultimate tensile strength, modulus of elasticity and Poisson's ratio.

Apparatus: 60T UTM, Gripping devices, Extensometer, Scale, Micrometer, Screw gauge, Punch and Hammer.

Theory: The definitions used in this experiment are as follows

- Gauge Length: The reference length over which the extension is measured.
- Stress: When material is subject to action of force, it develops resistance. The resistance per unit cross-sectional area is stress.
- Linear Strain: Change in length per unit length per is strain.
- Yield Stress: Stress at which considerable elongation first occurs in the test piece without increase in load.
- Ultimate Tensile Strength: The maximum load reached in a test piece divided by original cross-sectional area
- Modulus of Elasticity: It is the ratio of normal stress to axial strain up to proportional limit. This is also termed as 'Young's Modulus of Elasticity'.
- Percentage Elongation: Permanent elongation of gauge length after breaking. This is expressed as percentage of original gauge length.

The value of percentage elongation depends on gauges chosen. Its value is higher for small gauge length as the maximum stretching occurs near the point of fracture. According to ISI specification for rods, Gauge length is $5.56\sqrt{A_o} \approx 5d$.

Procedure: The diameter of the given specimen is found out with the help of micrometer screw gauge at two or three places. The centre point of the specimen is located and half the value of gauge length set off on either side of it using scale. The punch marks are made at these extreme points to facilitate to mounting of extensometer. The punch marks also made at the interval of 2.5d for calculation of percentage elongation. Permanent elongation is measured over the length of 5d, which contains neck.

The jaws for gripping the specimen are inserted in the bores provided in the cross-head and adjustable cross-head. The test specimen is fixed at its upper end in the top cross-head by operating hand wheel and locking lever. The adjustable cross-head is moved up to necessary height. The lower end of the specimen is gripped at its lower end and locked. The extensometer is mounted on the specimen. The points of the screw of the extensometer are fixed on the punch mark of the specimen. After initial reading or zero error at zero load, the extensometer readings are noted down at regular interval of increased load. Before yield point eight to ten readings are taken.

The hydraulic pump is now put into operation and rate of loading is adjusted so that rate of loading should not increase 1 kg/mm^2 or as desired per second up to yield point.
As the yield point approaches, the pointer of the load measuring gauge remains stationary and pointer of extensometer moves very rapidly indicating the flow of material without corresponding increase in load. As loading is continued, the pointer shows increasing load. The load reaches to its maximum value.. On further loading the pointer shows the decreasing order. This is due to formation of neck. Although the load goes on decreasing the length of the specimen goes on increasing, because real stress at neck goes on increasing.

The specimen thus breaks into two pieces with breaking sound. It is observed that the specimen has broken into cup and cone fashion, a typical ductile fracture.. The pieces are put together and final gauge length and final diameter at neck are recorded

<u>Observations</u>: Material of the specimen:

- Original diameter of the specimen =
- Original gauge length of the specimen =
- Final diameter of the specimen =
- Final gauge length of the specimen =
- Yield load =
- Ultimate tensile load =
- Breaking load =

Calculation:

- Percentage reduction in area $= \dfrac{Change in area of Cross - Section}{Original area of Cross - Section}$

- Percentage increase in length $= \frac{Change in length}{Original Length}$

- Yield Stress $= \frac{Yield Load}{Original Cross - Sectional area}$

- Ultimate Tensile Strength $= \frac{Ultimate Tensile Load}{Original Cross - Sectiona area}$

- Breaking Stress $= \frac{Breaking Load}{Origial Cross - Sectional area}$

- Modulus of Elasticity $= Slope of the plot (load vs elongation) x \frac{L}{A_0}$

<u>Results:</u>

Percentage reduction in area =

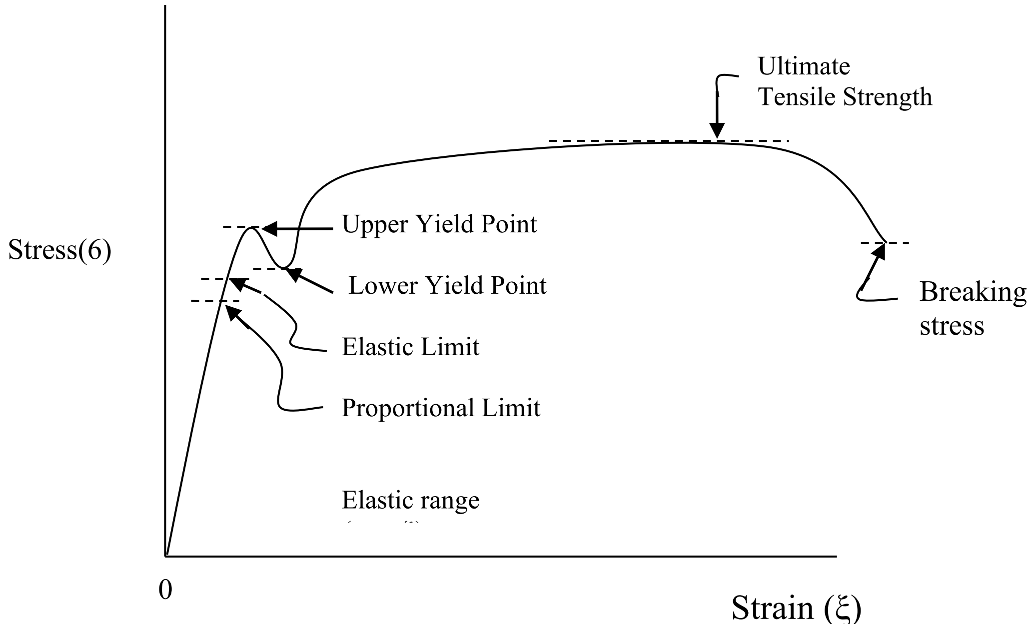
Percentage increase in length =

Yield Stress =

Ultimate Tensile Strength =

Breaking Stress =

Modulus of Elasticity =



[Universal Testing Machine]

Curve σ vs ξ is a typical class of steel known as Mild Steel. The relationship between stress and strain is linear up to proportional limit, the material is said to follow Hooke's Law up to point namely proportional limit. After this point the Hooke's Law ceases to be applied even though the material is in elastic stage. The point is called 'Elastic Limit' and region is called 'Elastic Range'. Up to this point, the specimen can be unloaded without permanent deformation, unloading will be along the linear portion of the diagram, the same path followed during loading. A peak value upper yield point is quickly reached followed by leveling off lower yield point. At this stage of loading, the specimen continues to elongate as long as load is not removed, even though load is not increased.

This constant stress region is called Plastic Range. When further load is applied, the curve rises continuously and becomes flatter until the maximum stress is reached known as 'Ultimate Tensile Strength'. Throughout the test the specimen elongates and the cross-sectional area decreases locally. This is due to slippage of planes formed inside the material and actual strain produced is caused by shear stress, thus resulting formation of neck gradually in this region. Since the cross-sectional area in this region decreases continuously. The smaller area can take ever decreasing load. Hence the stress-strain diagram tends to curve downward until the specimen breaks at breaking point known as 'Breaking Stress'.

COMMENTS/CONCLUSION:

ATTACHED GRAPH

Experiment No.-8

TEST ON BRICK – COMPRESSIVE STRENGTH

Aim: - To determine the compressive strength of bricks

Apparatus: - Compression testing machine, the compression plate of which shall have ball seating in the form of portion of a sphere centre of which coincides with the centre of the plate.

Fig: Compression Testing Machine

Specimens: - Three numbers of whole bricks from sample collected should be taken .the dimensions should be measured to the nearest 1mm

Sampling: - Remove unevenness observed the bed faces to provide two smooth parallel faces by grinding .Immerse in water at room temperature for 24 hours .Remove the specimen and drain out any surplus moisture at room temperature. Fill the frog and all voids in the bed faces flush with cement mortar (1 cement,1 clean coarse sand of grade 3mm and down). Store it under the damp jute bags for 24 hours filled by immersion in clean water for 3 days .Remove and wipe out any traces of moisture.

Procedure:-

(I) Place the specimen with flat face s horizontal and mortar filled face facing upwards between plates of the testing machine.

(II) Apply load axially at a uniform rate of 14 N/mm^2 ($140\ kg/cm^2$) per minute till failure occurs and note maximum load at failure.

(III) The load at failure is maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine.

CALCULATION

$$\text{Compressive strength} = \frac{\text{Maximum load at failure (N)}}{\text{Average area of bed face (mm}^2\text{)}}$$

The average of result shall be reported.

Range Calculation

Maximum compressive strength =

Contact area =

Maximum expected load =

The range to be selected is …………………

Result

Average compressive strength of the given bricks =………….. N/mm^2

Is specications

Speciation of Common Clay Building Bricks

Dimensions: The standard size of clay bricks shall be as follows

Length (mm)	**Width (mm)**	**Height (mm)**
190	90	90
190	90	40

Classification: The common burnt clay shall be classified on the basis of average compressive strength as given in table.

Class Designation	**Average compressive strength**	
	Not less than (N/mm^2)	**Less than** (N/mm^2)
350	35	40
300	30	35
250	25	30
200	20	25
175	17.5	20
150	15	17.5
125	12.5	15
100	10	12.5
75	7.5	10
50	5	7.5
35	3.5	5

Experiment No. 9

Domestic Wiring System

Aim: To study the residential wiring system and three phase induction motor.

Types of Wiring System: There are different types of electrical wiring used in domestic properties.

1. Cleat Wiring

This wiring comprises of PVC insulated wires or ordinary VIR that are braided and compounded. They are held on walls and ceilings using porcelain cleats with groves, wood or plastic. It is a temporary wiring system, therefore making it unsuitable for domestic premises. Moreover, cleat wiring system is rarely being used these days.

2. Casing and Capping Wiring

It was quite popular in the past but it is considered obsolete these days due to the popularity of the conduit and sheathed wiring system. The cables used in this electric wiring were PVC, VIR or any other approved insulated cables. The cables were carried through the wooden casing enclosures, where the casing was made of a strip of wood with parallel grooves cut lengthwise for accommodating the cables.

3. Batten Wiring

This is when a single electrical wire or a group of wires are laid over a wooden batten. The wires are held to the batten using a brass clip and spaced at an interval of 10 cm for horizontal runs and 15 cm for vertical runs.

4. Lead Sheathed Wiring

Lead sheathed wiring uses conductors which are insulated with VIR and are covered with an outer sheath of lead aluminum alloy which contains about 95% lead. The metal sheath gives protection to cables from mechanical damage, moisture and atmospheric corrosion.

5. Conduit Wiring

There are two types of conduit wiring according to pipe installation:

a. Surface Conduit Wiring- When GI or PVC conduits are installed on walls or roof, it is known as surface conduit wiring. The conduits are attached to the walls with a 2-hole strap and base clip at regular distances. Electrical wires are laid inside the conduits.

b. Concealed Conduit Wiring- When the conduits are hidden inside the wall slots or chiseled brick wall, it is called concealed conduit wiring. Electrical wires are laid inside the conduits. This is popular since it is stronger and more aesthetically appealing.

There are some Advantages and Disadvantages of Concealed Conduit Wiring System

Advantages

- It is a safe wiring system
- Safe from chemical effects, humidity and other external factors
- No risk of shock
- It is aesthetically appealing
- No risk of wear and tear, fire or damaged cable insulation
- Quite reliable
- Renovations can be easily performed as you can replace old wires easily

Disadvantages

- Expensive as compared to surface conduit wiring
- Changing the location of switches or appliances is difficult
- Installation is complex
- Hard to find defects in the wiring
- Adding additional conduit in future is a tedious task

When the wiring is not done properly or isn't maintained well, it may lead to dangerous situations such as electrical fires. Therefore, it is important that you take a lot of care while installing electrical wires and cables.

Electricity Supply Specifications: Electricity supply for domestic consumers, according to MS IEC 60038 standards, meets the following specifications: -

i. Single phase supply with nominal voltage of 230V, range +10%, -6%;
ii. Three phase supply with nominal voltage of 400V, range +10%, -6%;
iii. Permitted frequency is 50Hz + 1%;
iv. Earthing system type (TT System) as in Figure 2.1 and Figure 2.2.
All electrical equipment used must be suitable for operation with the stated electricity supply specifications.

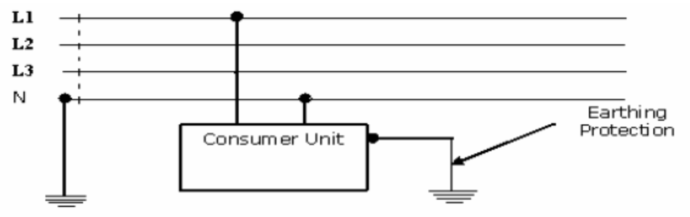


Figure .1 TT System (Single Phase)

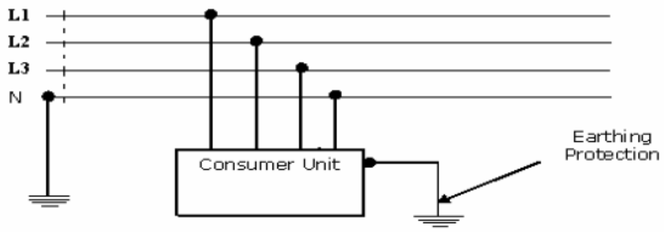


Figure .2 TT System (Three Phase)

Planning of Electrical Wiring Work: Prior to carrying out wiring work, the wireman/contractor should plan and determine the tasks to be undertaken so that the work carried out is tidy, neat and safe to be used. The wireman/contractor shall: -
i. Undertake a site visit;
ii. Determine the consumer load requirements;
iii. Calculate the maximum load demand; and
iv. Submit the plans, drawings and specifications.
The planning flow chart for building wiring installations is as shown in Figure 3.

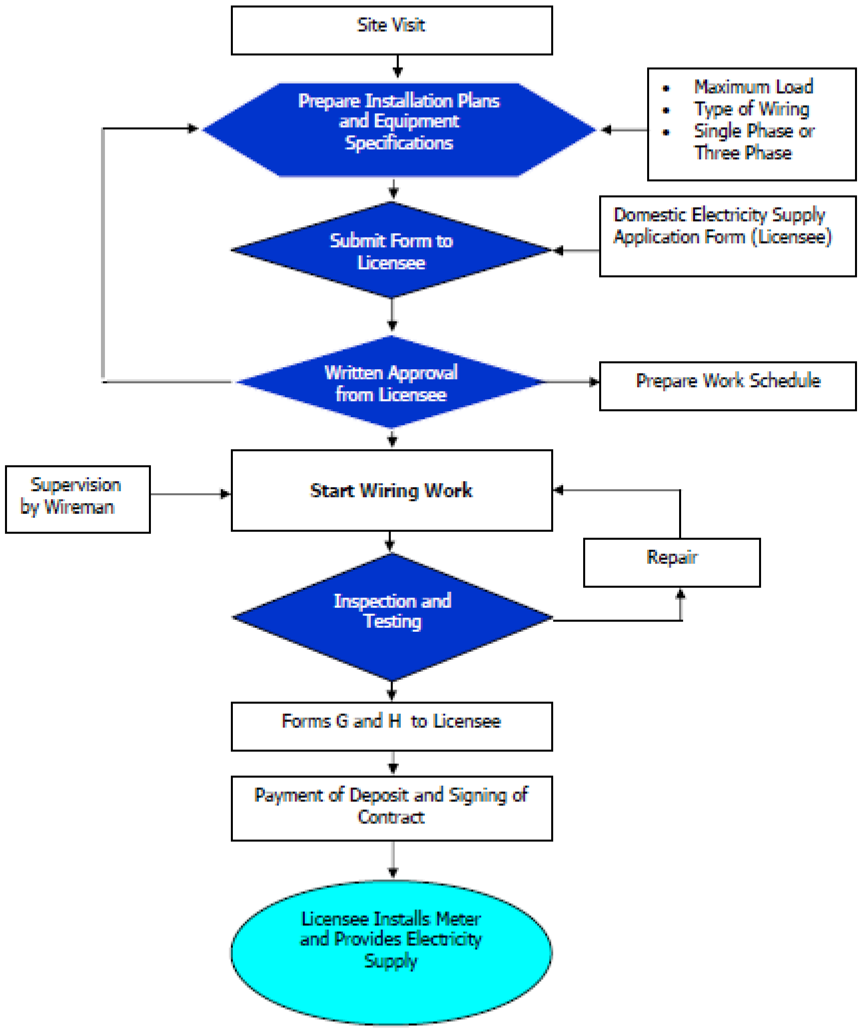


Figure.3 The Planning Flow chart for single phase and three phase supply building wiring installations.

1. Site Visit

The purpose of the site visit is to determine: -

i. Electrical equipment suitable for use;

ii. Maximum load demand;

iii. Single or three phase incoming supply;

iv. Type of wiring; and

v. Equipment arrangement.

2. Determining Consumer Load Requirements

With the aid of the building floor plans, the installation requirements such as the proposed load, placement of electrical equipment and installation design plans can be determined.

3. Calculating Maximum Load Demand

The estimate of the maximum load demand is for determining the specifications of the wiring equipment such as the cables and accessories and subsequently to prepare the electrical installation plans.

According to clause 311 of MS IEC 60364 Part 1, to determine the maximum demand for each circuit while ensuring an economic and reliable design within the permitted voltage drop limits. Diversity factors may be taken into account. The maximum current demand calculations for each circuit must be prepared. These details will show the current requirements, in amperes, for each phase and also assist in determining the cable sizes.

4. Submission of the Plans, Drawings and Specifications

Regulation 65 of the Electricity Regulations 1994 states that the eligibility to submit plans is as follows: -

i. Wireman with Single Phase Restriction – Low voltage single phase up to 60 amperes.

ii. Wireman with Three Phase Restriction – Low voltage up to 60 amperes.

Features of Electrical Wiring : Electrical wiring composes of electrical equipment such as cables, switch boards, main switches, miniature circuit breakers (MCB) or fuses, residual current devices (RCD), lighting points, power points, lightning arrestors, etc..

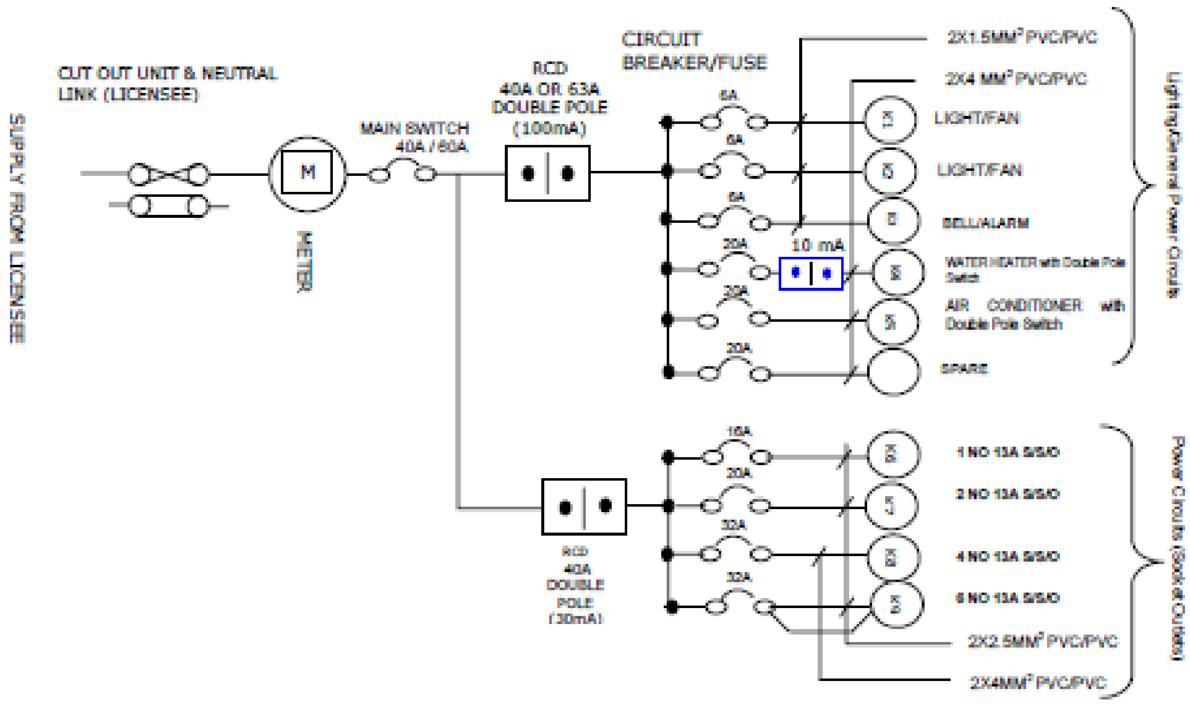


Figure.4 Example of Single phase consumer Electrical Wiring

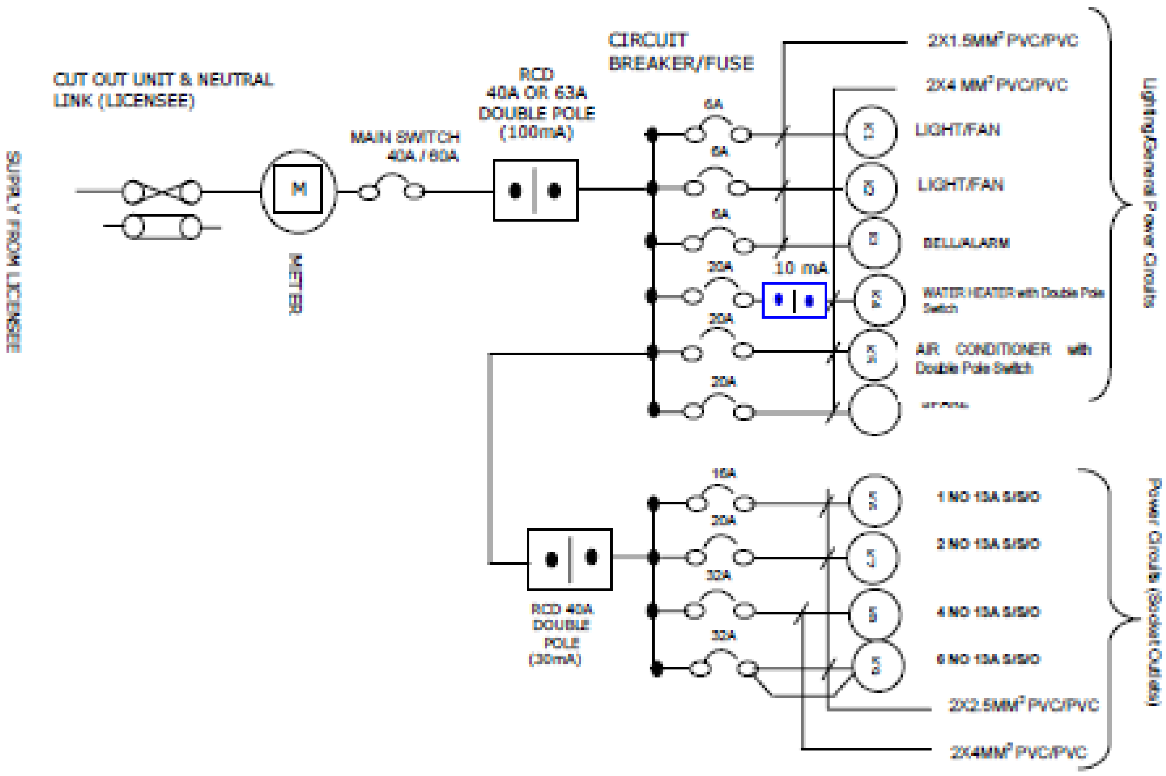


Figure 5. Example 2 of a Single phase consumer Electric Wiring

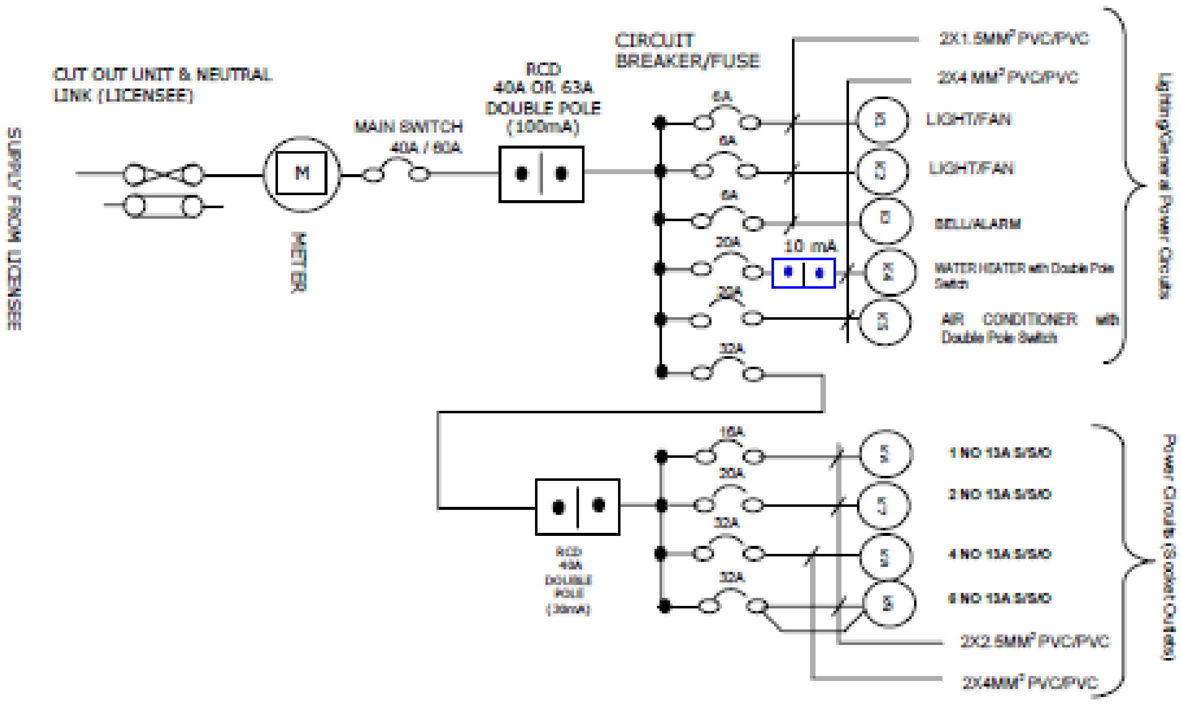


Figure 6. Example 3 of a Single phase consumer Electrical Wiring

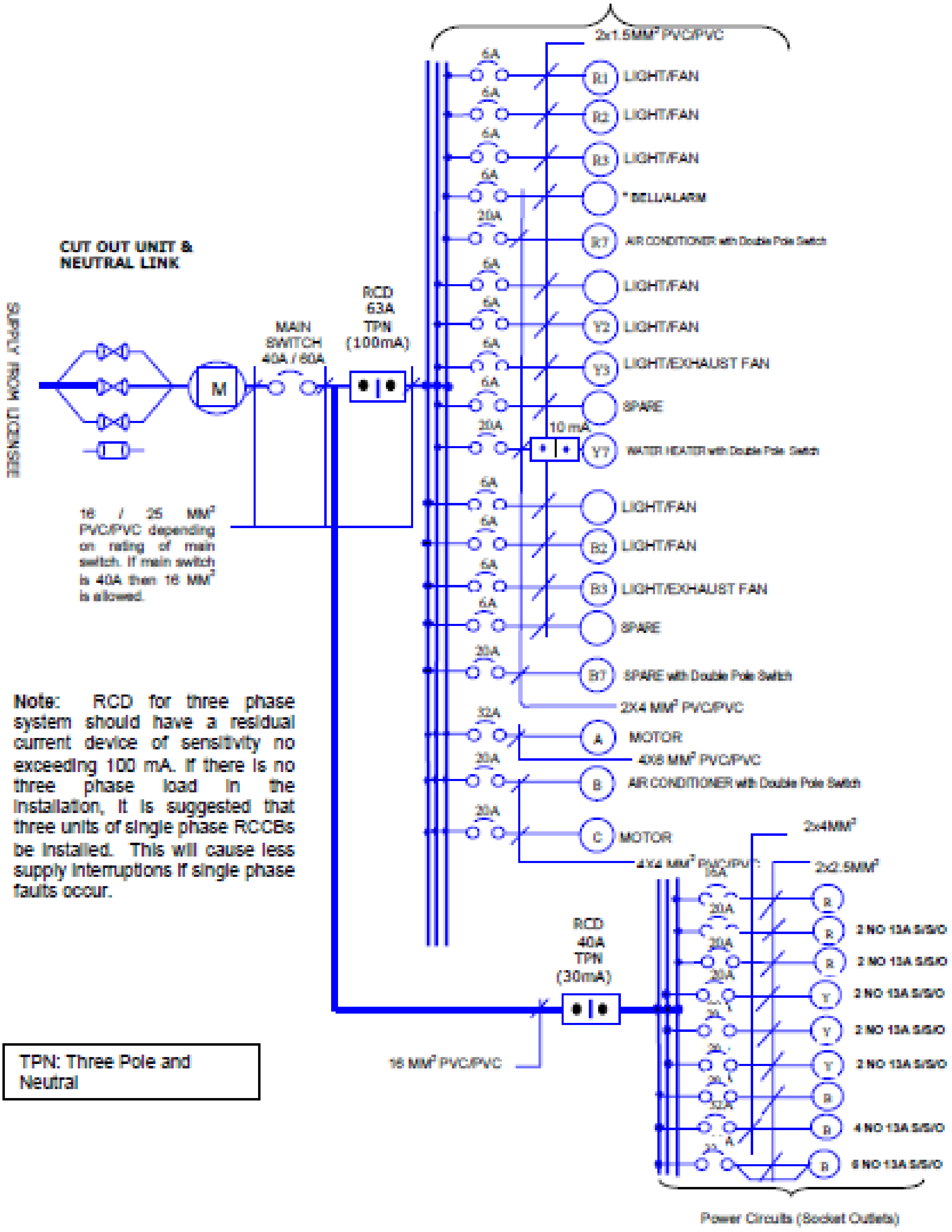


Figure. 7 Example 1 of a Three phase consumer Electrical Wiring

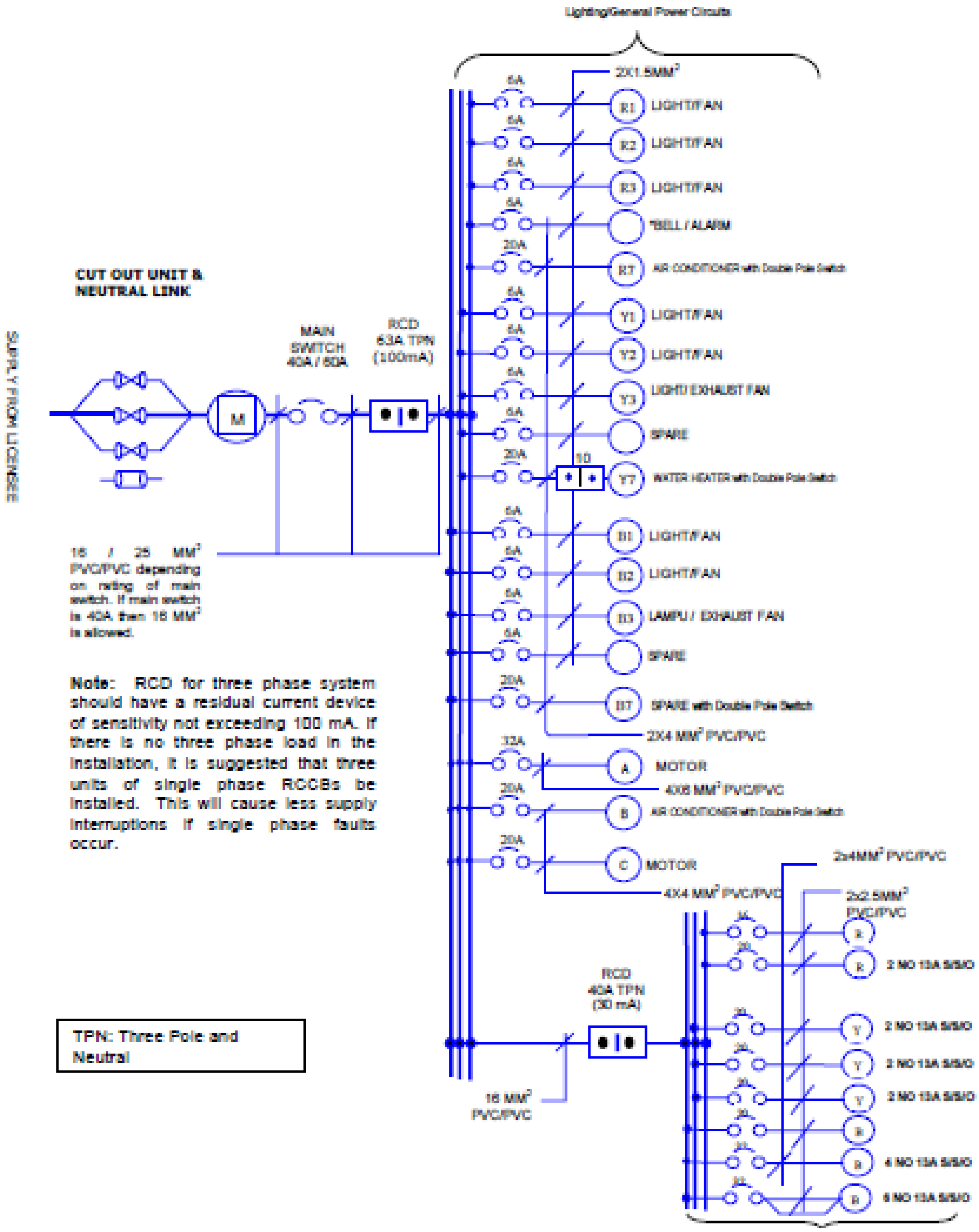
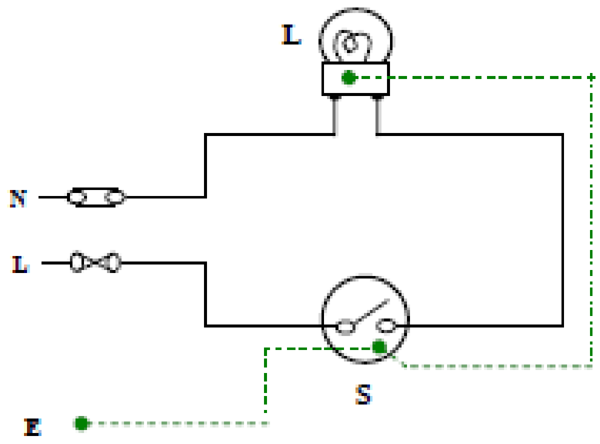
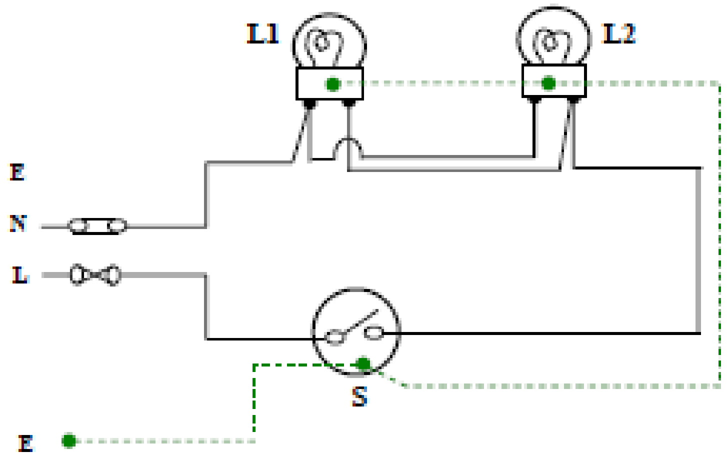


Figure. 8 Example 2 of a Three phase consumer Electrical Wiring

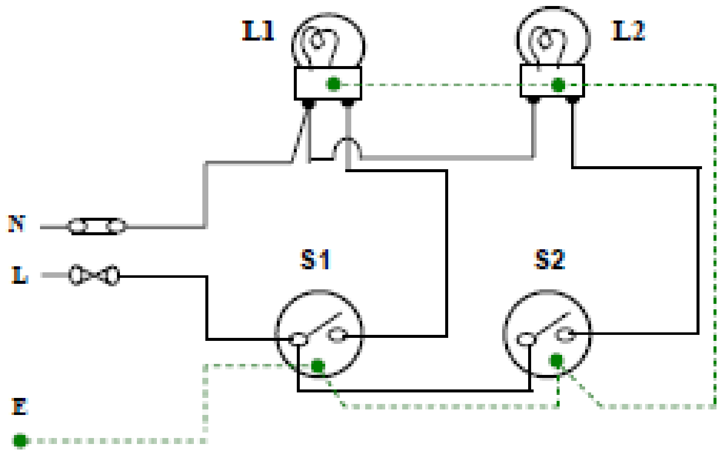
Examples of Lighting Circuits Schematic Wiring



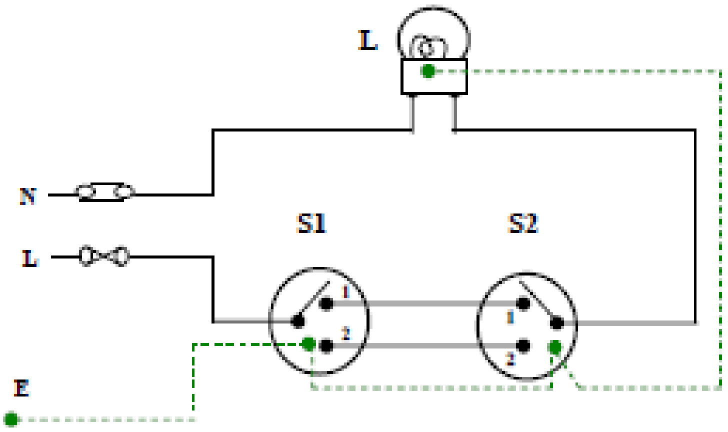
1 Single light point controlled by a one way switch



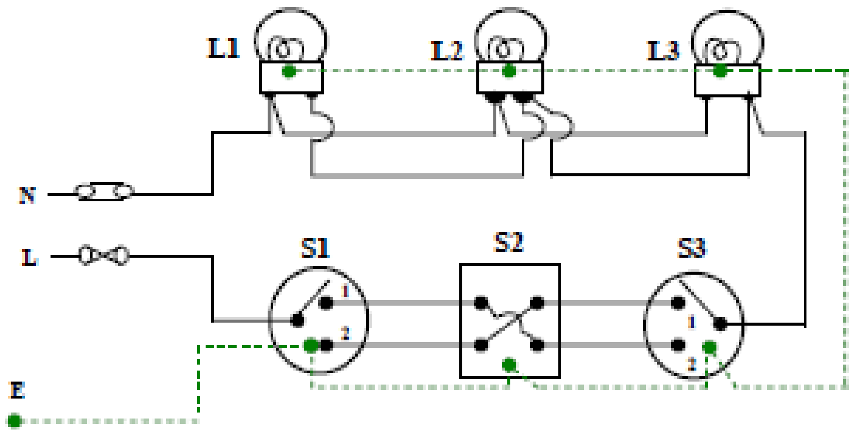
2 Two light points controlled by a one way switch



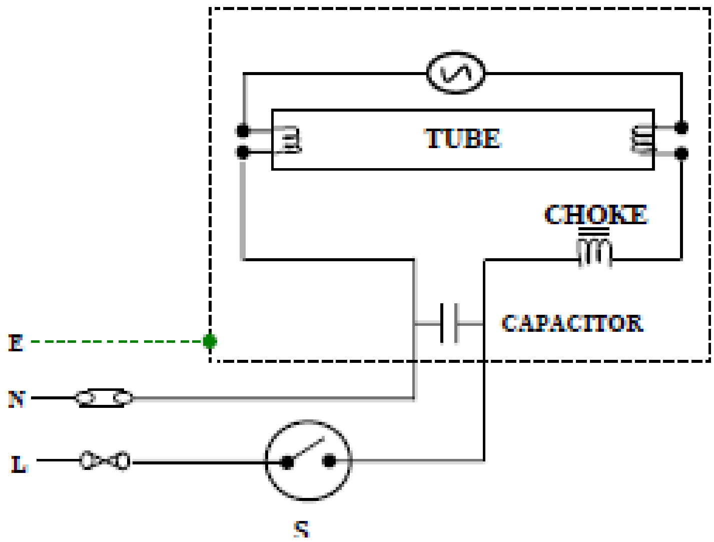
3 Two light points controlled separately by two one way switches



4 Single light point controlled by a two way switch



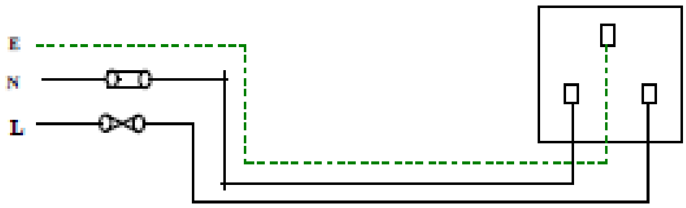
5 Three light points controlled by two way switches and intermediate switch



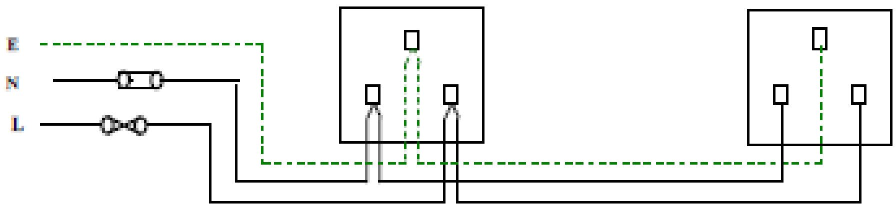
6 Single fluorescent light point controlled by a one way switch

Examples of Socket Outlet Schematic Wiring

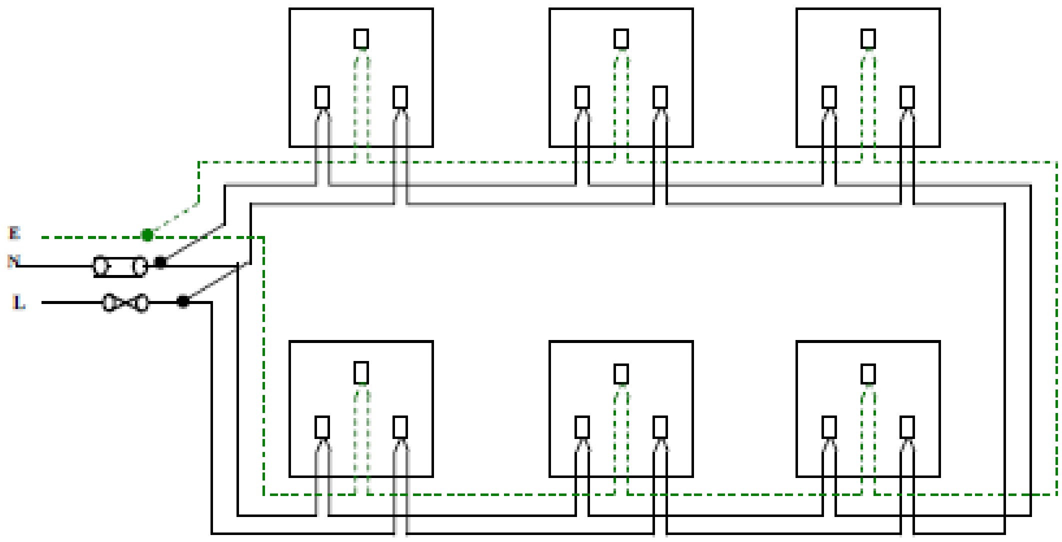
Socket Outlet – Single Socket



Socket Outlets – Radial Connection



Socket Outlets – Ring Circuit Connection



Selection of Wiring Accessories:

i. All wiring accessories to be used have to be of those approved by the Energy Commission and labelled.

ii. For all wiring using UPVC conduits: -

a) Switches, socket outlets, 3 pin plugs, ceiling roses, connectors, sockets – construction material shall be of polycarbonate type.

iii. For all wiring using metal conduits: -

a) Switches, socket outlets and connectors – construction material shall be of metal clad type, and

b) All accessories shall be effectively earthed.

iv. **Switch fuse** used in single phase installations shall have the fuse permanently connected and not move with the fuse.

v. **Fuse switch** used in 3 phase domestic installations also has fuse and switch. The fuse connector is installed together to allow the fuse to move simultaneously with the switch.

vi. **Lamp**:

a) Fluorescent lamps using magnetic ballasts (watt loss not exceeding 6 watts) shall be equipped with dry paper type capacitor;

b) Fluorescent lamps using electronic ballasts or high frequency electronic ballasts do not need capacitors;

c) Outdoor domestic lamp installations shall use weather proof and water proof lamps;

d) Submerged light installations (example in swimming pools, fountains, etc.) shall have water proof lamps with a voltage not exceeding 12 Volt AC.

vii. **Electric water heaters** is divided into 2 types, namely instantaneous water heaters and stored water heaters (storage tank type) a) Instantaneous water heaters shall be equipped with a 2 pole control switch and its own residual current device. Storage
water heaters (storage tank type) shall be installed with an isolator and its own residual current device; and

b) Water heaters exceeding 3kW shall be permanently connected to a 20A/30A rated circuit breaker/fuse with an isolator switch and residual current device.

viii. **Electric cookers** exceeding 3kW shall have its own circuit connected permanently to a 30A rated circuit breaker or fuse with an isolator switch and cooker control unit incorporated with a

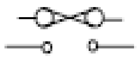
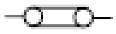
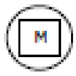
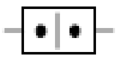
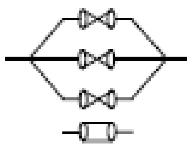
13A socket outlet. Two or more cooker appliances may be installed in the same room within a distance of 2 meters.

ix. **Electric motors** (fence gate, air conditioners, fountains, swimming pools, fish ponds, water pumps) exceeding 373W but not exceeding 2238W, shall be connected permanently to a 20A/30A rated circuit breaker/fuse together with an isolator, motor starter and 15A socket outlet. The motor starter shall be of Direct-On-Line type with the
appliance together with the contactor, overload relay and on-off control. The circuit breaker/fuse which controls the motor circuit shall be capable of withstanding the starting current of the motor.

x. **Electric bells** – the circuit shall have a push button switch and a AC/DC transformer.

xi. **Ceiling fans** shall conform to clause 21.101 of the MS 1219:2002 standard with regards to test on the suspension system of ceiling fans.

SYMBOLS

No.	Symbol	Details
1.		Switch fuse
2.		Fuse switch
3.		Fuse
4.		Neutral Link
5.		Kilowatt hour meter
6.		Miniature Circuit Breaker / Moulded Case Circuit Breaker (MCB / MCCB)
7.		Residual Current Device (RCD)
8.		Single phase cut out and neutral link
9.		Three phase cut out and neutral link

- An **RCD** is a sensitive safety device that switches off electricity automatically if there is a fault. An **RCD** is designed to protect against the risks of electrocution and fire caused by earth faults.
- A residual-current device, or residual-current circuit breaker, is a device that quickly breaks an electrical circuit to prevent serious harm from an ongoing electric shock.

Three Phase Induction Motor

Aim: To study the construction and working of Three Phase Induction motor.

Theory: An electrical motor is an electromechanical device which converts electrical energy into mechanical energy. In the case of three phase AC (Alternating Current) operation, the most widely used motor is a 3 phase induction motor, as this type of motor does not require an additional starting device. These types of motors are known as self-starting induction motors.

Construction: - A 3 phase induction motor consists of two major parts:

- A stator
- A rotor

Stator of 3 Phase Induction Motor

The stator of three phase induction motor is made up of numbers of slots to construct a 3 phase winding circuit which we connect with 3 phase AC source. We arrange the three-phase winding in such a manner in the slots that they produce one rotating magnetic field. when we switch on the three-phase AC supply source.

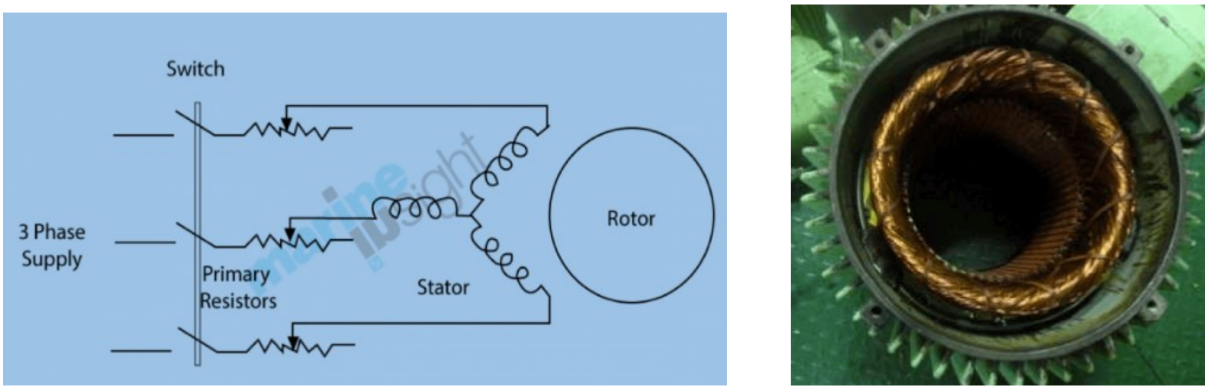


Fig 1. Stator of Three Phase Induction Motor

The windings are wound for a definite number of poles depending upon the speed requirement, as speed is inversely proportional to the number of poles, given by the formula:

$N_s = 120f/p$

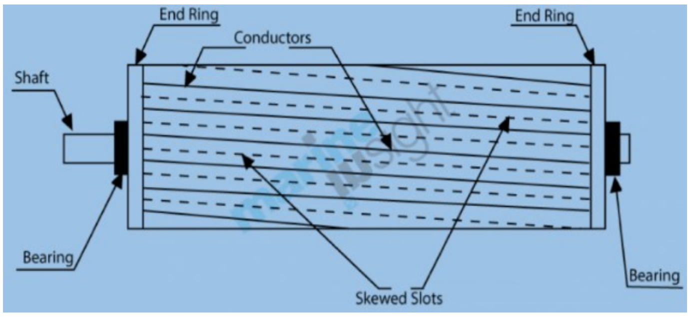
Where N_s= synchronous speed

f = Frequency

p = no. of poles

Rotor of 3 Phase Induction Motor

The rotor of three phase induction motor consists of a cylindrical laminated core with parallel slots that can carry conductors. The conductors are heavy copper or aluminum bars fitted in each slot and short-circuited by the end rings. The slots are not exactly made parallel to the axis of the shaft but are slotted a little skewed because this arrangement reduces magnetic humming noise and can avoid stalling of the motor.



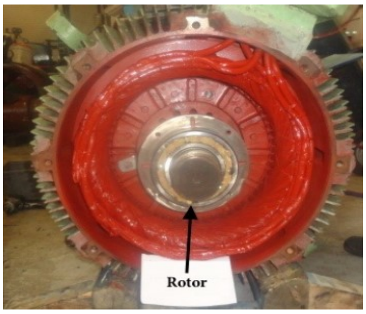


Fig 2. Rotor of Three Phase Induction Motor

Type of Induction motor: **There are two types of induction motor.**

1. **Squirrel cage induction motor**
2. **Slip-ring induction motor**

When rotor winding is short-circuited with no resistance in series, it is called a squirrel cage induction motor and when rotor winding is shorted through a resistance in series, it is called slip ring induction motor.

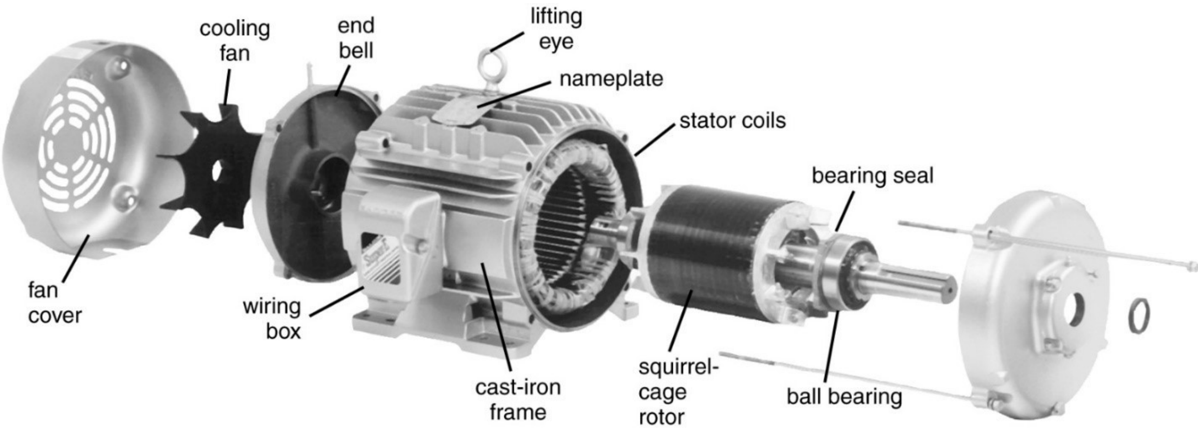


Fig.3. Internal part of Three Phase Induction Motor

Working of Three Phase Induction Motor

The stator of the motor consists of overlapping winding offset by an electrical angle of 120º. When we connect the primary winding, or the stator to a 3 phase AC source, it establishes rotating magnetic field which rotates at the synchronous speed.

According to Faraday's law an emf induced in any circuit is due to the rate of change of magnetic flux linkage through the circuit. As the rotor winding in an induction motor are either closed through an external resistance or directly shorted by end ring, and cut the stator rotating magnetic field, an emf is induced in the rotor copper bar and due to this emf a current flows through the rotor conductor.

Here the relative speed between the rotating flux and static rotor conductor is the cause of current generation; hence as per Lenz's law, the rotor will rotate in the same direction to reduce the cause, i.e., the relative velocity.

Thus from the working principle of three phase induction motor, it may be observed that the rotor speed should not reach the synchronous speed produced by the stator. If the speeds become equal, there would be no such relative speed, so no emf induced in the rotor, and no current would be flowing, and therefore no torque would be generated. Consequently, the rotor cannot reach the synchronous speed. The difference between the stator (synchronous speed) and rotor speeds is called the slip. The rotation of the magnetic field in an induction motor has the advantage that no electrical connections need to be made to the rotor.

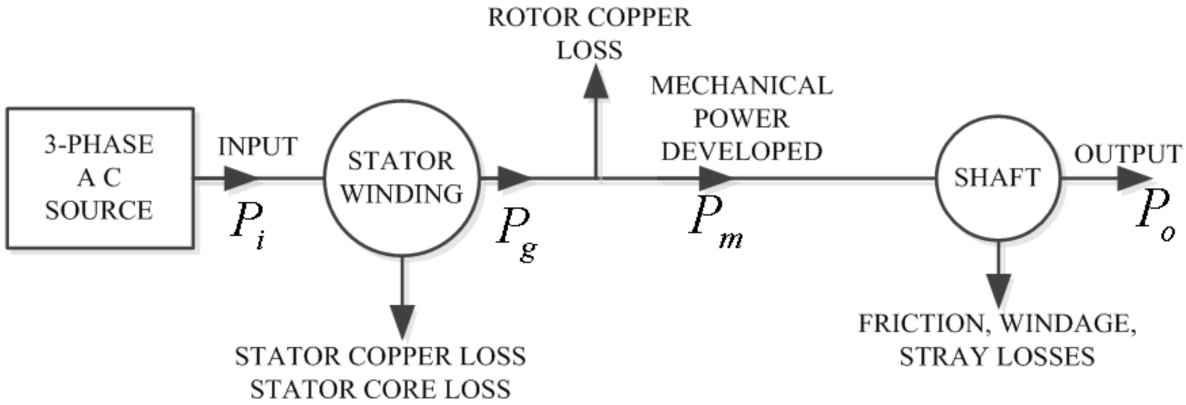


Fig.4 Power flow diagram of Three Phase Induction Motor

Thus the three phase induction motor is:

- Self-starting.
- Less armature reaction and brush sparking because of the absence of commutators and brushes that may cause sparks.
- Robust in construction.
- Economical.
- Easier to maintain.

Applications of Three Phase Induction Motor

- Lifts
- Cranes
- Hoists
- Large capacity exhaust fans
- Driving lathe machines
- Crushers
- Oil extracting mills
- Textile and etc.

Experiment No. 10

Aim: Study of the working of fluorescent lamp and ceiling fan.

Fluorescent Lamp : A fluorescent lamp is a low weight mercury vapour lamp that uses fluorescence to deliver visible light. An electric current in the gas energizes mercury vapor which delivers ultraviolet radiation through discharge process and the ultraviolet radiation causes the phosphor coating of the lamp inner wall to radiate visible light.

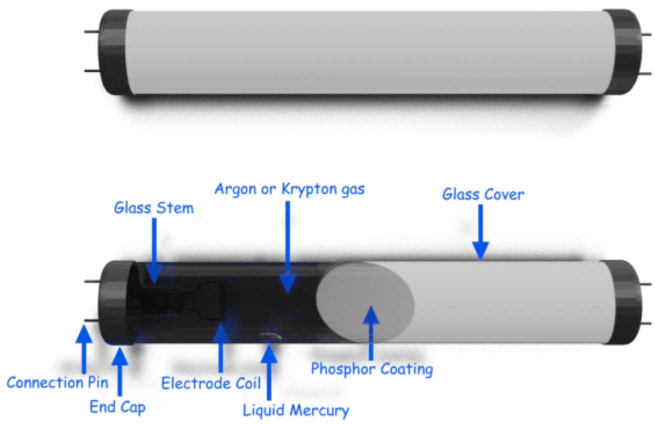


Fig.1 Fluorescent Lamp

A fluorescent lamp has changed over electrical energy into useful light energy to a great deal more proficiently than incandescent lamps. The normal luminous viability of fluorescent lighting frameworks is 50 to100 lumens per watt, which is a few times the adequacy of incandescent lamps with equivalent light yield.

Working:

The Complete circuit of a fluorescent lamp in other words circuit of tube light is shown in fig 2. Here we connect one ballast, and one switch and the supply is series as shown. Then we connect the fluorescent tube and a starter across it.

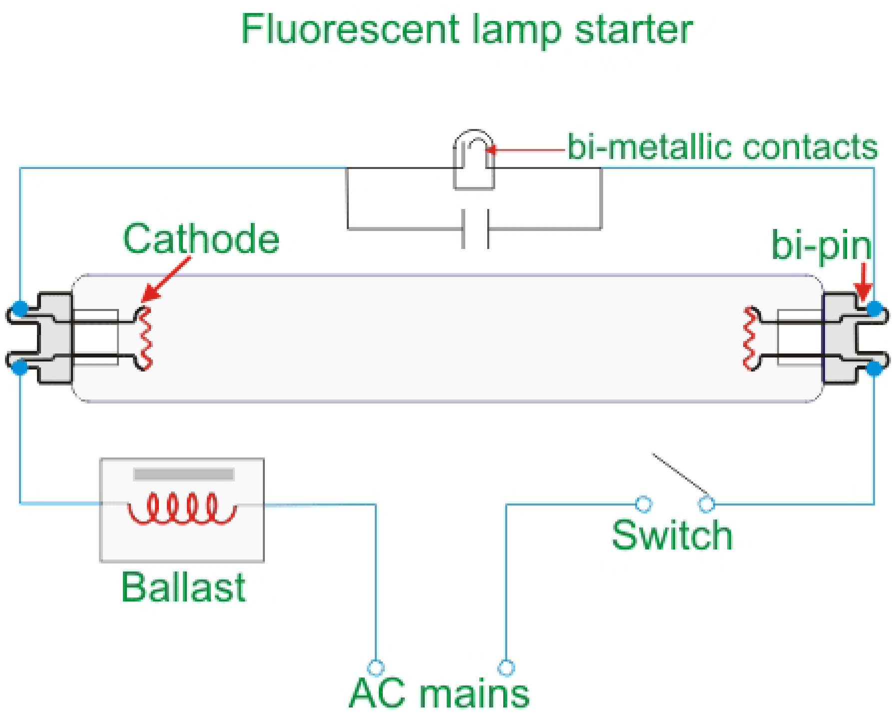


Fig 2 Circuit diagram of Fluorescent Lamp

When we switch ON the supply, full voltage comes across the lamp and as well as across the starter through the ballast. But at that instant, no discharge happens, i.e., no lumen output from the lamp.

- At that full voltage first the glow discharge is established in the starter. This is because the electrodes gap in the neon bulb of starter is much lesser than that of the fluorescent lamp.
- Then gas inside the starter gets ionized due to this full voltage and heats the bimetallic strip. That causes to bend the bimetallic strip to connect to the fixed contact. Now, current starts flowing through the starter. Although the ionization potential of the neon is more than that of the argon but still due to small electrode gap, a high voltage gradient appears in the neon bulb and hence glow discharge gets started first in the starter.
- As soon as the current starts flowing through the touched contacts of the neon bulb of the starter, the voltage across the neon bulb gets reduced since the current, causes a voltage drop across the inductor(ballast). At reduced or no voltage across the neon bulb of the starter, there will be no more gas discharge taking place and hence the bimetallic strip gets cool and breaks away from the fixed contact. At the time of breaking of the contacts in the neon bulb of the starter, the current gets interrupted, and hence at that moment, a

- large voltage surge comes across the inductor(ballast).

$$V = L\frac{di}{dt}$$

$$Where,\ L\ is\ inductance\ of\ inductor$$

$$and\ \frac{di}{dt}\ is\ rate\ of\ change\ of\ current.$$

- This high valued surge voltage comes across the fluorescent lamp (tube light) electrodes and strikes penning mixture (mixture argon gas and mercury vapor).
- Gas discharge process gets started and continues and hence current again gets a path to flow through the fluorescent lamp tube (tube light) itself. During discharging of penning gas mixture the resistance offered by the gas is lower than the resistance of starter.
- The discharge of mercury atoms produces ultraviolet radiation which in turn excites the phosphor powder coating to radiate visible light.
- Starter gets inactive during glowing of fluorescent lamp (tube light) because no current passes through the starter in that condition

When a sufficiently high voltage is applied across the electrodes, a strong electric field is set up. A small amount of current through the electrodes filaments heats up the filament coil. As the filament is oxide coated, a sufficient amount of electrons is produced, and they rush from the negative electrode or cathode to the positive electrode or anode due to this strong electric field. During the movement of free electrons, the discharge process gets established.

The basic discharge process always follows three steps:

1. Free electrons are derived from the electrodes, and they get accelerated by the electric field applied.
2. Kinetic energy of the free electrons is converted into the excitation energy of the gas atoms.
3. The excitation energy of the gas atoms gets converted into the radiation.

In the discharge process, a single ultra violates spectral line of 253.7 nm is produced at a low pressure of mercury vapor. To generate 253.7 nm ultra violate ray the bulb temperature is kept between 105 to 115^{o}F.

The length to diameter ratio of the tube should be such that fixed wattage loss happens at both ends. Where this wattage loss or glow of electrodes takes place is called cathode and anode fall region. This watt loss is very small.

Again the cathodes should be oxide coated. Hot cathode provides an abundance of free electrons. Hot cathodes, mean those electrodes which are heated by circulating current and this circulating current is provided by choke or control gear. Few lamps have cold cathode also. Cold cathodes have a larger effective area and higher voltage such as 11 kv is applied across them to get ions. Gas starts to be discharged due to this high voltage application. But at 100 to 200 V the cathode glow get separated from the cathode, it is called cathode fall. This provides a large supply of ions which are accelerated to the anode to produce secondary electrons on impact which in term produce more ions. But cathode-fall in hot cathode discharge is only at 10 V.

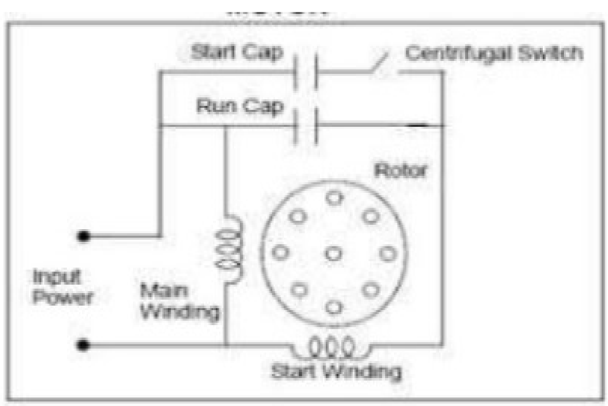
Ceiling Fan

Objective: To study the construction & working of ceiling fan**.**

Principle If a Current carrying conductor is placed in a magnetic field it experiences a force and start to rotate. The direction of rotation can be found by Fleming's left hand rule

Construction & Working of Ceiling Fan

The ceiling fan has a motor that converts electrical energy into mechanical energy. There is a single phase capacitor start & run motor. There is a main (running) winding and auxiliary (starting) winding in a fan. Starting winding has capacitor in its series. Due to this capacitor single phase is divided in two phase and a rotating magnetic field is produced and due to internal reaction motor start to rotate. First, the capacitor of the ceiling fan torques up the electric motor, thereby causing it to start and run. As the electrical current reaches the motor, it enters coils of wire that are wrapped around a metal base. When this current passes through the wire, it creates a magnetic field which further exerts force in a clockwise motion. In this way, the electric energy is converted into mechanical energy and causes the motor coils to spin. The blades attached to the motor also start gaining motion with the spinning of the coils.



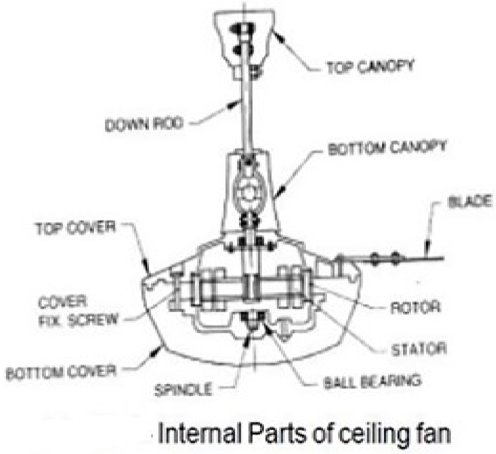


Fig .1 Capacitor Start/Run induction motor

Fig.2 Internal parts of fan

A ceiling fan has many components. They are:

- An electric motor
- Encasement that houses the electric motor
- A capacitor
- Blades, that are generally made from iron, aluminium, or plastic
- Blade irons (also known as blade brackets, blade arms, blade holders, or flanges), that connect the blades to the motor.
- A rotor, an alternative to blade irons.
- Flywheel – a metal or plastic or tough rubber double-torus which is attached to the motor shaft

How a Ceiling Fan Cools

The mechanism behind the ceiling fan is quite simple. It is a known fact that air naturally stratifies – the lighter, warm air rises up while the cool air, that is heavy, sinks down. The rotation mechanism of the ceiling fan is built in way so as to attract the warm air upwards. As the hot air rises up, the blades of the fan slice this air and push it down. This being a continuous process causes the air in the room to circulate in the entire room. Thus, a ceiling fan only moves the air around. Contrary to the common belief, fans do not exactly cool. Rather they speed up the process of evaporation of sweat on our body, which naturally makes us feel ‘cool’.

Type of Motor Is Used In A Ceiling Fan

In conventional ceiling fans, single phase induction motor is used. These motors consume minimum power and hence, are also known as fractional kilowatt motors. A single phase induction motor requires only one power phase for operating. It converts the electrical energy from the power input into mechanical energy. Single phase induction motors are used in ceiling fans owing to their simple design and the fact that they are easy to repair.

Experiment No 11

Aim- Introduction to Laboratory Equipment and Basic Components

OBJECTIVES: This experiment will provide exposure to various equipment used in electronics experiments. The devices and components will be used include function generators, oscilloscopes, bread-boards, multimeter, resistors, diodes, capacitors, inductors and transistors. At the end of this lab you will be able to use the equipment of measure current, voltage, inductance, capacitance, signal waveform, frequency, period, phase. You will also learn to recognize basic electronic components like resistors, capacitors, inductors, diodes and transistors.

A) Introduction to Cathode Ray Oscilloscope (CRO), Function Generator and Multimeter.

Apparatus and Components Required: Cathode Ray Oscilloscopes, Function Generators, Multimeter, Resistors, Breadboard, connectors and probes

Theory :

Cathode Ray Oscilloscope (CRO)

The oscilloscopes are basically a **graph displaying device**. It draws the graph of an electrical signal. It is employed for the study of several types of wave-forms. Some of the waveform are displayed in figure 1. It can measure various quantities such as peak voltage, frequency, phase difference, pulse-width, delay time, rise time, and fall time. The CRO comprises of a cathode-ray tube (CRT), and input circuitry for focusing and amplification.

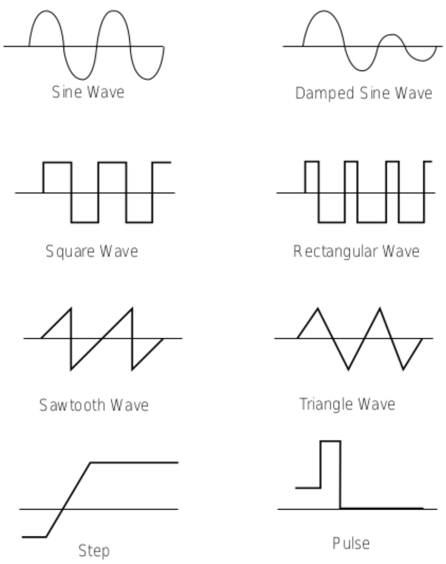


Figure 1. Common electrical waveform

Oscilloscopes can be classified as analog and digital types. Analog oscilloscope works by applying the measured signal voltage directly to the vertical axis of an electron beam that moves from left to right across the oscilloscope screen – usually a cathode - ray tube. The picture of a Cathode Ray Oscilloscope is shown in the figure 2.

Figure 2: Snapshot of a CRO.

The heart of the CRO is a Cathode Ray Tube shown schematically in figure 3. Cathode ray is a beam of electrons which are emitted by heated cathode and accelerated towards the fluorescent screen. The electron gun, which is the assembly of cathode, intensity grid, focus grid and accelerating anode, generate the electron beam and control its intensity and focus. There are two pairs of metal plates called as horizontal and vertical deflection plates lies between the electron gun and the fluorescent screen. One of the pair of plate provides horizontal deflection of the beam and another gives the vertical deflection to the beam.

Whenever an electron beam hits the screen, the phosphor is excited and light is emitted from that point.

The signals to be studied are amplified first and then applied to the vertical deflection plates to deflect the beam vertically and at the same time a voltage that increases linearly with time is applied to the horizontal plate thus causing the beam to be deflected horizontally at a uniform rate. The signal applied to the vertical plate is thus displayed on the screen as a function of time. The horizontal axis serves as an uniform time scale.

Sweep generator in the oscilloscope circuitry generates the linear deflection or sweep of the beam horizontally. The voltage difference between the horizontal plates is a sawtooth wave as shown in figure 4. When the voltage suddenly falls to zero, as at points (a) (b) (c), etc. as marked in figure 4, the end of each sweep - the beam flies back to its initial position. The horizontal deflection of the beam is repeated periodically, the frequency of this periodicity is adjustable by external controls.

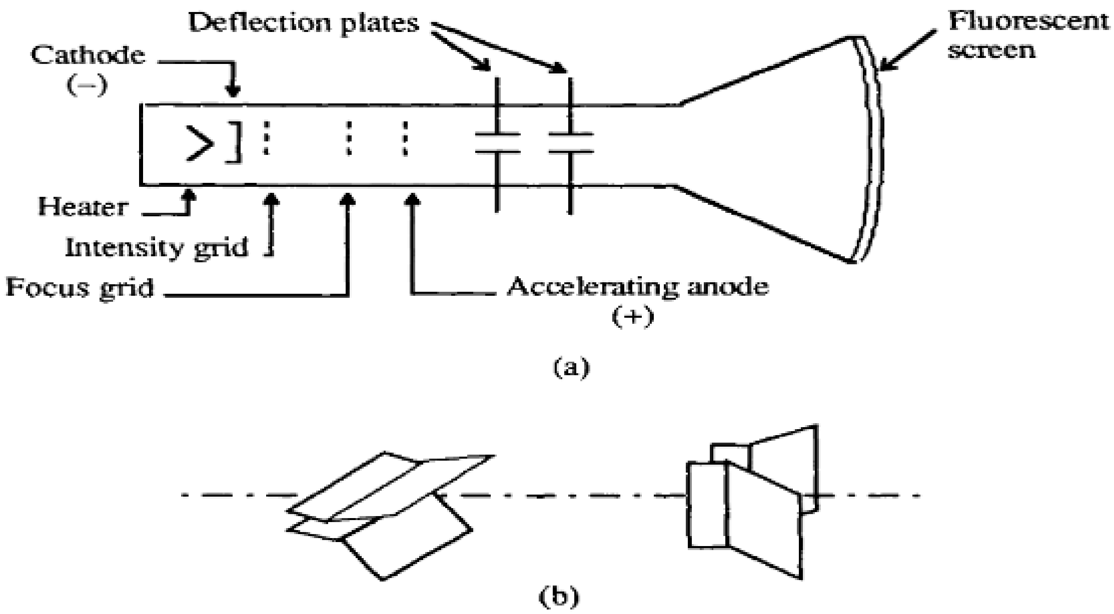


Figure 3 : Cathode Ray Tube (a) Schematic (b) Deflection plates

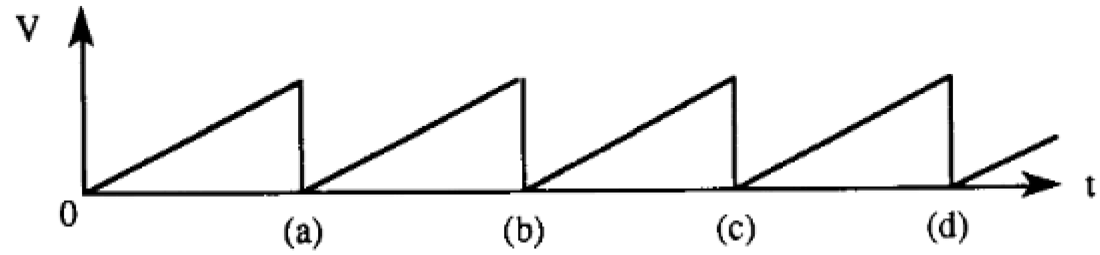


Figure 4: Voltage difference V between horizontal plates as a function of time *t*.

A simplified block diagram of the oscilloscope is shown in the figure 5.

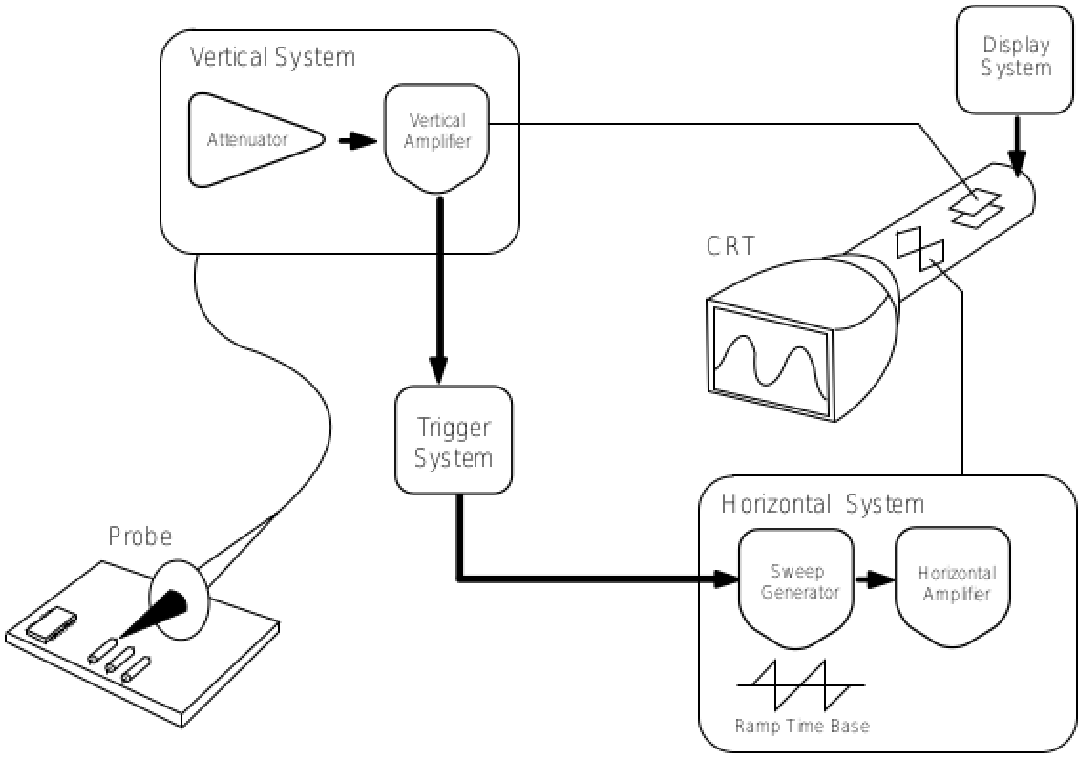


Figure 5 : The architecture of an analog oscilloscope.

When you connect an oscilloscope probe to a circuit, the voltage signal travels through the probe to the vertical system of the oscilloscope. Depending on how you set the vertical scale (volts / div control) an attenuator reduces the signal voltage and an amplifier increases the signal voltage.

Next, the signal travels directly to the vertical deflection plates of the CRT. Voltage applied to these deflection plates causes a glowing dot to move across the screen. The glowing dot is created by an electron beam that hits the luminous phosphor inside the CRT. A positive voltage causes the dot to move up while a negative voltage causes the dot to move down.

The signal also travels to the trigger system to start, or trigger, a horizontal sweep. Triggering the horizontal sweep causes the glowing dot to move across the screen from left to right within a specific time period. The dot may sweep at very high speed up to 500, 000 times per second.

The controls of the analog oscilloscope is shown in figure 6. Following features are clearly visible. A basic oscilloscope consists of four different systems. The vertical system, the horizontal system, trigger system and display system.

Screen - The most recognizable feature is the screen. As previously discussed, in older analog scopes this is CRT. In newer, digital scopes the screen is a CRT or flat panel display. The screen usually have the graticule on it of about 1 cm^2.

Channels – Channels are the signal inputs, typically called CH1, CH2 etc. and one external trigger input called as “EXT TRIG”

Vertical Controls – A collection of controls related to the vertical part of the display is associated with the input signals. These controls the kind of coupling to the input. The amount of amplification applied to the signal is controlled by the knob.

Horizontal Controls – These controls set the time axis. This determines the time base and setting is called sweep rate.

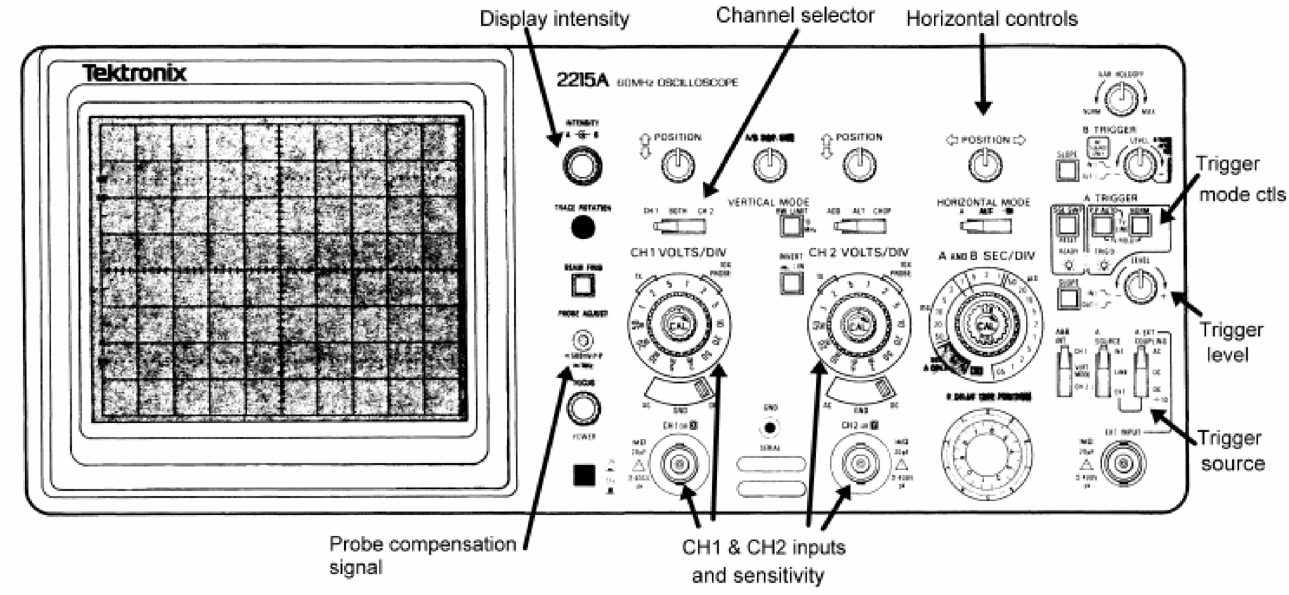


Figure 6: Schematic of front panel layout of the analog scope.

Trigger related controls – A collection of controls called the trigger, are used to synchronize the input signal to the horizontal display. Use the trigger level to stabilize a repeating signal, or to trigger on a single event.

The front panel of cathode ray oscilloscope comprises of many measurement knob by which an experimenter can shift the wave form according to need of measuring parameter.

Figure 7: Front Panel Control section of an oscilloscope.

Controls of An Oscilloscope

Figure 8 is the diagram of dual channel CRO. The following sections will explain the controls of such an oscilloscope.

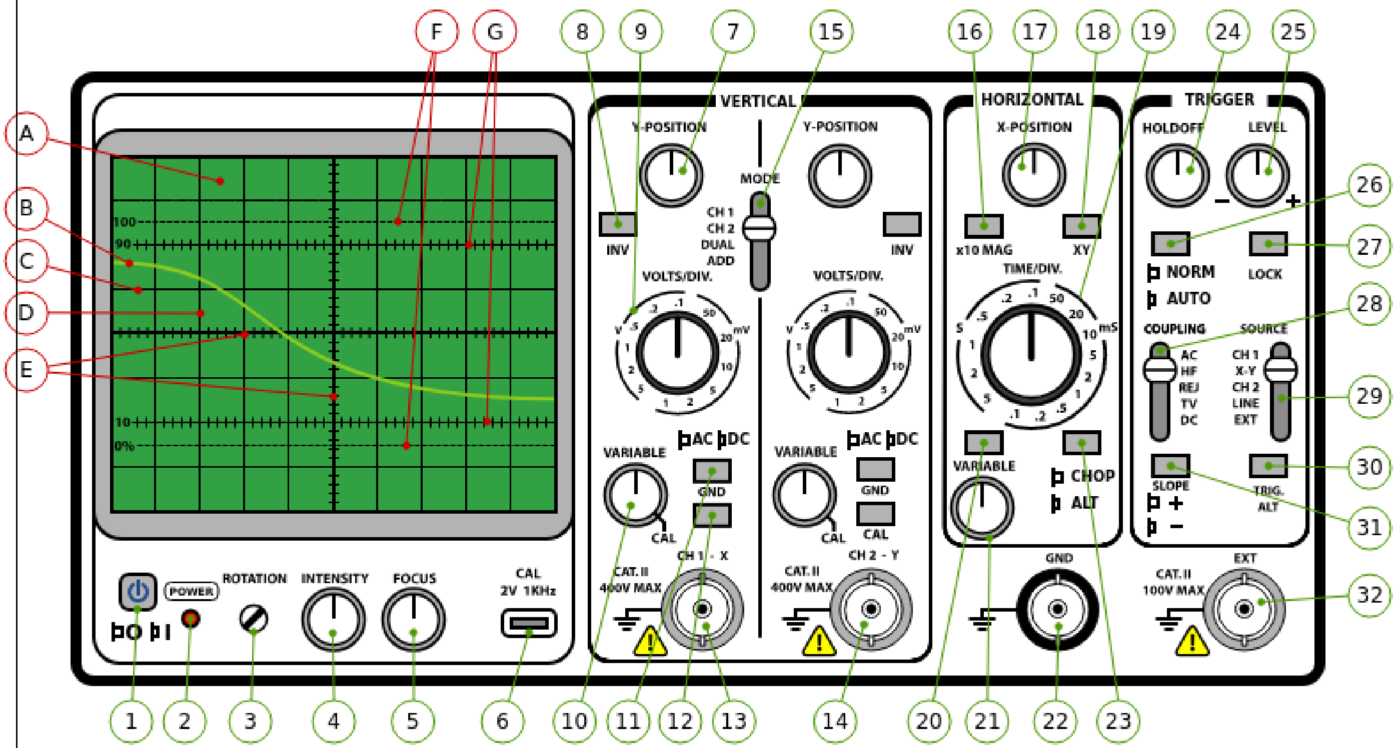
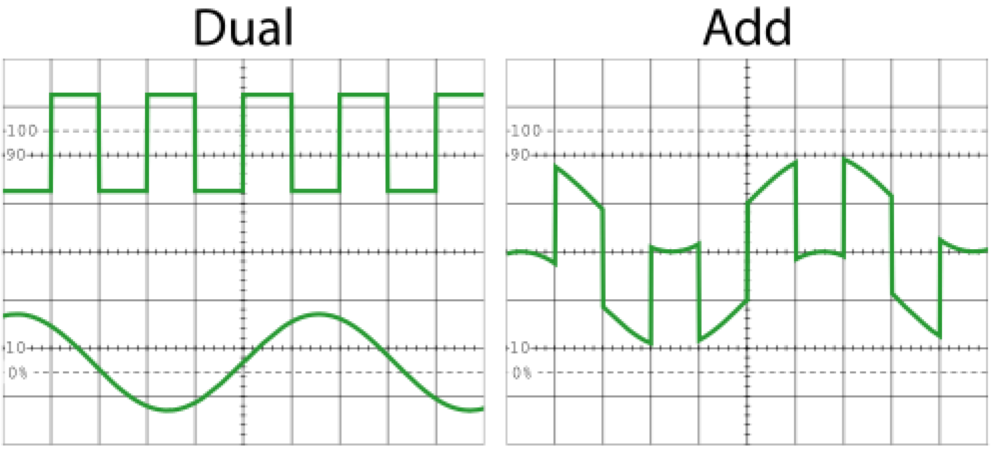


Figure 8: Front panel of a generic CRO with numbered controls and display

Label	Description
A	Display:- This can be a phosphor screen or an LCD, and is usually about 100 mm corner to corner.
B	Trace: line drawn by scope to represent the signals
C , D	Horizontal (C) and vertical lines (D) forming the grid , called the graticule.
E	The central horizontal and vertical lines are thicker and are divided into minor divisions, usually five per major division
	Power, Calibration and Display Controls
1	Power On and Off Button
2	The Power indicator
3	Trace Rotation control – This sets the inclination of the flat signal relative to the graticule.
4	Intensity of the trace. Turning this up increases the brightness of the trace

5	Focus control - The trace can get fuzzy if the electron beam is not focused correctly. The focus control (5) sets this. Most scopes can focus the beam to form a trace about 1mm wide
6	Calibration Point - This gives a steady square wave at a set frequency and voltage, allowing the scaling of the trace to be set accurately. Sometimes, more than one frequency and voltage is available to give a more representative calibration. The standard calibration signal is between 0V and 2V at 1KHz.
Vertical Axis Control	
7	controls the position of the trace. It can be adjusted to set the voltage relative to a ground, or it can be adjusted to separate the two signals - perhaps the first channel in the top half of the screen and the second channel in the bottom
8	inverts the relevant channel. That is, the negative voltage is displayed, and the trace is upside-down
9	is the vertical scale control, often called the volts/div. control. This sets the height of the trace. It operates in discrete steps
10	is a variable height control. It can adjust the height of the trace up to the next set increment on the volts/div. control. When set to CAL, the height is as stated on the volts/div. control.
11	is the AC/DC toggle. When set to AC, any DC component of the voltage is filtered out by switching a capacitor in series with the input signal, leaving just an AC voltage. This is useful when the DC component swamps the AC component, making it either too small to see or driving it off the top of the screen. When set to DC, the signal is displayed as is.
12	is the GND toggle. By selecting this, the input signal is ignored, and the trace shows 0V. This can be useful to measure a voltage or to eliminate one of the traces from the display.
13	is the Channel 1 signal input
14	is the Channel 2 input.
15	The way the channels are combined is set using 15, which is usually a sliding switch. When set to CH. 1, only the trace from Channel 1 is displayed, and likewise for CH. 2. When DUAL is selected, the traces are shown side by side

	This is when the chop/alt control applies. ADD shows the sum of the two traces as one trace. By inverting the traces, one can be subtracted from the other. This can be seen in the illustration below. This shows a square wave on one channel and a sinusoidal wave on the other. On the left, the scope is set to "dual", and the two traces are shown side by side. On the right, the scope is set to "add", and the trace is the sum of the two signal  Figure 9: On Left the scope is set to “Dual” and on right it is set to “Add”
Horizontal Axis Controls	
16	X10 MAG control is a very useful control if you want to quickly zoom in on a feature without changing the timebase and losing your settings. This buttom magnifies the central area of the trace by a factor of 10 in the horizontal direction (but leaves the voltage height unchanged).
17	The position of the trace from side to side is controlled by 17. This is useful if part of the trace is off the edge of the screen but you don't want to change the time base
18	toggles the mode between the usual voltage vs. time format and the XY mode. This continuously plots the voltage on Channel 1 along the horizontal axis against the voltage on Channel 2 (the vertical axis). This can be extremely useful to analyse frequency or phase relationships
19	When operating in the normal voltage vs. time mode, this axis represents time. The primary control is the time base selector, 19. The time base is the length of time displayed per major horizontal division on the screen. This ranges from about 0.1 milliseconds to about 1 second (or more on digital scopes).
20,21	20 and 21 act in much the same way as 10 does on the vertical axis. This diagram shows it to be slighly different from the vertical control. To select a non-standard

	timebase, press 20, and adjust 20 until the correct setting is obtained. To return to a calibrated time base, press 20 again. Sometimes these controls are the same style as 10, sometimes the vertical controls are like these
22	is the GND terminal of the scope. This is used to set a "datum" voltage against which to measure the voltages on the input channels
23	toggles between chop-mode and alt-mode. Chop-mode means that when the scope is drawing two signals side by side it alternates rapidly between the two over the course of passing across the screen. This action is called chopping. Alt-mode alternates at the end of each pass, and can appear to flicker at slow speeds
Triggering Controls	
26, 29	Triggering source and mode. You will use the scope to observe signals that repeat frequently. The scope must start the sweep at the same point on the waveform every time in order to produce a stable image on the screen. This function is called "triggering". For many common applications you should the source switch on "internal" and the mode switch to "auto". This lets the scope decide when to trigger.
31	Trigger Slope. Usually the signal voltage will equal the triggering voltage twice, once going up and once coming down. A trigger slope control enables you to select which voltage the scope will trigger on.
25	Trigger Level. This sets an internal voltage which is compared to the voltage of the input signal. When the input signal voltage equals the trigger voltage, the scope triggers. If you get an image that seems to be a superposition of many waves, turn the level knob back and forth slowly until you get a stable image.
28	Trigger coupling is the trigger path counterpart to input coupling on the acquisition path, typically referred to as AC or DC. DC trigger coupling will deliver the entire frequency content of the input signal (up to the bandwidth of the trigger system) to the trigger, including any DC offset, whereas AC coupling will block any DC component In addition to trigger coupling settings, some scopes also have additional filtering selections like “Low-Frequency Reject,” “High Pass,” etc. Like AC coupling, these are essentially just filters, applied in the trigger path only, that can help isolate the signals you’re interested in.

Waveform Measurements

i) Measurement of peak-to-peak voltage and peak voltage

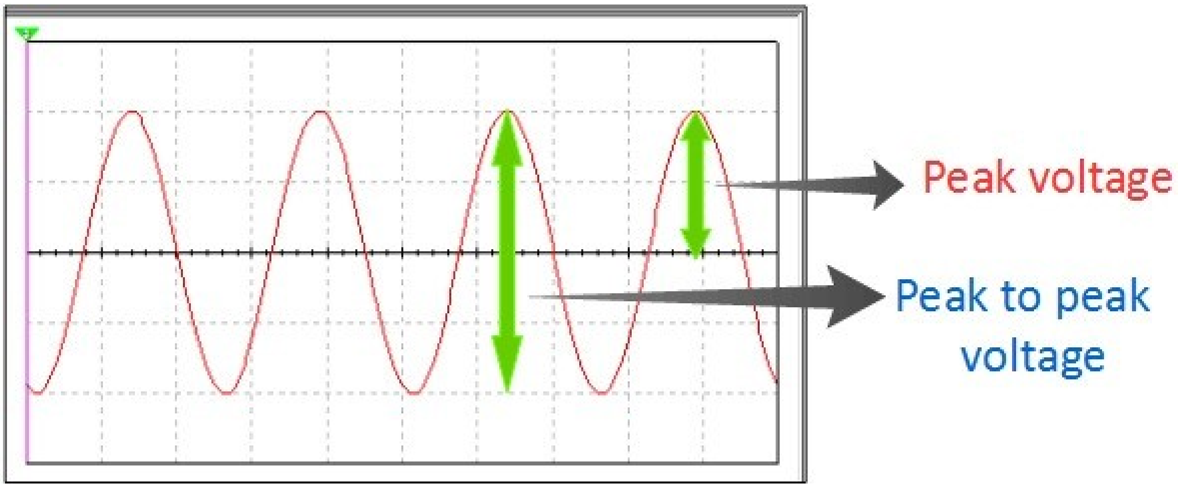


Figure 10: AC signal

To measure the ac.voltage of sinusoidal waveform. The input ac. signal is applied from the signal generator to a channel of CRO. The voltage/div switch (Y-plates) and time base switch (X-plates) are adjusted such that a steady picture of the waveform is obtained on the screen.

The vertical height (L) i.e. peak-to-peak height is measured. When this peak-to-peak height (L) is multiplied by the voltage/div. (voltage deflection sensitivity 'n') we get the peak-to-peak voltage ($2V_o$). From this we get the peak voltage (V_o).

ii) Measurement of the DC voltage

The trace (horizontal line) is adjusted such that it lie on the X-axis of the screen. The DC input voltage to be measure is then fed to the input channel of the CRO in the DC mode. The shift of trace from the horizontal line occurs which gives the measure of the magnitude of the DC voltage.

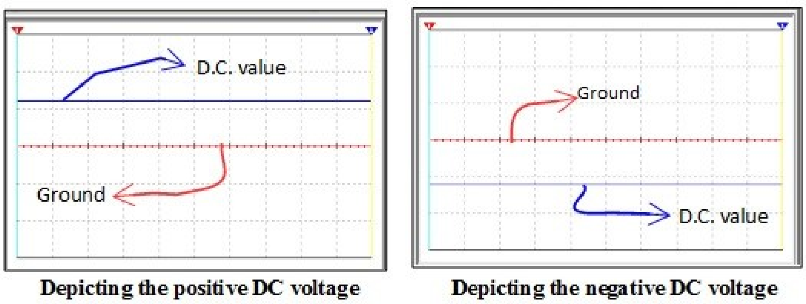


Figure 11 – Measuring DC voltage

iii) Measurement of frequency

(a) Method 1

From the trace the time period of the input signal is equal to ‘t’ times the value of time/div setting. Suppose that the time period of the input signal is T. As we know frequency is the reciprocal of time period. Then, the frequency of the signal =1/T

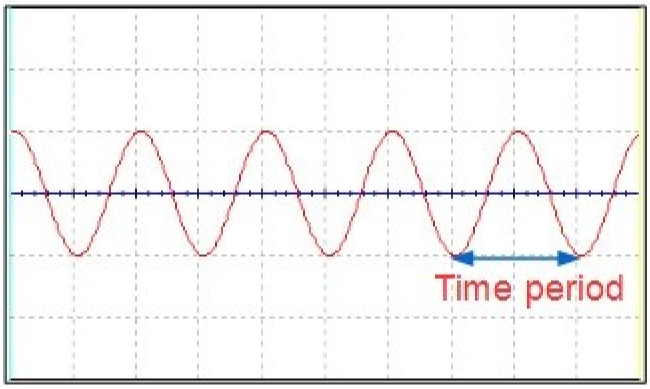


Figure 12: Measurement of frequency

(b) Method 2

The Lissajous figure method is the quickest method to measure the frequency. In this method the standard known frequency signal is applied to horizontal plates and simultaneously unknown frequency is applied to the vertical plate

Such patterns obtained by applying simultaneously two different sine wave to horizontal and vertical plates are known as Lissajous figure.

The shape of the Lissajous figure depends on the (a) Amplitudes of two waves (b)Phase difference between two waves and (c) Ratio of frequencies of two waves.

When two signals having some frequency are applied to input terminal of CRO and get superimposed perpendicularly (when A/B or B/A is pressed), then a pattern of closed figure is obtained which is known as **LISSAJOUS FIGURE**. This is easily done on an oscilloscope in XY mode. The signal whose frequency to be measured is given on vertical plate and signal whose frequency is given to horizontal plate. Now the known frequency is adjusted such that a Lissajous pattern can be obtained, which depends on the ratio of the two frequencies.

Let f_y be the frequency of unknown signal (applied at vertical plate) and f_x be the frequency of known signal (applied at horizontal plate)

f_V = frequency applied on the vertical plate and is unknown

f_H = frequency applied on the horizontal plate and is known.

Using the shift control, stationary Lissajous figure is obtained on screen such that to the figure vertical and horizontal axes are tangential to one or more points. The pattern depends on the ratio of two frequencies f_V and f_H as shown in the figure 13 below.

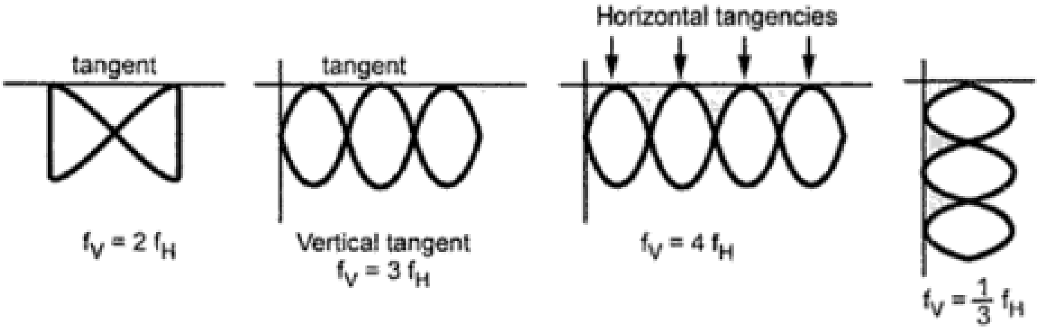


Figure 13: Few Lissajous patterns and frequencies

The ratio of the two frequencies can be obtained as

$$\frac{f_V}{f_H} = \frac{\text{number of horizontal tangencies}}{\text{number of vertical tangencies}}$$

(iv) Measurement of Phase Difference

If two or more signals are being monitored simultaneously, a time delay may occur between the signals (that is one signal may lead the other or vice-verse), called as phase difference. Two waves that have the same frequency, have a phase difference that is constant (independent of t).

When the phase difference is zero, the waves are said to be in phase with each other. Otherwise, they are out of phase with each other.

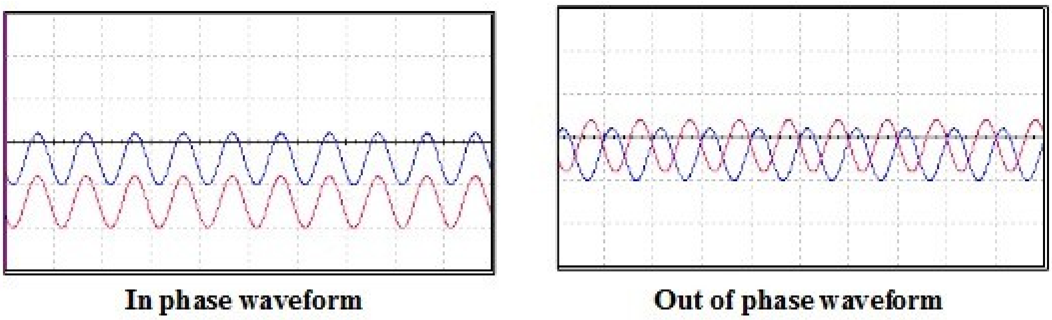


Figure 14 : Waveform with Phase Differences.

If the phase difference is 180º (radians), then the two signals are said to be in anti-phase. If the peak amplitudes of two anti-phase waves are equal, their sum is zero at all values of time, t.

The phase difference is expressed in terms of radians or degrees.

Method 1) Dual Beam Method

This method is used for determining phase difference between two waveforms of same frequency and equal or different amplitudes is quite accurate. It involves displaying both the signals on the CRO simultaneously. The distances between the two identical points on two traces are measured. This is done through XY mode of the dual slope oscilloscope. In the XY mode, the x-axis data is taken on one channel, y-axis data is taken on the other. In that way, Channel I is related with Channel II which is presented by means of graph, so that the variation of a signal with respect to another can be observed.

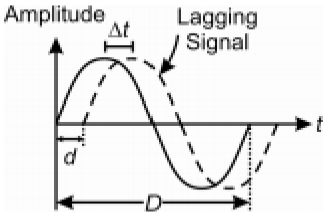


Figure 15: Phase difference measured on dual trace CRO

To begin with, obtain traces of both waveforms on the CRO screen. Measure the horizontal distance D required for one full cycle of either waverform and calculate the scale factor $S = 360^o / D$. Next measure the horizontal distance *d (cm)* between corresponding positive slopes of two waveforms. The phase angle between two waveforms is therefore obtained by:

$\theta = S.d = (d/D) X 360^o$

In order to obtain two sinusoidal waves of equal frequency but differing in phase a circuit shown in the figure below may be used.

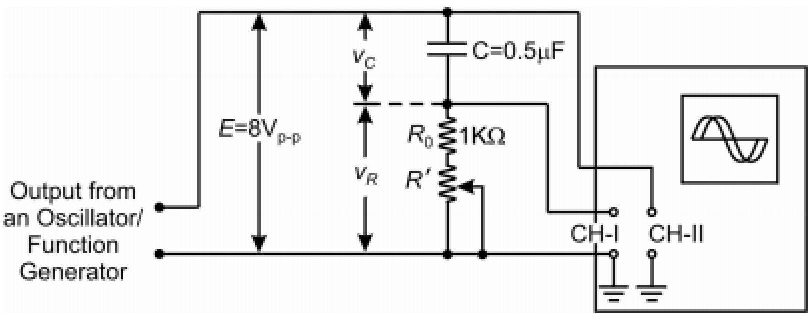


Figure 16: The network for measuring phase difference.

Function Generator

A function generator is a very versatile instrument that is used in electronics, mechanics, bio-engineering, physics and many other fields. A wide variety of synthesized electrical signals and waveform can be created for testing, repairing and diagnostic applications. It produces different types of waveform such as sine, square, triangle and saw-tooth over a wide range of frequencies.

The saw-tooth wave and triangular-wave outputs of function generators are commonly used for those applications which need a signal that increases (or reduces) at a specific linear rate. They are also used in driving sweep oscillators in the X-axis of X-Y recorders oscilloscopes. By providing a square wave for linearity measurements in an audio-system, a simultaneous saw-tooth output maybe used to drive the horizontal deflection amplifiers of an oscilloscope, providing visual display of the measurement result. A triangular wave and a sine wave of equal frequencies can be produced simultaneously. If the zero crossing of both the waves are made to occur at the same time, a linearly varying waveform is available which can be started at the point of zero phase of a sine wave. The various outputs of generator can be made available at the same time e. g. the generation can provide a square wave to test the linearity of an amplifier and simultaneously provide a saw-tooth to drive the horizontal deflection amplifier of the CRO to provide display. A function generator is shown in figure 17.

Figure 17 : A Function Generator with its controls

Waveform Characteristics

The term “wave” can be defined as a pattern of varying quantitative values that repeats over some interval of time. Waves are common in nature: sound waves, brain waves, ocean waves, light waves, voltage waves, and many more. All are periodically repeating phenomena. Signal generators are usually concerned with producing electrical (typically voltage) waves that repeat in a controllable manner.

Each full repetition of a wave is known as a “cycle.” A waveform is a graphic representation of the wave’s activity — its variation over time. A voltage waveform is a classic Cartesian graph with time on the horizontal axis and voltage on the vertical axis. Note that some instruments can capture or produce current waveforms, power waveforms, or other alternatives.

Amplitude: A measure of the voltage "strength" of the waveform. Amplitude is constantly changing in an AC signal. Signal generators allow you to set a voltage range, for example, —3 to +3 volts. This will produce a signal that fluctuates between the two voltage values, with the rate of change dependent upon both the wave shape and the frequency.
Frequency: The rate at which full waveform cycles occur. Frequency is measured in Hertz (Hz), formerly known as cycles per second. Frequency is inversely related to the period (or wavelength) of the waveform, which is a measure of the distance between two similar peaks on adjacent waves. Higher frequencies have shorter periods.

Phase: In theory, the placement of a waveform cycle relative to a 0 degree point. In practice, phase is the time placement of a cycle relative to a reference waveform or point in time.
Rise and Fall Time: Edge transition times, also referred to as rise and fall times, are characteristics usually ascribed to pulses and square waves. They are measures of the time it takes the signal edge to make a transition from one state to another. (Figure 18)
Pulse Width: Pulse width is the time that elapses between the leading and trailing edges of a pulse. Note that the term "leading" applies to either positive-going or negative-going edges as does the term "trailing." In other words, these terms denote the order in which the events occur during a given cycle; a pulse's polarity does not affect its status as the leading or trailing edge.

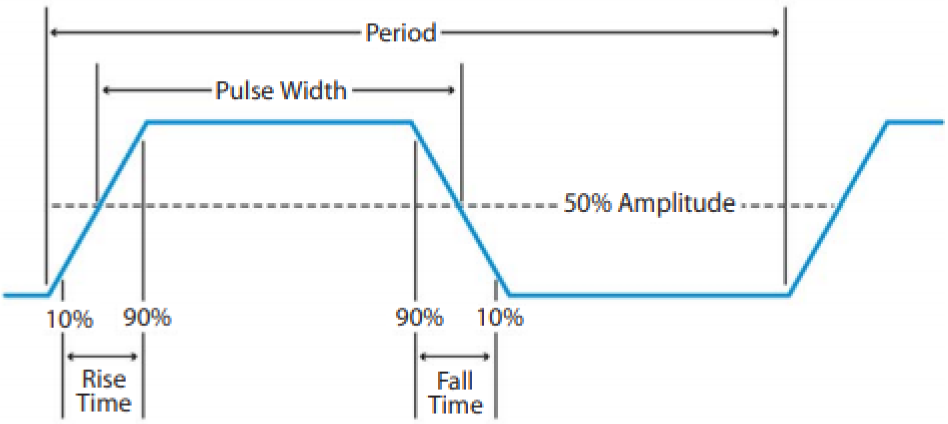


Figure 18: Rise and Fall time of a signal.

Offset: Not all signals have their amplitude variations centred on a ground (0 V) reference. The "offset" voltage is the voltage between circuit ground and the centre of the signal's amplitude. In effect, the offset voltage expresses the DC component of a signal containing both AC and DC values, as shown in Figure 19.

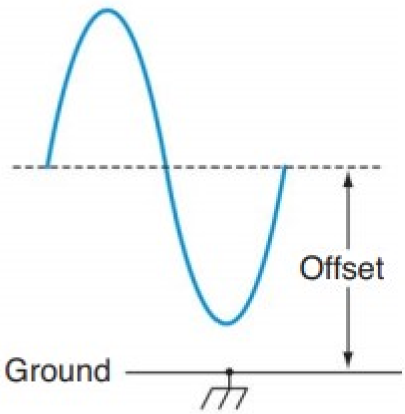


Figure 19: Offset to a signal.

Waveforms come in many shapes and forms. Most electronic measurements use one or more of the following wave shapes, often with noise or distortion added: Sine waves, Square and rectangular waves, Sawtooth and triangle waves, Step and pulse shapes and Complex waves (Figure 1)

Controls of the Waveform Generators

- **Display Screen**: Shows basic information about the signal generated, like frequency, waveform type, modulation and attenuation information.

- **Selection Buttons:** The buttons for selecting maximum frequency range, type of waveform selection, Modulation selection and attenuation etc.

- **Knobs –** Knobs for controlling duty cycle, fine tuning frequency, amplitude level (Maximum $V_{peak\text{-}peak}$ level to 20V)

- **Output Terminals:** Several output terminals have been provided for serial, generatoroutput.

Digital Multimeter (DMM)

Multimeter is an electronic measuring instrument combination of different measuring devices used to measure resistance, current, voltage. Mainly the multimeter are of two types:
i) Analog multimeter
ii) Digital multimeter

Analog multimeters use a microammeter whose pointer moves over a scale calibrated for all the different measurements that can be made.

Digital multimeters (DMM, DVOM) display the measured value in numerals, Digital multimeters are now far more common than analog ones, but analog multimeters are still preferable in some cases, for example when monitoring a rapidly-varying value.

A multimeter can be a hand-held device useful for basic fault finding and field service work, or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls, domestic appliances, power supplies, and wiring systems.

The Digital multimeter is a portable professional measuring instrument with large LCD to show three lines of readings, as well as back light for easily reading.

The digital multimeter can perform measurements of AC/DC voltage and current, resistance, frequency, duty cycle, capacitance, as well as continuity and diode test.

Both the reading and unit of measurement are displayed on the LCD.

The humidity and temperature functions are suitable for measuring ambient humidity and temperature, as well as temperature of objects.

The following parts are clearly visible on the Digital Multi-meter
a) LCD (Liquid-crystal display)
b) Auto/manual switch button (RANGE)
c) Relative measurement switch button (REL)
d) Reading hold/back light button (HOLD/B.L.)
e) Hz/duty cycle switch button (Hz/DUTY)
f) Panel
g) Rotary selector
h) 10A input jack
i) mA/µA/TEMP input jack
j) COM input jack
k) V, Ω, Hz, input jack
l) OFF-switch off power

m) Function switch button (SELECT)
n)˚C/˚F switch button(˚C/˚F)

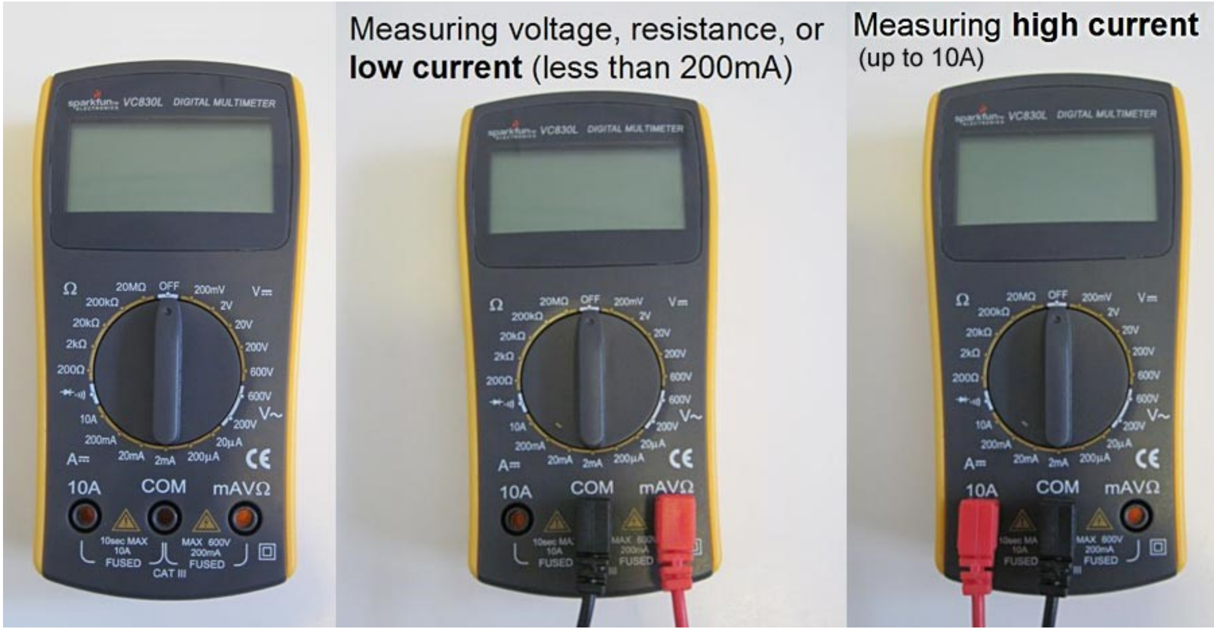


Figure 20: The common controls in Digital Multi-meter. This multimeter has 3 ports labelled 10A, COM and mAVΩ. The probe connections for measuring voltage, resistance and low current and high current

A multimeter is a combination of a multirange DC voltmeter, multirange AC voltmeter, multirange ammeter, and multirange ohmmeter. An un-amplified analog multimeter combines a meter movement, range resistors and switches.

Resolution and Accuracy

The resolution of a digital multimeter is often specified in the number of decimal digits resolved and displayed. If the most significant digit cannot take all values from 0 to 9 is often termed a fractional digit. For example, a multimeter which can read up to 19999 (plus an embedded decimal point) is said to read 4½ digits.

Digital multimeters generally has greater accuracy as compared to their analog counterpart. Standard analogue multimeters measure with typically ±3% accuracy, though instruments of higher accuracy are made. Standard portable digital multimeter are specified to have an accuracy of typically 0.5% on the DC voltage range.

Accuracy figures need to be interpreted with care. Digital meters usually specify accuracy as a percentage of reading plus a percentage of full-scale value, sometimes expressed in counts rather than percentage terms.

Switch, Buttons and Input Jacks:

Figure 21: Switch, Buttons and Input Jacks to a Multimeter

Hold button for holding the reading.
Select button for switching among measuring functions.
Range button for switching between auto and manual ranges.
Hz button for switching functions and ranges.
OFF position for turning power off.
10A input jack for measuring current up to 10A.
mA/µA/temp jack for measuring current up to 400mA.
COM input jack is a common input connection for current, voltage, resistance, frequency, duty, capacitance, diode, continuity, temperature measurements.
VΩHz input jack for measurements of resistance, voltage, diode, continuity, frequency, capacitance, etc.
Rotary function switch for selecting different functions and ranges.

i) Measuring DC Voltage

- Select the V(—) with the rotary function switch. Insert the black probe in the COM jack and red test probe in the VΩHz input jack. Connect the ends of probes where you want to measure the voltage. Note the voltage.

ii) Measuring AC Voltage

- Select the V(~) with the rotary function switch. Insert the black probe in the COM jack and red test probe in the VΩHz input jack. Attach the probe tips to the voltage source. Note the voltage.

iii) Measuring DC/AC current:

- Select the µA/mA with the rotary function switch. Break the circuit point to be measured. Connect the two test leads to complete the broken circuit. If the measured current is too high, the display will indicate "OL". In this case the higher current range should be selected.

iv) Measuring resistance:

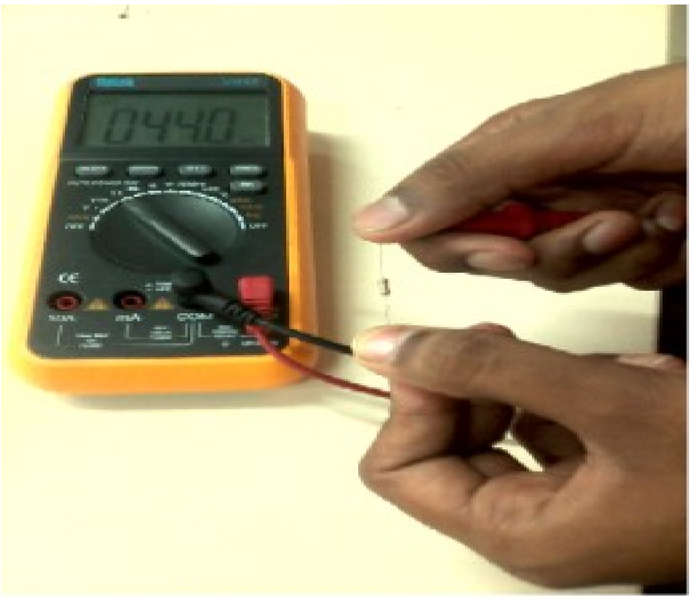


Figure 22: Figure showing the resistance measurement using Multimeter

- Select the Ω position with rotary function switch. Insert the black test probe in the COM input jack and red test lead in the VΩHz input jack. Touch the both end of resistance with the test leads as shown in the figure. Note the resistance from the screen of multimeter.

v) Checking continuity of the circuit

- Select Ω/-))) position with the rotary switch. Press the function key one time. Connect the both test leads as shown in the figure. A beep sound will be produced.

vi) Diode Testing

- Select diode position with the rotary function switch. Insert the black test lead in the COM input jack and red test lead in the VΩHz input jack. Touch the both end of diode with the test leads. Note the result from the multimeter screen.

vii) Frequency

- Select Hz with the rotary function switch.Insert the black test lead in the COM input jack and red test lead in the VΩHz input jack. Attach the test lead tips to signal source. Display will read the measured frequency.

viii) Capacitance

Figure 23: Figure showing the measurement of Capacitance.

- Select the 'capacitance' position with the rotary function switch. Discharge the capacitor to be measured. Attach the test lead tips to the capacitor.

Safety Precautions

- Do not measure the voltage in excess of 1000V.
- Disconnect the test leads from the test points before changing the meter function and range.
- Be careful not to touch the terminals or probes tip when measuring above 60 VDC or 25 VAC.
- Never attempt a voltage measurement with a test lead into the AMP or mA input terminal.
- Do not continue measuring high current above 10V for more than 10 seconds.
- Do not attempt a current measurement where the voltage is above 250V.
- Always connect multimeter in series while measuring current.
- Always connect multimeter in parallel while measuring voltage.

B) Introduction to Basic Electronic Components

Basic Electronic Components like Diodes, resistors, capacitors, inductors, transistors, integrated circuits etc. are the basic building blocks of all the electronic circuits. In this section we present brief overview of different building blocks

Resistors

A resistor is a component that resists the flow of current. It's one of the most basic components used in electronic circuits. Resistors come in a variety of resistance values (how much they resist current, measured in units called ohms and designated by the symbol Ω and power ratings (how much power they can handle without burning up, measured in watts).

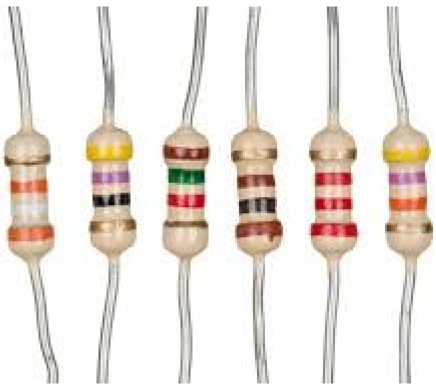
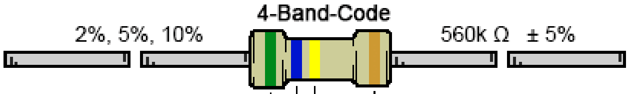


Figure 24: Resistors

The resistors value are encoded as pattern of different colours as shown above. The value of resistance can be computed by using the colour code scheme shown in figure 25.



COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	100MΩ	± 0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

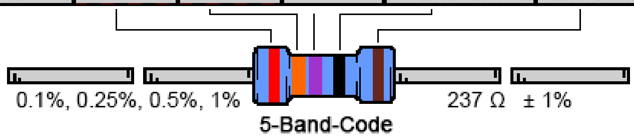


Figure 25: Resistor Colour Code

Capacitor

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electrostatically in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e., insulator). The conductors can be thin films of metal, aluminum foil or disks, etc. The 'nonconducting' dielectric acts to increase the capacitor's charge capacity. A dielectric can be glass, ceramic, plastic film, air, paper, mica, etc. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, a capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge (+Q) to collect on one plate and negative charge (-Q) to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if an accelerating or alternating voltage is applied across the leads of the capacitor, a displacement current can flow.

An ideal capacitor is characterized by a single constant value for its capacitance. Capacitance is expressed as the ratio of the electric charge (Q) on each conductor to the potential difference (V) between them. The SI unit of capacitance is the farad (F), which is equal to one coulomb per volt (1 C/V). Typical capacitance values range from about 1 pF (10^{-12} F) to about 1 mF (10^{-3} F).

The capacitance is greater when there is a narrower separation between conductors and when the conductors have a larger surface area. In practice, the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, known as the breakdown voltage. The conductors and leads introduce an undesired inductance and resistance.

Figure 26: Few Types of Capacitors

Diodes

Testing Diodes using Multimeter

Digital multimeters can test diodes using one of two methods:

– Diode Test mode: almost always the best approach.

– Resistance mode: typically used only if a multimeter is not equipped with a Diode Test mode.

A multimeter’s Diode Test mode produces a small voltage between test leads. The multimeter then displays the voltage drop when the test leads are connected across a diode when forward-biased. The Diode Test procedure is conducted as follows:

Make certain a) all power to the circuit is OFF and b) no voltage exists at the diode. Voltage may be present in the circuit due to charged capacitors. If so, the capacitors need to be discharged. Set the multimeter to measure ac or dc voltage as required. Turn the dial (rotary switch) to Diode Test mode. It may share a space on the dial with another function.
Connect the test leads to the diode. Record the measurement displayed.
Reverse the test leads. Record the measurement displayed.

Diode test analysis
A good forward-based diode displays a voltage drop ranging from 0.5 to 0.8 volts for the most commonly used silicon diodes. Some germanium diodes have a voltage drop ranging from 0.2 to 0.3 V.
The multimeter displays OL when a good diode is reverse-biased. The OL reading indicates the diode is functioning as an open switch.
A bad (opened) diode does not allow current to flow in either direction. A multimeter will display OL in both directions when the diode is opened.
A shorted diode has the same voltage drop reading (approximately 0.4 V) in both directions

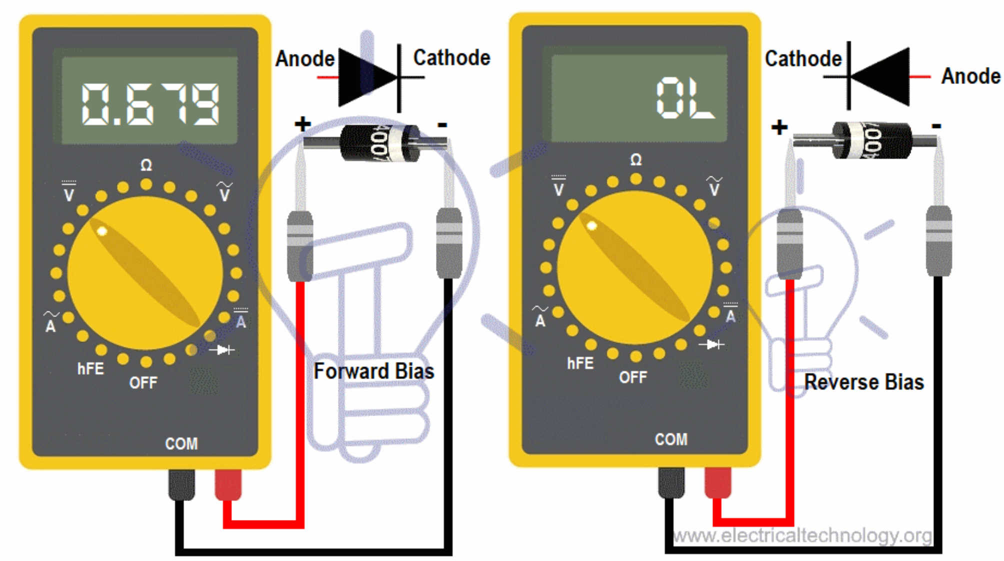


Figure 27: Diode Testing using Multimeter

A multimeter set to the Resistance mode (Ω) can be used as an additional diode test or, as mentioned previously, if a multimeter does not include the Diode Test mode.

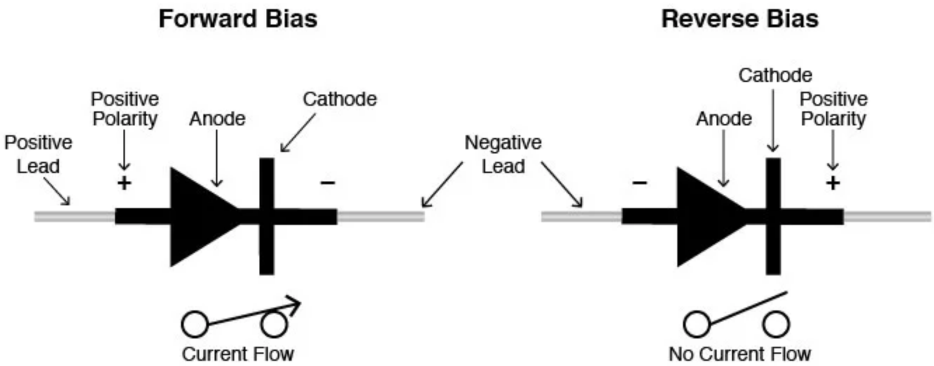


Figure 28 - Diode Terminal Connection for Testing Diodes

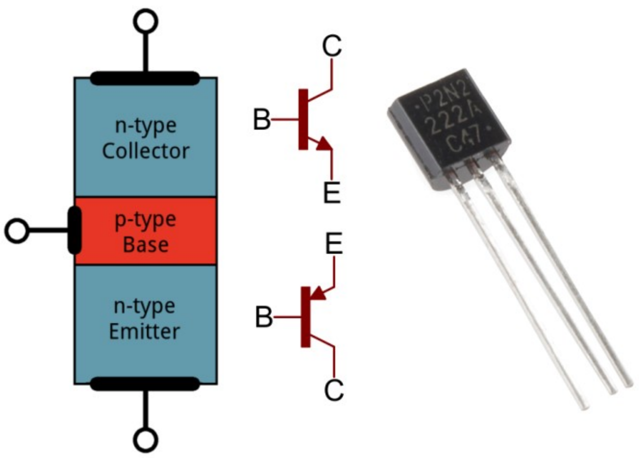
A diode is forward-biased when the positive (red) test lead is on the anode and the negative (black) test lead is on the cathode.
The forward-biased resistance of a good diode should range from 1000 Ω to 10 MΩ.

The resistance measurement is high when the diode is forward-biased because current from the multimeter flows through the diode, causing the high-resistance measurement required for testing.
A diode is reverse-biased when the positive (red) test lead is on the cathode and the negative (black) test lead is on the anode.

The reverse-biased resistance of a good diode displays OL on a multimeter. The diode is bad if readings are the same in both directions.

Transistors

A transistor is an electronic device having three terminals where small current at one terminal is used to control current at the other terminals. Transistors are mainly used for the amplification of the electronic signal.



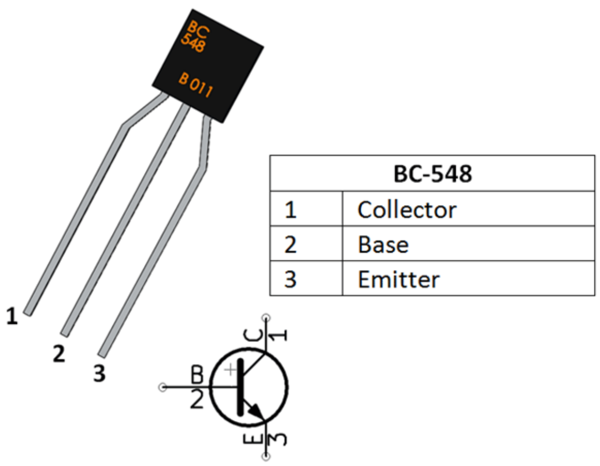


Figure 29 Transistors , symbols and different terminals of BC-548 transistor

Experiment No. 12

Aim: Design and Development of Regulated DC Supply

Objective: To design and develop regulated DC power supply

Introduction

Power supply means that provides energy i.e. power. If we use this in terms of electronics, we can consider it as a source of either voltage or current. A dc power supply is that takes ac as input and convert it to dc output. It uses a transformer, rectifier, capacitor filter or LC filter circuit to get the work be done. DC power supplies can be used as a single voltage, dual voltage and multi-voltage output. Two or more DC power supplies can be connected to get desired output.DC power supplies are of two types- Regulated and unregulated. Unregulated dc power supply is the basic and simplest power supply to construct.

Figure 30 - Regulated DC Power supply

(A) PRINCIPLE OF OPERATION

This is a specialized signal generator in which the frequency is controlled by varying the magnitude of current which drives the integrator where in other common instruments, frequency is controlled by varying the capacitor in the LC or RC circuit.

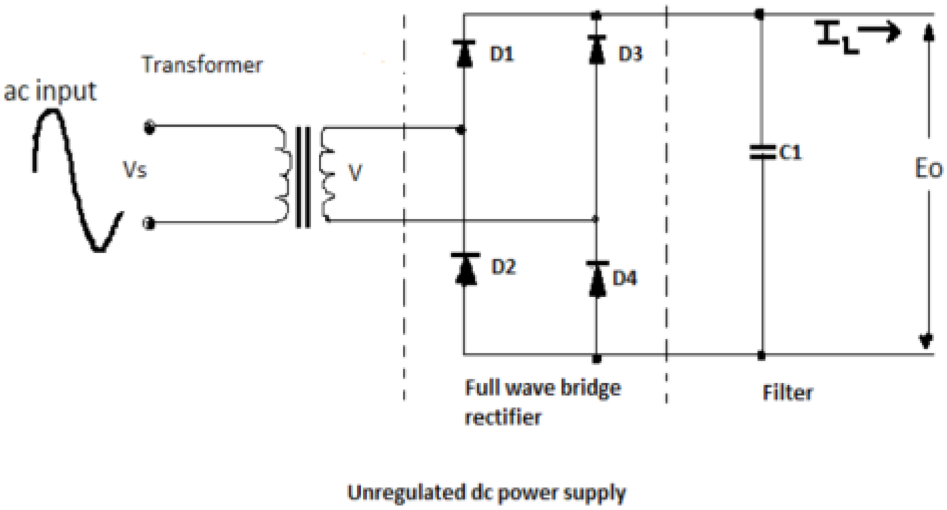
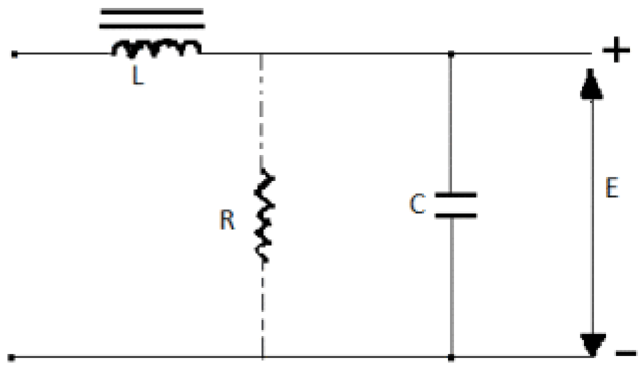


Figure 31 – Unregulated DC Power Supply

Transformer secondary voltage turns ON the diodes D1 and D4 during positive half-cycle and diodes D2 and D3 in negative half cycle respectively. The capacitor(C1) is charged up to the peak of th rectifier output voltage i.e. Eo(max). If there is no load current, the capacitor voltage remains constant.
If there is a load current drawn from the supply, capacitor partially discharges between voltage peak that is to Eo (min). This gives an output ripple voltage whose amplitude is Vr. The capacitor acts as a source (reservoir) to supply load current according to the requirement.

(B) TO GET SMOOTH WAVEFORM
The transformer and bridge rectifier circuit supply recharging current to capacitor as a series of repetitive pulses as shown in previous slide. The voltage obtained from the power supply has an average dc level Eav) with the ripple voltage superimposed. The amplitude of the ripple voltage depends on the size of the reservoir capacitor and the level of load current. If we do not change in the size of capacitor and increase the load current, the ripple voltage amplitude is also gets increased.

(C) FOR DC IDEAL VOLTAGE
We can get almost constant dc output by using an inductor together with the reservoir capacitor; this arrangement is called filter circuit. By doing so, reduction in the amplitude of output ripple voltage takes place. When there is no output load current, a resistor (called bleeder resistor R) is required in the circuit to maintain a minimum current flow in the choke (inductor) . This keeps the choke operating and thus helps to minimize the change in voltage drop across the choke when load current is demanded. The inductor-capacitor (choke-capacitor) filtering gives the most constant dc output voltage with the lowest ripple content.



Choke-capasitor circuit
for reducing the output repple amplitude from an unregulated power supply

Figure 31 – Choke Capacitor Circuit

There are two secondary windings of transformer. These coils can be connected either in series or in parallel. When windings are connected in series, the dc output voltage is 2V volt. When windings are in parallel, it gives an output of only V volt. However the 2V volt output might be capable of supplying current (i), while parallel secondary windings with V volt output may supply 2i A current.

(D) Block diagram of regulated dc power supply

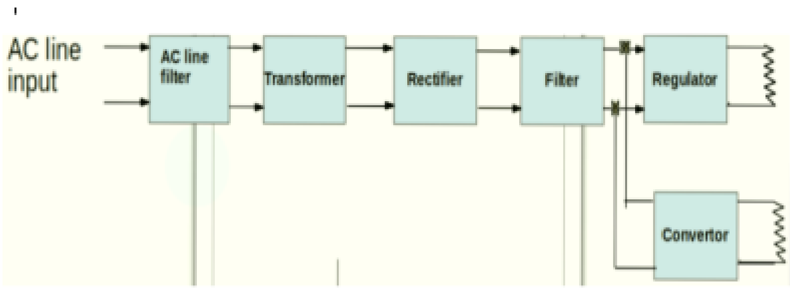


Figure 32 – Block diagram of Regulated DC power Supply

(E) Working of Regulated DC Power Supply

- **AC line Filter**: Eliminates noise from the ac line input.
- **Transformer:** Step the input ac voltage level up or down.
- **Rectifier:** It converts ac sine wave into fluctuating dc.
- **Filter**: It removes pulsation and create a constant output.
- **Regulator**: Helps to maintain a fix or constant output voltage.

2A - HALF WAVE RECTIFIER

For this part of the experiment, you will require one conventional diode and a 10kΩ resistor for R_1. You will also need to use the Function Generator and oscilloscope for all the inclusive tests.

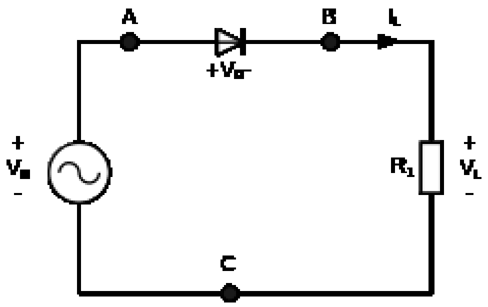


Figure33 - Half Wave Rectifier Circuit

Connect up the half-wave rectifier circuit as shown in Figure 33. Switch on the scope, and prior to making any connections, use the AUTO SET button to initialise both channels.

Set up V_S using the Function Generator, and use the appropriate controls and a BNC-BNC cable to obtain a sine wave signal with a frequency of 500Hz and a peak to peak voltage 4.0V, using the 50Ω output. Ensure that the DC OFFSET button on the frequency generator control panel has been pushed in. Use the SEC/DIV and VOLTS/DIV dials to obtain a suitable display on the screen, so that you can adequately see two cycles. Note down the corresponding settings.

Once you have set up V_S, draw this signal in your lab book, noting down the waveform's dimensions and scope settings.

Apply this signal to your circuit, by connecting a BNC-croc clip cable from the Frequency Generator to points A (red) and C (black – this is the earth/common point), and use another lead to observe this signal on CH1 of the scope. On Channel 2, observe the waveform at B (red) with respect to earth at C (black). Use the same VOLTS/DIV as you used when setting up V_S. Draw V_{BC} in your lab book, noting down the dimensions (peak-to-peak voltage, period) and scope settings. Note how V_{BC} is periodic (i.e. repetitive at equal time intervals). Based on your observations, can you explain why this is called *half wave* rectification? You should have observed that only the positive half cycle of the sine wave appears across R_1, hence the circuit being known as a half wave rectifier.

2B - BRIDGE RECTIFIER

In practice it is more common to use a four-diode bridge rectifier for power supply applications. Such a circuit is shown in Figure 34, where R_1 is a 10kΩ load resistor and point C is the earth point. Prior to carrying out the tests, ensure that both channels of the scope have been centred, and that DC coupling has been selected for both channels. Once this has been done, carefully construct the circuit of Figure 34 on your breadboard. For this part of the investigation, you <u>do not need</u> to include the capacitor.

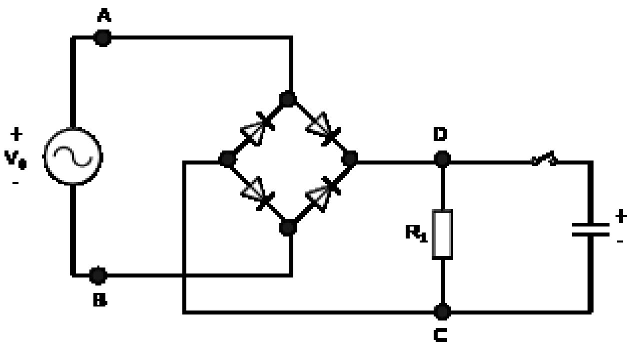


Figure34 - Full Wave Bridge Rectifier Circuit

For the same scope set up as described in the previous section, observe the output and the diode (BC) voltage waveforms V_{DC} and V_{BC} on the oscilloscope. Use the scope controls to obtain clear waveforms, and draw both waveforms in your lab books, not forgetting to note the dimensions and settings.