

Basic Skills on Electronic Equipments

SEC0200903

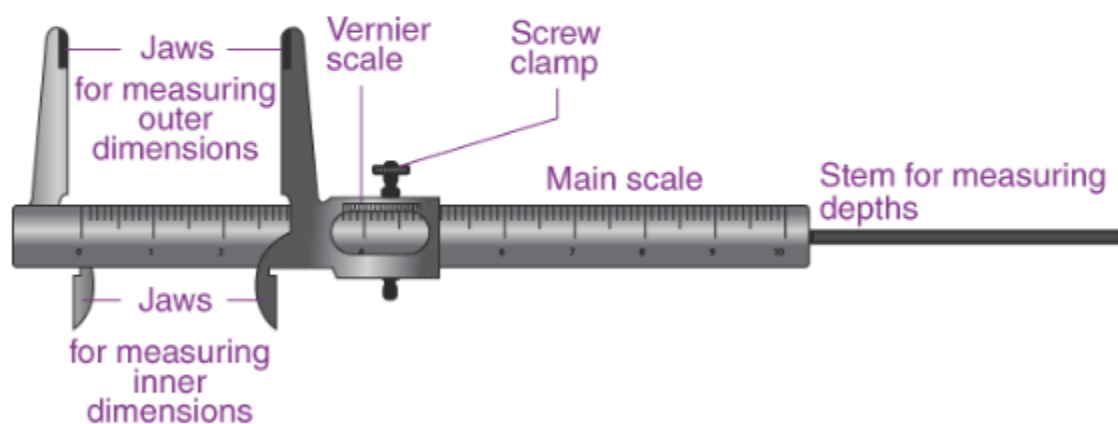
UNIT 3: Use of Laboratory Instruments

Vernier Calliper

What Is Vernier Calliper?

A vernier calliper is defined as a measuring device that is used for the measurement of linear dimensions. It is also used for the measurement of diameters of round objects with the help of the measuring jaws.

Vernier Calliper Diagram



French mathematician Pierre Vernier invented the vernier scale in 1631. The main use of the vernier calliper over the main scale is to get an accurate and precise measurement.

Least Count of Vernier Calliper

The least count of vernier callipers is also known as the vernier constant. It is defined as the difference between one main scale division and one vernier scale division.

It is mathematically given as:

$$VC = 1 \text{ MSD} - 1 \text{ VSD}$$

When there are n divisions on the vernier scale, which coincides with $(n-1)$ division on the main scale, then the least count of vernier calliper is:

$$LC = (1 - \frac{n-1}{n}) \text{MSD}$$

Therefore, the least count of vernier calliper is 0.1 mm.

Where,

- VC is the vernier constant
- MSD is the main scale division
- VSD is the vernier scale division
- LC is the least count

What Is Zero Error?

Zero error is defined as the condition in which the measuring device registers a reading when there should not be any reading.

The zero error of the vernier calliper is calculated as:

Actual reading = Main scale + Vernier scale – (Zero error)

There are two types of zero error:

- Positive zero error: When the jaws of the vernier calliper are closed, the reading is positive and away from the actual reading of 0.00 mm. For instance, if the reading is 0.08 mm, then the zero error is +0.08 mm.
- Negative zero error: When the jaws of the vernier calliper are closed, the reading is negative and away from the actual reading of 0.00 mm. For instance, if the reading is 0.10 mm, then the zero error is -0.10 mm.

Solved Examples

Example 1:

If the jaws of the vernier callipers are in contact with each other, then determine the zero error of the vernier calliper if the VSD is 3.

Solution:

Given:

The jaws of the vernier calliper are in contact with each other.

Therefore, the least count of the vernier calliper is given as:

$$LC = MSD - VSD$$

$$LC = 1 - (9/10) = 0.1 \text{ mm}$$

The main scale reading, MSR = 0 mm

The vernier scale reading, VSR = 3

Therefore,

$$\text{Zero error} = \text{MSR} + \text{VSR} \times \text{LC}$$

$$\text{Zero error} = 0 + 3 \times 0.1 = 0.3 \text{ mm}$$

Example 2:

1 mm marks are present on the main scale of the vernier scale. The total no. of divisions on the vernier scale are 20 which matches the 16 main scale divisions. Calculate the least count of this vernier scale.

Solution:

Given:

One main scale division, MSD = 1 mm

20 vernier scale divisions, VSD = 16 main scale divisions, MSD

Therefore, 1 VSD = $16/20$ MSD = 0.8 mm

The least count, LC = 1 MSD – 1 VSD = 1 – 0.8 = 0.2 mm

How to Read Vernier Calliper?

- The first step is to measure nothing through which we can check if the main and the vernier scales are aligned.
- When the main scale reading and the vernier scale reading are at zero, it means there is no zero error.
- Now, place a ball between the two jaws of the vernier scale.
- Look at the 0 mark on the vernier scale lining with the main scale.
- That gives the main scale reading.
- Next, look for the point on the vernier scale, which is aligned with the main scale, which gives the vernier scale reading.
- It is important to note that the readings will most of the time be in decimals.
- The number before the decimal point is the main scale reading, while the number after the decimal point is the vernier scale reading.

Main Scale

It is a large scale that runs along the body of the vernier calliper. Depending on the usage, the reading on the main scale could be either in centimetres or millimetres. 1 mm is the lowest main scale division according to the SI units. The main scale is stationary.

Vernier Scale

This is the smaller scale attached to the main scale, moving along the main scale. The vernier scale's movement depends on the jaws' opening. The main function of the vernier scale is to provide accuracy to the main scale reading by dividing the reading into smaller increments. The vernier scale in a metric calliper can have divisions up to 50 increments, each of which measures 0.02 mm.

Lower Jaws

These jaws are considered one of the most prominent features of vernier calliper. One of the jaws is fixed and attached to the main scale. While the other jaw is movable and is attached to the vernier scale. These jaws are designed mainly to grip the objects firmly. The main function of the lower jaw is to measure the outer dimensions such as diameter, width and length.

Upper Jaws

These jaws are similar to the lower jaws but are smaller than, the lower jaws. These jaws are attached to the upper part of the vernier scale. One of the jaws is fixed, while the other jaw is movable. The main function of the upper jaw is to measure the inner dimensions of the objects. The jaws are opened until they touch the objects' edges before taking the reading. The inside diameters of objects such as hollow pipes and jars can be measured using upper jaws.

Depth Rod

The depths of the jars can be measured using the depth rod. It is a thin rod located at the end of the main scale. Using a depth rod for measuring is simple. The edge of the main scale is placed on the object's top surface. Then the jaws are slowly opened. The opening of the jaws results in the extension of the depth rod. The jaws need to be opened until the depth rod reaches the bottom of the object.

Thumb Screw

This screw is located at the bottom of the vernier scale. The main function of the thumbscrew is to provide grip to the users so that the sliding of the jaws becomes easy.

Lock Screw

The main use of the lock screw is to fix the position of the jaws once the object is firmly fixed between the jaws. This also makes it easy to take proper readings.

Applications of Vernier Callipers

- Medical usages
- Science labs
- Industries such as steel and aerospace
- Educational sectors

Frequently Asked Questions – FAQs

Q1 What is the principle of vernier calliper?

The vernier calliper's principle is that the vernier scale's graduations are of the length n division, which is equal to the $n-1$ division on the main scale.

The number of divisions on the vernier scale, in general, is 10 divisions. Therefore, the number of divisions on the main scale is given as $n-1 = 10 - 1 = 9$, which is equal to 9 mm. Therefore, we can say that each division on the vernier scale is equal to $1/10$ mm.

Q2 Why is the vernier calliper more accurate?

Vernier calliper is more accurate because it measures up to one-hundredth of a millimetre and one-thousandth of an inch.

Q3 What are the advantages of vernier calliper?

There are two main advantages of vernier calliper:

- The measurements provided by the vernier calliper are accurate and precise.
- It can be used for measuring both inner and outer surface dimensions.

Q4 What are the limitations of vernier calliper?

- The improper angle of vision might result in the noting of wrong reading.
- The least attentiveness might lead to the recording of the wrong reading.

Q5 How to read the depth using vernier calliper?

The following are the steps to be followed for measuring depth with a vernier calliper:

- Place the edge of the main scale on the brim of the beaker.
- Rotate the thumbscrew till the tip of the depth rod reaches the bottom of the beaker.
- Tighten the lock screw so the jaws are held firmly.
- Record the measured readings.

Q6 What are the types of vernier callipers?

There are three types of vernier callipers:

- Manual readout, which is the original vernier calliper
- Dial readout
- Digital readout

Screw gauge

Screw Gauge is an amazing device used for measuring small objects precisely. It is defined as an instrument that is used for measuring very small lengths, i.e. diameter of thin wires, the thickness of small sheets, papers, etc.

What is Screw Gauge?

A **screw gauge** is an instrument that accurately measures small lengths and diameters. The balance is comprised of a calibrated screw and a scale. Fine threads, one turn, and a short distance. Turning the screw causes movement of the measuring spindle against or away from the reference surface that stays put. The screw gauge has a scale from which one can take readings. This is an exact measure of an object being studied.

It consists of two scales: The pitch **Scale** and the **Circle Scale**.

- **Pitch Scale:** Pitch scale determines how far does the screw move in one turn. It assists in making sure that actual determination is done by tracking the screw movement and its turns.
- **Circle Scale:** A numerical scale that runs along the periphery of the screw is known as the circular scale. It's just like a ruler but in a circular shape.

Total Reading = Pitch Scale Reading + Circular Scale Reading \times least count of the gauge

Screw Gauge Formula

- **Pitch:** This is the amount of travel of the screw for every turn which it completes. The formula for pitch of the Screw is:

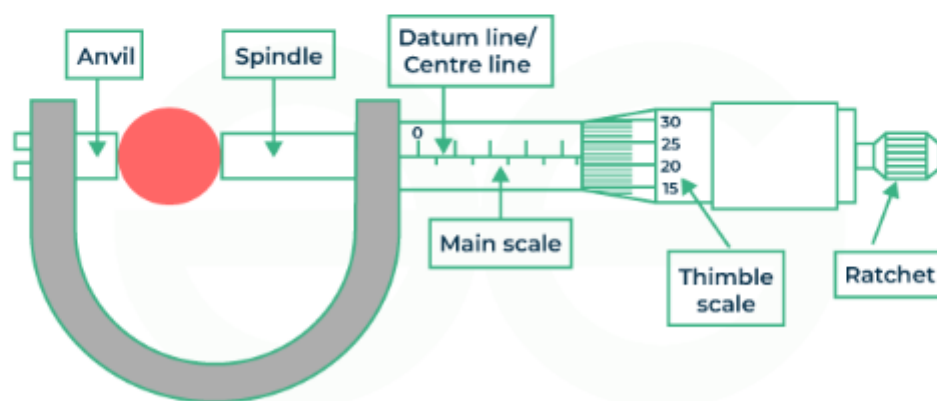
***Screw Gauge Pitch = Distance Moved By Screw/Number of Full Rotation
Given***

- **Least Count:** The screw gauge measures it precisely, the smallest measure. The formula for least count (LC) is:

$$\text{Least Count} = \text{Pitch} / \text{Total Number of Division on Circular Scale}$$

Screw Gauge Diagram

The diagram of screw gauge is added below,



Screw Gauge



Parts of Screw Gauge

Various Components of Screw Gauge are,

- **Screw:** The measurement element of this screw gauge is the main feature.
- **Anvil:** In this case, the anvil has an object placed on it, and the spindle moves against the object.
- **Spindle:** As the thimble is turned, the spindle will move towards the anvil.
- **Thimble:** The moving part of the screw gauge is called this.
- **Thimble lock:** In order to fix the spindle when making a measurement this part is put under tension. It is sometimes called lock-nut or lock-ring.

- **Ratchet stop:** This keeps the thimble from revolving any more than is necessary for it.
- **Barrel/Main Scale:** This is referred to as a sleeve or stock, which is one of the non-movable components marked either linearly or Vernier-wise, as displayed in the diagram of screw gauge.

Working Principle

A screw gauge uses the precise motion of a calibrated screw and interactions between the main scale and a circular scale to work. Here's a step-by-step explanation of the working principle:

Structure of Screw Gauge

- A screw gauge comprises a frame in the shape "U" that contains fixed end-flat anvil and moveable end-pointed spindle.
- It has a fine-threaded screw in the spindle.

Rotation of Screw

- Turning of the circular head or thimble rotates the screw, thereby causing movement of the spindle toward or away from a stationary anvil.

Measurement Principle

- The pitch is defined as the distance advanced by the screw when it undergoes one full turn of rotation.
- The screw's movement transfers over onto the spindle and therefore causes its axial motion.

Interaction with Scales

- The main scale, which can be found on the frame, represents a linear scale that has been designed for measuring the total turns of the screw.
- A circular scale is used for measuring the fractions of rotation with a circular head or thimble.

Reading Measurement

- To measure an object, one turns the screw until it becomes the tight position with which it will be clamped in between the anvil and then spindle.
- The main scale reading shows the number of full turns, while the circular scale reading provides the fraction.

Calculating Measured Value

- The measured value is determined as a combination of the main scale reading, and multiplication of least count and the quantity of circular scale divisions.

Screw Gauge Measurement

The following steps can be implemented to record the measurement using Screw Gauge,

- **Diameter of Thin Wires:** It can be used for determining the diameters of extremely thin wires that are employed in electronics or even scientific research.
- **Thickness of Small Objects:** Screw gauge can be used in measuring the thickness of small objects such as metal sheets, glass slides, and thin plate.
- **Component Dimensions:** This is crucial for the measurement of small-scale items used for making parts that have exact size limitations.
- **Microscopic Samples:** It is able to take measurements of samples at a microscope scale for example, in biological work or even materials science.
- **Accuracy in Engineering:** Screw gauge is a precision instrument used by an engineer with small mechanical parts or component that are highly accurate, and the precision is key to their functioning.

Inch Micrometer Screw Gauge

Here are the key features and components of an inch micrometer screw gauge:

- **Frame:** Micrometer has a frame as its major part which forms the basis for its stability and support.
- **Anvil and Spindle:** One component is stationary (anvil) and another (spindle) is movable. Such jaws hold the object being measured.
- **Sleeve:** An outer cylindrical portion of a micrometer known as sleeve contains a thimble, which is usually marked with either inches or millimeters.
- **Thimble:** A micrometer has a rotating outer part; it is the thimble. It comes with marking, usually corresponding with the main scale and gives other related measurements.
- **Main Scale:** It will be shown mainly on the sleeve and it should represent all the parts (inches or millimeters).
- **Vernier Scale or Thimble Scale:** A finer scale, called the Vernier scale or the thimble scales allows more precise and accurate measure.⁴

Least Count of Screw Gauge

The least count of a screw gauge is the smallest reading and recording unit of an instrument. The screw gauge comprises a principal marking and a moving one called thimble that goes around the principle marking.

$$\text{Number of Divisions on Circular Scale} = \text{Pitch/Least Count}$$

Since the pitch for the screw in this case equals 1 mm and the instrument's circular scale has 100 divisions, its least count would therefore be **0.01 mm**.

Least Count of Screw Gauge Formula

The least count of Screw Gauge formula is given as:

$$\text{Least Count (LC) of Screw Gauge} = (\text{Pitch}) / (\text{Total Number of Divisions on Circular Scale})$$

$$\text{Least Count of Micrometer Screw Gauge} = (1 \text{ mm}) / (100) = 0.01 \text{ mm}$$

In other words, users must place the object between the anvil and the spindle, and then turn the thimble so as to get the two objects into contact with each other. When using the least count accuracy, it is important to minimize errors like parallax and wrong alignment so that accurate readings are obtained.

Errors in Screw Gauge

There are many reasons why errors may occur during the screw gauge measurement. Here are some common errors associated with screw gauges:

Zero Error

- **Positive Zero Error:** Thimble scale zero mark moves ahead of main scale zero mark when anvil and spindles touch leading to positive zero error (+Z).
- **Negative Zero Error:** Thimble scale zero marking lags behind main scale zero mark whenever contact occurs between the anvil and spindles thus resulting into negative zero error (-Z).

Parallax Error: It happens where the eye does not run parallel with the scale of measurements causing misreading at the eye level. To do this successfully, make sure your eye is upright with scale line – if you want to get clear information.

Frictional Errors: These may result in mistakes, particularly in accurate readings. This error can be minimized with regular cleaning and lubrication.

Wear and Tear: Continuous usage may lead to wear and tear of the screw gauge components, affecting its accuracy over time. Regular maintenance and calibration are necessary to minimize errors due to wear.

- Temperature Variation:** Changes in temperature can cause the metal components of the screw gauge to expand or contract, leading to inaccuracies in measurements.
- Human Errors:** Incorrect handling, misalignment of the object being measured, or misinterpretation of readings can result in human-induced errors.
- Incorrect Calibration:** If the screw gauge is not calibrated correctly or if the least count is not accurately determined, it can lead to measurement errors.

Learn about, [Errors in Measurement](#)

Screw Gauge and Vernier Caliper

The difference between Screw Gauge and [Vernier Caliper](#) is added in the table below,

Difference Between Screw Gauge and Vernier Caliper		
Feature	Screw Gauge	Vernier Caliper
Measurement Principle	thickness and diameter are measured via a calibrated screw	length, diameter, or thickness are measured by sliding a calibrated scale.
Scale Graduations	Usually measured in millimeters (mm) or fractions of a millimeter.	The scale has two main scales (in cm/mm) and a Vernier scale for more accurate readings
Main Use	applications for a variety of measurements, including length, diameter, and depth.	Accurate measurement of small lengths or diameters, frequently utilized in manufacturing and engineering. Used in mechanical and industrial purposes.

Reading Accuracy	Higher accuracy due to fine screw thread with least count often in hundredths or thousandths of a millimeter.	Provides accurate readings with a least count down to 0.02 mm or even finer
Working Mechanism	Measuring dimensions by movement of calibrated screw through a spindle and thimble	It uses two scales, one fixed (main scale) and one movable (Vernier scale) that slide to each other for measurements
External vs. Internal	Majorly used for taking external measurements (outer diameter)	Take readings for both; including external (outer) as well as internal (inner) dimensions with specially shaped jaws
Usability in Industries	Majorly in use around precision engineering, labs and manufacturing units	Widely used across mechanical workshops, automotive, and aerospace industry for varied set of measurements

Uses of Screw Gauge

Various uses of Screw Gauge are,

- **Engineering and Manufacturing:** Screw gauges are precision small component dimension meters that are applied in numerous industries including the manufacturing industry.
- **Laboratories:** Screw gauges work at scientific research facilities and laboratories for the definition of small characteristics like size, depth of the cross section, etc.

- **Machine Shops:** Machine shops use screw gauges in fabricating and machining parts of the required sizes.
- **Automotive and Aerospace:** Automotive and Aerospace industry where precision is crucial, adhering to strict standards and requirements.
- **Jewelry Making:** Screw gauge is often used by jewelers to make an accurate measurement of gemstones, wires, and other fine components.
- **Medical Field:** Screw gauge is used in specific medical applications as a measurement means for dental and surgical instruments or for analyzing tiny biomolecules where accuracy is imperative.
- **Educational Institutions:** In classrooms, screw gauges can be used as a means of teaching how measurements are conducted and measured.

Frequently Asked Questions on Screw Gauge

What is Least Count of Screw Gauge?

Least count in screw gauge refers to distance travelled by tip of screw, at movement through one division on head scale.

What is Backlash Error?

Backlash Error is a motion error occurring when gears are changed in a Screw Gauge. This error occurs when, after reversing the direction of rotation of the thimble tip of the screw does not immediately begin moving in the opposite direction but remains stationary for a portion of the rotation.

Who invented Screw Gauge Instrument?

William Gascoigne made the earliest micrometer Screw Gauge in the 17th century.

What is Smallest Measurement Increment of Screw Gauges?

The tiniest measurement increment of the screw gauge is 0.001 mm.

What is Screw Gauge Pitch?

Pitch of a Screw Gauge is defined as the distance traveled by spindle per revolution. The formula to calculate the pitch of a screw gauge is, $p = d/n$, where d is the distance moved by a screw and n is the number of rotation given.

How to Read Screw Gauge?

Screw Gauge reading is read using the formula,

Total Reading = Pitch Scale Reading + Circular Scale Reading \times LC of Gauge

Spherometer

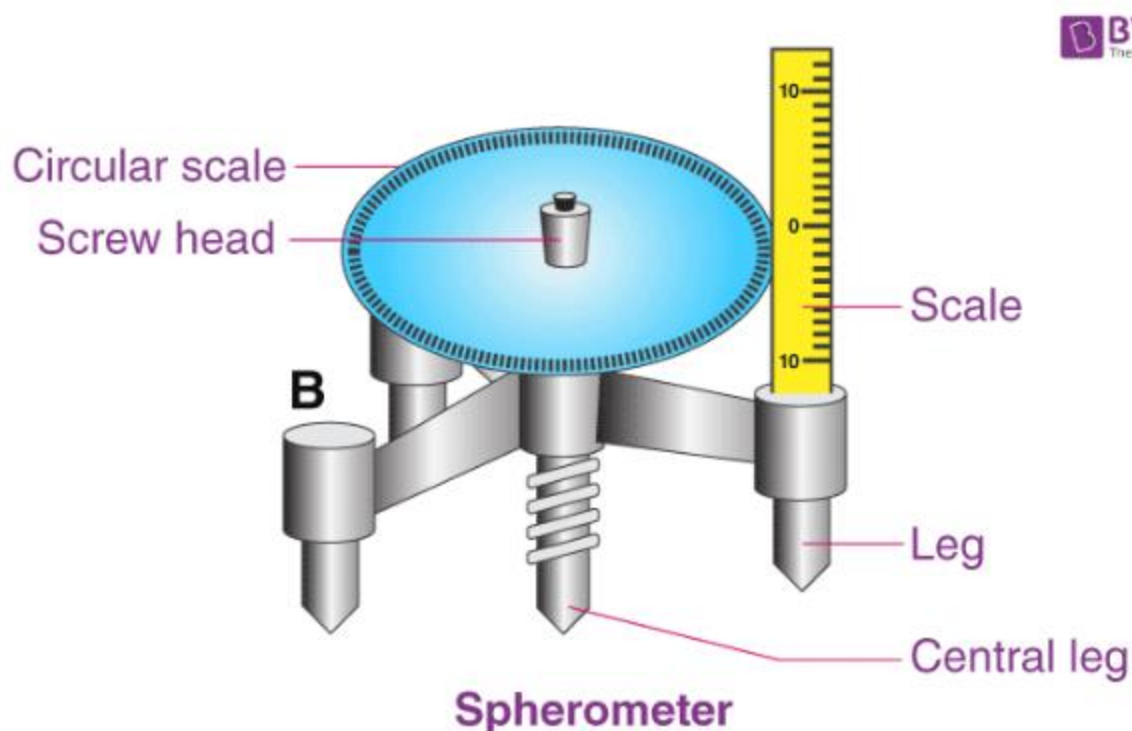
What is Spherometer?

A spherometer is defined as

An instrument that is used for precise measurements of the radius of curvature of either sphere or a curved surface.

The first spherometer was invented by Robert-Aglae Cauchoix who was a French optician in 1810. These were primarily manufactured for the use of opticians in grinding lenses. Astronomers also used this instrument in grinding lenses and curved mirrors.

Spherometer Diagram



Spherometer Working Principle

The working principle of a spherometer is based on the micrometer screw. It is used for measuring with a small thickness of flat materials such as glass or for measuring the radius of curvature of a spherical surface.

Parts of Spherometer

A spherometer generally consists of a base circle of three outer legs, a central leg and a reading device.

- A spherometer consists of a base circle of three outer legs, which is also known as the radius of the base circle, a ring with a known radius of the base circle.
- The outer legs of the spherometer can be adjusted according to the inner holes. This is done to accommodate smaller surfaces.
- The central leg can be moved in an upward and downward direction.
- For taking the measurements, the reading device on the central leg should be moved.

Principles of Operation

If R is the radius of spherical material, then the mean length between two outer legs can be determined by using the formula:

$$R = \left(\frac{h}{2}\right) + \left(\frac{a^2}{6h}\right)$$

Where h is the sagittal measure.

The spherical radius R can be determined by a different spherometer without legs and with circle cup and dial gauge, D is given by the formula:

$$R = \left(\frac{h}{2}\right) + \left(\frac{D^2}{8h}\right)$$

Least Count of Spherometer

Number of divisions on the circular scale = 100

Distance moved by the screw in 10 complete rotations = 10 mm

Pitch = Distance moved/number of complete rotations

Least count = Pitch/number of divisions on the head scale = $1/100 = 0.01$ mm

How to use a Spherometer?

The following is the procedure to use spherometer:

- The instrument is first placed on the perfect plane surface such that the middle foot is screwed down slowly till it touches the surface. When the middle foot touches the surface, the instrument turns rounds on the middle foot as the centre.
- The spherometer is then carefully removed from the surface to take the reading from the micrometre screw. If the instrument is working fine, then the reading should be 0-0. However, there is always a slight error in the instrument which could be either a positive or negative error.
- Take the instrument off the plane and draw the middle foot back.
- Let's consider that we are measuring the radius of the sphere from the convex side.
- Now read the scale and screw-head. If the reading is 2.0 and 0.155, then the total reading is 2.155.
- If the reading is below the zero lines, then the reading should be added to the zero error. If the reading is above the zero lines then the reading should be subtracted from the zero error.
- To measure the length between the two legs, the instrument should be placed on the plain card and using a meter scale the length should be measured.
- Now, calculate the radius of curvature using the following equation:

$$r = \left(\frac{l^2}{6a} \right) + \left(\frac{a}{2} \right)$$

Frequently Asked Questions – FAQs

Q1 Why does a spherometer have three legs?

A spherometer has three legs so that it forms an equilateral triangle. The three legs of the spherometer are used for measuring both positively and negatively curved surfaces.

Q2 How to find the zero error in a spherometer?

A spherometer does not have a zero error because the result obtained is by taking the difference between the final and initial reading.

Q3 Why is a spherometer so called?

A spherometer is so-called because it is used for measuring the radii of curvature of spherical surfaces.

Q4 What is the pitch of spherometer?

The pitch is defined as the distance covered by the circular disc in one complete rotation along the main scale. Therefore, the pitch of a spherometer is given as $1 \text{ mm} = 0.1 \text{ cm}$.

Q5 What is zero error in a spherometer?

The zero error in a spherometer is equal to the reading on the plane glass sheet.

Digital Multimeter (DMM)

A multimeter, shown in Figure 1, is a device used to measure two or more electrical quantities. A multimeter can be used to measure electrical functions such as voltage, current, resistance, continuity and some are able to measure electrical frequency.



Fig.1: Digital Multimeter



Digital Multimeter

A digital multimeter (DMM) is a multifunctional meter that displays its electrical quantitative values on an LCD screen. A digital multimeter much like an analog meter, it is able to read voltage, current, and resistance. What makes a digital multimeter differ from the analog meter is its ability to display measured electrical values quickly without any computations. Because of its design, a processor can be built into the meter which allows the user to take measurements of frequency, the inductance of a coil, capacitance of a capacitor, and a host of other high functional electrical measurements. There two types of digital multimeters (DMM): **scalable digital multimeter** and **auto-ranging digital multimeter** as shown in Figure 1. When working with the scalable digital multimeter you need to have an idea of the value of voltage, current, or resistance that you are attempting to measure. Failure to observe these values will result in inaccurate readings and possible damage to the meter. The auto-ranging digital multimeter is more widely used due to its ease, high functionality, and quick display readings achieved without the user completing the calculations.

The Digital multimeter is the most advanced measuring instrument that makes use of modern Integrated circuits for making electrical measurements. Some of its features which make it famous in the eyes of professional technicians are:

1. It is light in weight.
2. Capable of giving more accurate readings.
3. It measures lots of physical quantities like voltage, current, resistance, frequency, etc.
4. It is less costly.
5. It measures different electrical parameters at high frequencies with the help of special probes.

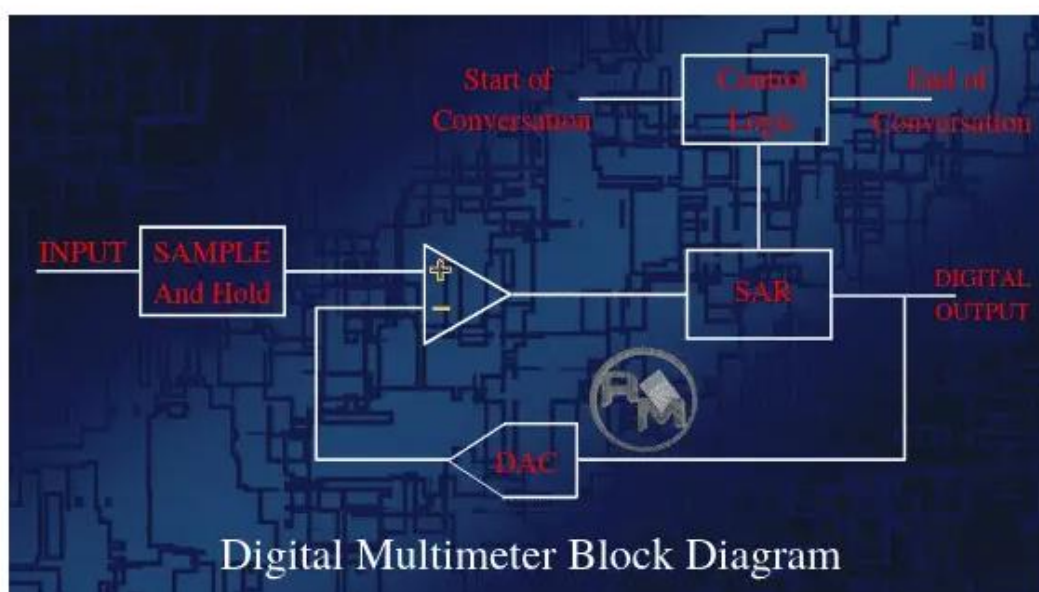
Block diagram of Digital multimeter

The Key process that occurs within a Digital multimeter for any measurement that takes place is that of voltage measurement. If you measure voltage then you can easily measure other electrical parameters with the help of mathematical formulas.

To understand how digital multimeter works, first of all, we have to understand this process.

As we know, Digital multimeters gave output in numeric form due to ADC registers present inside these multimeters. One that is most widely used in digital multimeters, DMMs is known as the successive approximation register or SAR. For better accuracy, these SAR ADCs may have resolution levels of 12 bits.

Generally, a Digital multimeter has resolution levels of 16 bits with speeds of 100k samples per second. These levels of speed are more than adequate for most DMM applications, that's why we are using these registers depending upon the requirement.



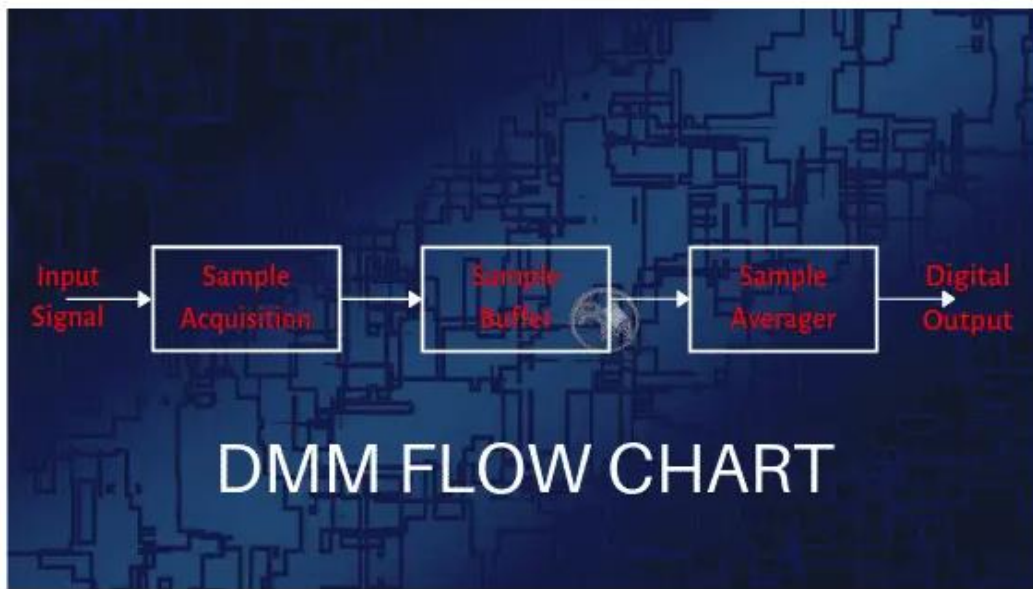
As shown in the diagram, the first stage of the process is a sample and hold used to sample the voltage at the input of the Digital multimeter and then to hold it steady. The output of the first stage becomes one of the inputs of the operational amplifier and another input of the op-amp is digital output feedback through the DAC.

The output obtained becomes the input of the SAR which generates results in digital form with a good resolution level. With a steady input voltage, the register starts at half its full-scale value. It basically sets the most significant bit, MSB to "1" and all the remaining ones to "0".

To see how it works take the simple example of a 4-bit SAR. Its output will start at 1000. If the voltage is less than half the maximum capability the comparator output will be low and that will force the register to a level of 0100. If the voltage is above this, the register will move to 0110, and so on.

Operation of Digital multimeter

The flow chart given below shows the operation flow of the digital multimeter.



As shown above, sample acquisition is done with the help of the sample and hold circuit. Inside the sample and hold circuit the capacitor is present which gets charge to match the input analog voltage known as the acquisition process.

When the capacitor is released from the acquisition circuit then the voltage is considered to be sampled. After this, the noise generally comes which will adversely affect the accuracy of the digital multimeter. To overcome this, we buffered and averaged the samples to achieve high accuracy and resolution.

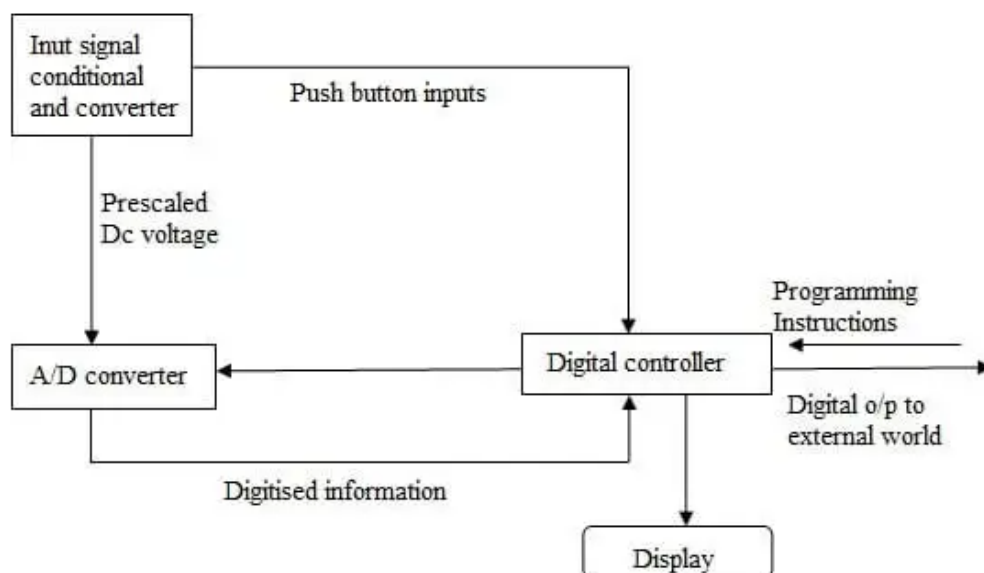
After knowing this you can easily [use a Digital multimeter](#) for measurements of electrical parameters like Ac & Dc voltage, current, Resistance, capacitance etc.

Working Principle of Digital Multimeter

As shown in the block diagram, in a typical Digital multimeter the input signal i.e. ac or dc voltage, current, resistance, temperature, or any other parameter is converted to dc voltage within the range of the ADC. The analog to digital converter then converts the pre-scaled dc voltage into its equivalent digital numbers which will be displayed on the display unit.

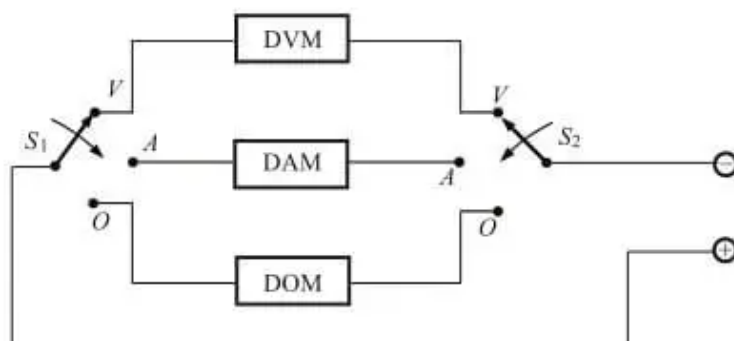
Sometimes, a digital controller block is implemented with a microcontroller or a microprocessor to manage the flow of information within the instrument. This block will coordinate all the internal functions as well as transferring information to external devices such as printers or a personal computer.

In the case of some handheld multimeter, some or all of these blocks may be implemented in a VLSI circuit while the A/D converter and display driver can be in the same IC.



Digital Multimeter as Voltmeter, Ammeter and Digital Ohmmeter

In digital multimeter, we can incorporate many types of meters like ohmmeter, ammeter, a voltmeter for the measurement of electrical parameters. Its block diagram is shown below in the figure. Let us have a look at its working and specification one by one.

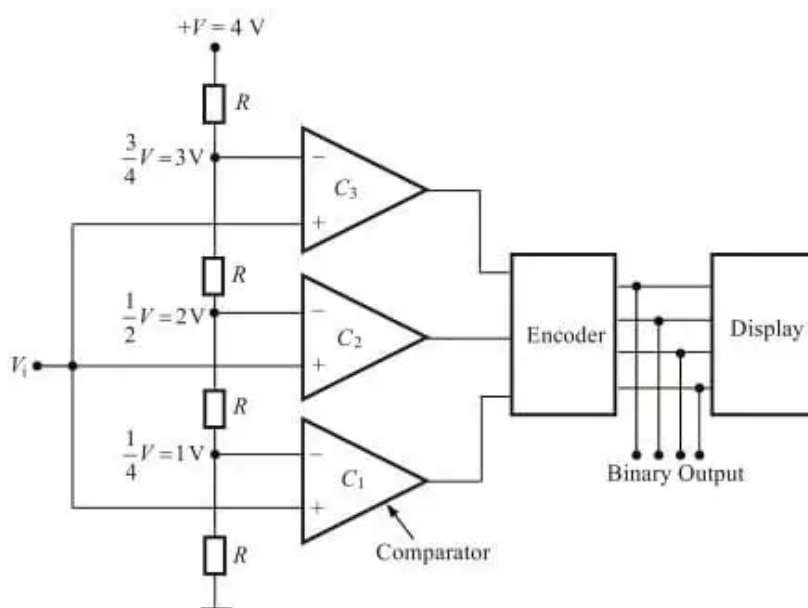


(i) Digital voltmeter (DVM):

Digital voltmeter is the basic instrument used for measurement of voltage through the use of Analog to Digital converter. The basic principle behind digital multimeters is the Analog to digital converter because without this we are not able to convert the analog output into digital form.

There are several ADC available in the market, but we mainly use Flash type ADC due to its simplicity and fastest speed. Let's have a look at its basic operation.

(a) Flash AD converter: It comprises comparators, encoders, and digital displays. Comparators are driven by a resistor divider network, the encoder converts its inputs to corresponding outputs that drive the digital display.

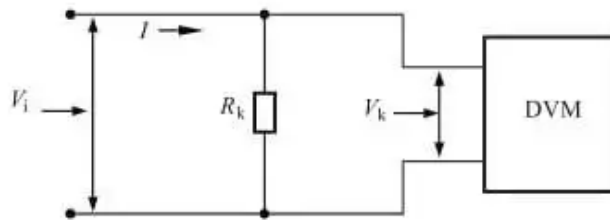


As shown above, three [resistors](#) of value R drives the comparators C_1 , C_2 , C_3 . Let the input voltage $V_i = 1\text{ V}$, $+V = 4\text{ V}$ and comparators i.e. C_1 , C_2 , C_3 voltages equal to 1 V , 2 V and 3 V respectively. If the output of the $C_1 = +1$ and $C_2 = C_3 = 0$, then we fed 001 as the input to the encoder which further converts it into 0001.

This binary output drives the seven segment display to read 1 V on it. With the help of this method, we read the voltages of magnitude 1 V , 2 V , 3 V and we also add more comparators for more accurate readings as per our requirement.

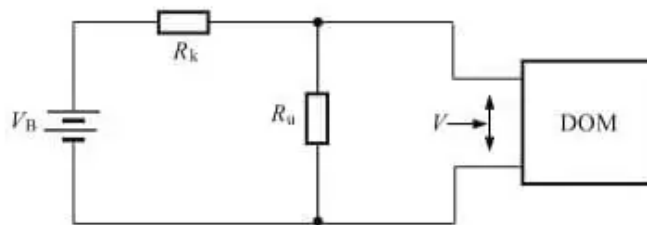
(ii) Digital Ammeter (DAM):

A **digital ammeter** uses a shunt resistor to produce a calibrated voltage proportional to the current flowing. As shown in the diagram, to read the current we must first convert the current to be measured into a voltage by using a known resistance R_K . The voltage so developed is calibrated to read the input current.



(iii) Digital ohm meter (DOM):

A digital ohmmeter is used to measure electrical resistance which obstructs the path to the flow of current.



As shown in the diagram, a resistance network comprising of a known resistance R_K and unknown resistance R_u used to develop a voltage across the unknown resistance. The voltage is given by:

$$V = V_B R_u / R_K + R_u$$





where V_B = Voltage of the built-in battery

After calibrating voltage, the meter can be calibrated in terms of ohms.

What do symbols on Digital Multimeter mean?

Some common Digital multimeter symbols and its description are given in the table below. These symbols are often found on the multimeter & their schematics are designed to symbolize components and reference values of electrical parameters.

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Symbol	Measurement Function	Description
~	AC voltage	Measures Ac voltage value in the circuit
===	DC voltage	Measures Dc voltage value in the circuit
Hz	Hertz	Measures Frequency
Ω	Ohm	Measures resistance value in the circuit
	Diode	A Device used to control the direction of flow of current
μF	MicroFarad	Unit of capacitor
	Capacitor	A Device used to store electrical charge
	Continuity	Audible indication of continuity for low resistance
A	Ampere	Measures Value of Current in circuit
CE	European Union Directive	It indicates the guarantee of an instrument
	Caution	Refers to the instruction before use and indicates that its misuse results in equipment failure
REL	REL	Measures relative or offset reading
Min/Max	Minimum and Maximum	Shows minimum and maximum recorded readings

DMM Parts and functions

A Digital Multimeter is divided into three parts:

(i) Display: The LCD screen present on the upper portion of the multimeter basically displays four or more digits and also shows a negative value if necessary. A few of today's multimeters have illuminated the display for better viewing in low light situations.

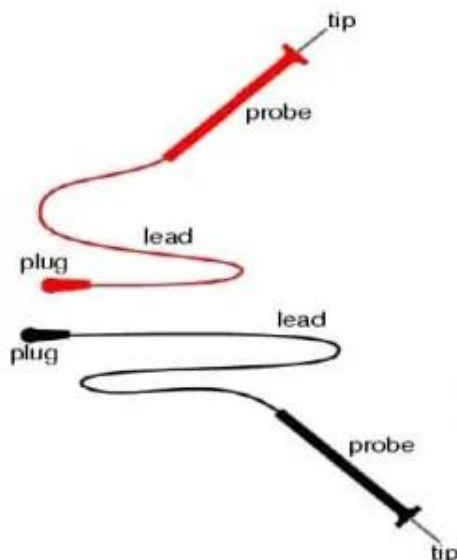
(ii) Selection Dial: It allows the user to set the multimeter to read different electrical parameters such as milliamps (mA) of current, voltage, resistance, capacitance, etc. You can easily turn the dial anywhere for specific parameter measurements.

(iii) Ports: Two ports are available on the front of every multimeter except in some four ports are available for measuring current in mA or A. We plugged two probes into these ports which are of different colors i.e. one is of red color and the other is of black color. Different Ports in multimeter are:

(a) COM: It stands for common and is almost connected to the ground or considered as a -ve connection of a circuit. We generally insert the black color probe into the COM port.

(b) mAVΩ: This port allows the measurement of current (up to 200 mA), voltage and resistance; and is considered as a +ve connection of a circuit. We generally insert the red color probe into the mAVΩ port.

DMM Leads:



In the box of a digital multimeter, we got leads of different colors. Here we are going to explain these leads in detail. DMM leads are subdivided into four parts:

(i) Red lead

1. Connected to voltage, resistance, or ampere port.
2. Considered as a +ve connection of a circuit

(ii) Black lead

1. Connected to the common or ground port
2. Considered as a -ve connection of a circuit

(iii) Probes:

These are the handles used to hold the tip on the tested connection. There are different types of probes available, they are:

- Banana to Alligator Clips: These are great cables for connecting to large wires or pins on a breadboard. Good for performing longer-term tests where you don't have to hold the probes in place while you manipulate a circuit.
- Banana to IC Hook: IC hooks work well on smaller ICs and legs of ICs.
- Banana to Tweezers: Tweezers are handy if you need to test SMD components.
- Banana to Test Probes: If you ever break a probe, they are cheap to replace.

(iv) Tip:

These are present at the end of the probes and basically, provide a connection point.

Digital Multimeter Measurement Time:

Professional technicians always prefer those instruments whose **time of measurement** plays a crucial role leads to good results with better accuracy. Measurement of time basically depends on the following factors:

i) **Settling time:** When the value to be measured is applied to the input of the circuit it would take a certain time to settle is known as settling time. This will overcome any input capacitance levels when high impedance tests are made.

(ii) **ADC calibration time:** In some DMMs, a calibration is periodically performed must be accounted for especially where measurements are taken under automatic or computer control.

(iii) **Switch time:** The switch time is the time required for the instrument to settle after the input has been switched. This includes the time to settle after a measurement type has been changed, e.g. from voltage to resistance, etc.

(iv) **Auto-zero time:** To ensure accuracy it is necessary to zero the meter when auto-range is selected, or range changes are made.

(v) **Signal measurement time:** This is the basic time required to make the measurement itself. For AC measurements, the frequency of operation must be taken into account because the minimum signal measurement time is based on the minimum frequency required of the measurement.

Digital Multimeter Accuracy

A Digital multimeter is an ideal choice for every professional technician because of its better accuracy. It is the amount by which the displayed reading can differ from the actual input. Digital multimeter usually defines accuracy as a percentage of reading plus a percentage of full-scale value. Accuracy depends upon the specifications of the instrument varies from manufacturer to manufacturer. There are a number of ways in which the **multimeter accuracy** may be expressed:

1. **DMM Accuracy = \pm (ppm of reading + ppm of range)**
2. **DMM Accuracy = (% Reading) + (% Range)**
3. **DMM Accuracy = (% Reading) + Offset**

Factors affecting the accuracy of Multimeter are:

(i) Temperature: To a large extent, the temperature can affect the accuracy of Digital multimeters. Today many multimeters have an inbuilt temperature feature which eliminates the need for any external device. You can express them as \pm (ppm of reading + ppm of range)/°C.

(ii) Resolution: Resolution is directly proportional to accuracy. If you want accuracy you have to take care of resolution also. The **resolution of a Digital multimeter** is expressed in terms of the number of digits displayed. Typically this will be a number consisting of an integer and a half i.e. 3 ½ digits etc. By convention, a half digit can display either a zero or 1.

Note: Different multimeters from different manufacturers may work in different ways. It is always recommended to consult the manufacturer's instructions to understand how a particular digital multimeter works.

DMM Safety Precaution:

Before operating multimeters, we have to follow some safety precautions. Here we are going to explain to you some safety information about DMM.

1. If the DMM test leads are damaged then never use the meter.
2. Always ensures that the test leads and dial are in the right position for the desired measurement.
3. When a test lead is plugged into the 10 A or 300mA input jack then never touch the probes to a voltage source.
4. When power is applied never measure resistance in a circuit.
5. While making measurements always keep your fingers behind the finger guards on the test probes.
6. To avoid damage or injury, never use the meter on circuits that exceed 4800 watts.
7. Replace the battery as soon as possible to avoid false readings which could lead to possible electric shock or personal injury.
8. Be careful when working with voltages above 60 V DC or 30 V AC RMS. Such voltages pose a shock hazard.

How to use a digital multimeter

Step by Step Guide on how to use a multimeter to test for voltage

Testing for voltage is carried out to ensure the effectiveness of the electrical system. Loads (for example lights or motors) that are designed to do the work need a nominal voltage to operate. Overvoltage will result in equipment failure and not enough voltage will result in the load not turn on. When testing voltage there is an expected voltage reading to look for. If the load is rated at 120 volts then the expected reading from the outlet needs to be 120 volts plus or minus 10%. If the voltage reading is out of specifications then the problem can be found using the voltmeter to isolate the load and find if there is a problem with the source or the load.

Here is a step by step guide on how to use a multimeter to test for voltage:

1. First, figure out whether the application being testing utilizes AC or DC voltage. Afterward, adjust the meter dial to the suitable function to DC Voltage or AC voltage.
2. Adjust the range to the number little higher than the predictive value. If the value being measured is unknown, then set the range to the maximum available number.
3. Plug in the test leads into the common (black) and voltage (red) terminals.
4. Apply the leads to the test circuit.
5. Position and reposition the test till a dependable reading appears on the meter LCD.
6. While measuring AC voltage, variations may happen in the reading. As the test continues the measurement will steady.

Step by Step Guide on how to use a multimeter to test for Current

Testing for current is used when there is no physical way to tell if a load is doing its job because there are no indicators or the load is located in a hazardous area. When the voltage is tested and found to be present at the load, it doesn't tell the whole story until a current is measured. It is important to understand a load consumes power which is measured in watts. Watts is calculated by multiplying volts by the amps. A digital multimeter is used to measure or give a good indication of current flowing.

Testing current with a Digital Multimeter

1. Plug the leads into the terminals marked mA for low current or A for currents over 500mA.
2. Set the dial to AC or DC current depending on the circuit being measured.
3. Apply the leads to the open circuit current and observe the measurement.

Note: For current measurements above 1A, normally clamp meter is used while for current less than 1A, a standard DMM is used.

Step by Step Guide on how to use a multimeter to test for Resistance

Resistance testing is done to ensure the load or circuit being tested is complete. A complete circuit means there is no break or opening in the wires connected to the load or the internal components of the device being tested. An open circuit or broken line means that the load will not work as designed. Resistance testing is sometimes referred to as continuity testing. Continuity testing does the same action as resistance testing with the exception that continuity testing emits an audible sound indicating that the circuit or wires are complete. The resistance testing and continuity testing are also a good way to check for short-circuits and the ground fault which are events that cause circuit breakers to trip, fuses to blow, and possible injury to workers in the field.

To test resistance with a Digital Multimeter

1. Turn the power off in the circuit being tested.
2. Adjust the meter dial to the resistance mode.
3. Choose the suitable range on the dial.
4. Plug in your test leads into the suitable terminals.
5. Connect the leads to the component being tested and note a reading.

Note: It is important to have good contact between the test leads and circuit being tested. Dirt, bodily contact, and poor test lead connection can considerably alter the readings.

Test continuity with a Digital Multimeter

1. Adjust the dial to the meter continuity (the little speaker) function.
2. Plug the test leads into the suitable terminal.
3. Touch the component under test using the leads

The DMM beeps under good continuity that allows the flow of current. If no continuity exists, the DMM does not beep.

Circuit Tester

A circuit tester is a handy dandy tool for all kinds of electrical functions. People who design their own homes find this tool very useful to check the wiring. There are many types of testers and one might be an expert identifying the varieties. However, it'd be great to know how it works.

The basic function of the tester is simple. When you attach the two leads of the tester to the wires or to an electric socket, the little neon bulb in the tester lights up. This means the circuit of the socket is complete and properly wired. When the metallic tip touches the conductors, the tester completes the circuit by using the capacitance in the tester. The flow of voltage from the sockets to the tester lights up the neon bulb.

What Is A Circuit Tester?



There are many **types of electric testers** to measure the voltage, current, continuity, and resistors. And circuit tester is one of them.

A circuit tester is a device that measures the flow of electricity of open-wire or electric circuits. It also measures the absence and presence of voltage at any point of the circuit wires. It basically tells you if a circuit is working or not. We often need a circuit tester to test ground wires. Also, the tester informs us if a circuit is good or not. So, it's ideal to buy a circuit tester that is rated for up to 500 voltage source.

Another interesting fact about circuit testers is that these tools don't need any batteries to run. Even if you have a voltage stick, you can keep the circuit tester as a back. Because it will come in handy once the battery of other testers runs out.

A circuit tester is also called a **receptacle tester** or an **outlet tester**.

Constructions Of A Circuit Tester

Now that we know what a circuit tester is let us find out how it's constructed. The constructions and the integral parts of the tester are important because they'll help you find out the function of the tester. Knowing the construction also helps the diyers.

In a typical circuit tester, there are mainly four parts that we need to know about. In this article, we'll be discussing these four parts.



The Metal Rod

A two-lead circuit tester consists of two wires. These two wires have a cylindrical metal screwdriver/rod/probe at the terminal. This is the part that is attached to an outlet/wire/switch. Some probes run with a battery. The current flows through these metal leads to the light bulb and resistors within.

Plastic Body

The resistance, neon light bulb, and the wires from the metal leads are covered by a plastic insulated body. The wires from the meatal leads are also in the plastic body.

Resistor

A resistor opposes the amount of current flow. Using a tester without a resistor is dangerous. The reason is that without the resistor the current flowing through the wires could break the neon light bulb/test lights. A resistor in-circuit testers is placed between the neon light bulb and the metal wires. This way high current cannot reach the test lamp.

Test Light

This is the most crucial part of a circuit test. **Test lights** are the only indicator of a complete circuit. And it doesn't require a lot of currents to light up the bulb. That's why tester with light bulbs are more reliable.

Caution

While working with the wires, you need to keep this information in mind-

- Make sure you don't touch the metal leads/probes when they are connected with wires.
- Keep away from the hot wire while using a voltage tester.
- Do not let the hot wire come in contact with anything else.

Just like we promised, using the circuit/wiring tester is simple and will not take much of your time. What's more interesting, the mechanism of a tester is easier than using it.

How Does A Circuit Tester Function

By now, we hope you'll be able to use circuit testers. The process of the tester is even more interesting.

There are many kinds of **electrical tester screwdrivers**. Some of which detects voltage, some measure the amount of current and some measure the amount of resistance. However, among all the other electric testers, a circuit/wiring tester is the most reliable and safest way to find out the current flow of a circuit.

When metal probes/metal tip are connected to the hot and ground wire, current flows from one lead to the other. This current flows through the resistor and the neon light bulb. Neon indicator lights don't require much voltage. It only takes a little amount of voltage, in most cases 100V to light up the neon test lamp.

So if the light bulb of the tester lights up then the circuit is in perfect condition. You don't have to fret about it anymore.

Another important of data about these tool, the resistor in the tester is also a hero in this case. Because it reduces the amount of current passing through the wires. This converts the high current to a suitable amount for the test light bulb. Otherwise, the test light bulb may get damaged.

In this way, a current running through the circuit/wiring tester can help you identify the functional circuits of your home.

Why Do We Need Circuit/wiring Tester?

If I answer simply, we need circuit testers for home wiring.

Suppose you've moved to a new home, and you want to figure out if all the circuits are grounded or not. Whether all the sockets are functional. In this case, the only way to check the circuits is by testing with circuit testers. Using the tester, we will be able to find out if there are any wiring errors.

Again, if you have designed your own home, you'll need a tester to find out if all the circuits are fine and in working conditions.

Moreover, you can test all your circuits to check if they are grounded properly or not.

Aren't circuit testers lifesavers?

Electronic Balance

What is electronic balance?

An electronic scale is a tool used to accurately measure the weight of materials.

An electronic scale, also known as a digital scale, is a weighing instrument that measures the mass or weight of an object with high accuracy.

Principle:

Electronic scales are weighed according to the principle of electromagnetic force balancing. When measuring an object, the principle of balancing the electromagnetic force with the gravity of the object to be measured is used to obtain the measurement. When the weighing pan is on the machine or the object to be weighed is removed, the scale becomes unbalanced. At this time, the displacement of the coil in the magnetic steel can be detected by the displacement detector, and the current is digitally displayed by the automatic compensation circuit of the electromagnetic force beyond the weight of the object.

Common types:

Electronic scales, also known as digital scales, are precision weighing instruments used in various scientific and industrial applications. There are several types of electronic scales, each designed for specific purposes. Here are some common types:

Analytical Balances: They are highly sensitive instruments used for accurate weighing in laboratories. As a rule, they have higher accuracy and accuracy than other types of electronic scales. Analytical balances can measure mass with an accuracy of 0.0001 grams (0.1 milligrams).

Precision balances: These are similar to analytical balances, but offer slightly less precision and accuracy. They are often used in research, quality control and manufacturing where high accuracy is required, but not at the level of analytical balances. Precision scales typically have a resolution of 0.001 grams (1 milligram).

Top Loading Scales: They are versatile instruments suitable for a wide variety of applications. They have a higher load capacity than analytical and precision balances and are used when a higher load capacity is required while maintaining acceptable accuracy. Top-loading scales usually have a resolution of 0.01 grams (10 milligrams) or better.

Moisture balance: It is also known as moisture analyzers or moisture meters, are specialized electronic balances used to determine the moisture content of a sample. They include heating elements and precise temperature control to measure the weight loss of a sample as it dries, allowing calculation of moisture content.

Portable scales: They are compact, lightweight, battery powered scales designed for portable weighing applications. They are usually used in the field or in situations where mobility is required. Portable balances have lower capacity and accuracy than laboratory balances, but provide sufficient accuracy for many applications.

Counting Scale: It is used to determine the number of items based on their weight. They are equipped with a piece counting function that calculates the number of pieces based on the weight of one piece and the total weight of the sample.

Heavy Duty Scales: They are heavy duty weighing instruments designed for large, heavy loads. They have a higher payload capacity than other types of scales, often ranging from a few kilograms to a few tons, depending on the model.

These are some of the most common types available in the market. The choice of balance depends on your specific weighing requirements, required accuracy, sample size and intended application.

Balance sheet structure:

Weighing Bowl: The weighing bowl is mounted on the sensor and is usually round or square in shape and mainly made of metal materials.

Sensor: The body, magnetic steel, pole shoe, and coil make up one of the primary parts. Under the balance. The accuracy is very high and very sensitive. The balance must be kept clean and the sample must not be spilled to prevent correct operation of the sensor.

Position detector: Its role is to convert the load on the weighing pan into an electrical output signal.

PID controller: ensures fast and stable operation of the sensor.

Power Amplifier: The purpose of a power amplifier is to amplify weak signals.

Digital-to-analog converter: high conversion accuracy, easy auto-zero and effective noise reduction.

Screen

shell

Legs: Adjust the level by adjusting them.

Index of the main features of electronic scales:

Stability: This is the ability of the balance to automatically return to its original balanced position after being disturbed. After the balance is affected by the interference, although the value has changed, the original value can be restored after the interference is removed, indicating that the balance is stable.

Sensitivity: Sensitivity refers to how fast the scale can read. The smaller the mass variation that can be detected by the balance, the greater the sensitivity.

Accuracy: that is, the accuracy of the measurement.

Invariance

How to manage the balance?

Level control: Verify that the level's bubbles are in the ring's centre before turning on the scale. The horizontal bladder is adjustable with bolts on the legs.

Warm-up: A minimum warm-up time of 30 minutes is required after switching on. Therefore, do not turn off the power often.

Weighing: To activate the display, press ON.

Wait for the device self-test: According to the display, the self-test is completed before weighing.

Insert the weighing card and press the Tare button. The display shows zero and the entered weighing object.

After weighing, switch off the display.

What are the advantages of electronic scales?

Electronic scales are generally more accurate than their analog counterparts because they use digital technology to provide more accurate measurements. In addition, these scales often have built-in calibration functions that ensure accuracy and precision.

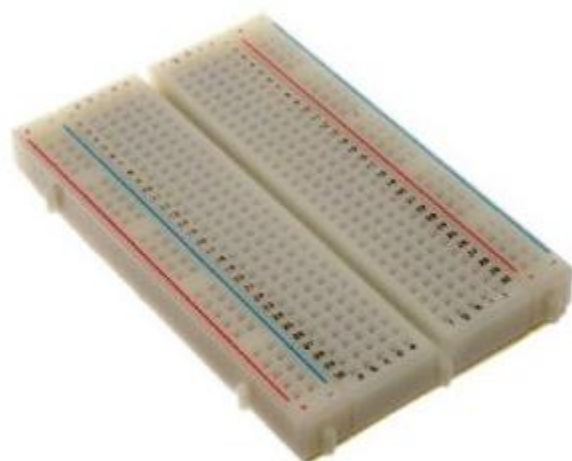


Breadboard

In the initial days of electronics manufacturing, engineers and designers have realized that sometimes designing a temporary circuit needs without soldering the **components**. So, an engineer took cardboard and arranged several rows into it to place nails. As per the circuit diagram, they placed components and nailed them through short wire pieces. The electrical connection can be provided by wrapping wire or soldering around the nails, and then components could be soldered to the wires. But by using cardboard, some resistive features may cause power loss. So, to overcome this process, at present breadboards were implemented by the scientists. Breadboards are one of the most essential rectangular pieces, used to build different circuits without soldering. This article discusses an overview of what is a breadboard, working, types and applications.

What is a Breadboard?

As the name suggests, the term breadboard can be derived from two terms namely bread & board. Initially, this was used to cut the bread into pieces. Further, it was called a breadboard & it was used in electronics projects and electronic devices in the year 1970. A breadboard is also known as a solderless board because the component used on the breadboard does not need any soldering to connect to the board, so it can be reused.



Breadboard

The arrangement of different components on a breadboard can be done by inserting their terminals into the breadboard, so it is frequently known as a plugboard. Breadboard definition is a plastic board in rectangular shape that includes a lot of small holes in it to allow you to place different components to build an electronic circuit is known as a breadboard. The connection on the breadboard is not permanent but they can be connected without soldering the components.

If you make any mistake while connecting the components, you can place or remove the components effortlessly. For beginners of electronics, this device is very helpful to make mini-projects. If a designer builds a simple circuit that they desire to analyze, then a breadboard gives a quick solution. The breadboard diagram is shown below.

The material used to make the breadboard is white plastic. At present, most of the breadboards are solderless types, so we can directly plug in the components directly and connected them through the exterior power supply. The different kinds of breadboards are accessible according to the specific point holes. For instance 400 point type, 830 point type, etc.

Specifications & Features

The **specifications & features of a breadboard**, include the following.

- Distribution Strips are two
- Wire Size is 21 to 26 AWG wire
- Tie Points are two hundred
- Withstanding Voltage is 1,000V AC
- Tie points within IC are 630
- Insulation Resistance is DC500V or 500MΩ
- Dimension is 6.5*4.4*0.3 inch
- Rating is 5Amps
- ABS plastic through color legend
- ABS heat Distortion Temperature is 183° F (84° C)Hole or Pitch Style is 2.54mm

Types of Breadboard

Breadboards are classified into two types like a solderless breadboard and a solder-able breadboard.

Solderless Breadboards

This is the most commonly used breadboard for prototyping as well as testing electronic circuits without soldering the components. These are available in different shapes, sizes as well as ratings.

The circuits on these breadboards are not permanent so we can check & test the functionality of a circuit before confirming its design onto a **PCB**. These breadboards include rows & columns with holes that allow the leads of components & wire gauges.

If the terminal of the component does not place into the hole of a breadboard, then a connecting wire can be soldered to the lead of a component that will insert in the breadboard hole.

Advantages

The **advantages of solderless breadboards** include the following.

- It doesn't require soldering to connect the components on board.
- If the circuit is not working properly then, we can easily check and rectify them by taken out the components & replace them easily.

Disadvantages

The **disadvantages of solderless breadboards** include the following.

- Components that are connected to the breadboard can come loose once the breadboard is pushed or moved.
- This kind of breadboard is available with high parasitic capacitances because of the capacitances among different components which are being close to each other.
- These breadboards are restricted to below or 10 MHz frequencies.

Solderable Breadboards

These types of breadboards offer a permanent setup for your **electronic circuits**. This kind of breadboard gives a stronger setup. It includes holes for electronic components including copper tracing. These components can be soldered using soldering iron for soldering the components to the breadboard so that an electrical connection can be formed through the copper tracing.

For designing a circuit, jumper wires are needed for soldering separately in between these components to make a lane to permit the flow of current. These types of breadboards are available in different sizes based on the requirement.

Advantages

The **advantages of solderable breadboards** include the following.

- These breadboards are robust and your circuit will be very secured on this type of breadboard.
- This kind of breadboard gives your project a more specialized look.
- Less cost and saves time while designing a circuit.

Disadvantages

The **disadvantages of solderable breadboards** include the following.

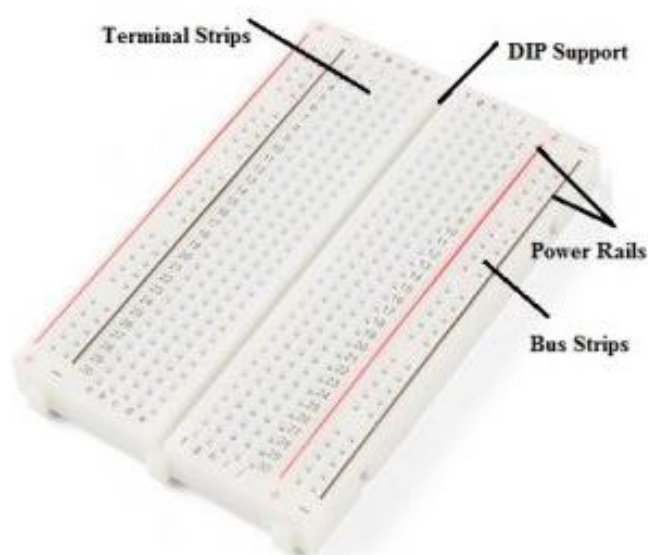
- If there is any error occurs in the circuit then de-soldering may cause damage to components
- This board cannot be reused.

Selecting the breadboard from these two types will depend on the requirement as well as application. We have already discussed the pros and cons of these types of breadboards, so you can select accordingly

A solderless breadboard is suitable when you want to check a circuit without soldering the components. Similarly, if you want to check your circuit below some conditions that involve several movements similar to a robot then a solderable breadboard is the best option.

Breadboard Connections/Layout

Breadboards include several holes which are called tiny sockets. The arrangement of these can be done on a 0.1 grid. Most of the terminals of components can be placed directly into the holes on the board. **Integrated circuits (ICs)** are arranged across the middle gap through their dot or notch to the left. The designing of wire links can be done using a wire coated with plastic and single-core and the diameter of the wire is 0.6mm. Here, each connection on the breadboard is discussed below.



Breadboard Layout

Different electronic components are compatible with breadboards like resistors, capacitors, switches, diodes, etc. These components which include lengthy metal legs are known as leads whereas components that include shorter metal legs are known as pins. All the electronic components including different sizes of leads will function through a breadboard.

Breadboards are mainly designed with holes to insert the components in the holes tightly, so they cannot fall out but they can drag them to detach them. The appearance of a breadboard includes rows, column, numbers, letters, blue & red lines

Letters

Letters on the breadboard are printed at the top & bottom that ranges from A to J that runs horizontally & the holes can be divided consistently into vertical lines.

Numbers

The horizontal rows can be identified through 1 to 30 numbers which are printed on the right and left edges on half-size breadboards, whereas in full-size boards 60 or 63 numbers are printed. Both the numbers & letters together will direct you to place a specific hole simply while designing complicated circuits.

Terminal Strips

In the breadboard connection, the metal rows include small clips under the holes of a breadboard. The arrangement of every socket and metal strip can be spaced through a typical pitch with 2.54mm. These clips give support to connecting wires as well as leads of components to stick into the breadboard holes.

When any component is placed on a breadboard then the power supply can also be provided to any hole in that row because these are conductive & permits the flow of current from any end in that strip. Each strip in the breadboard includes five clips so we can connect simply five components within one specific section in the breadboard.

The row in the breadboard includes ten holes where each row can be separated through a crevasse or ravine in the center of the breadboard. This ravine separates both sides of rows & they are not connected electrically.

Power Rails

In the breadboard, there are horizontal and vertical rows, where the horizontal rows can be known as power rails and vertical rows are known as terminals. These are mainly useful in connecting the power supply toward the breadboard.

On this board, the red lines are positive rails whereas the blue lines are the negative rails. Usually, breadboards have different connections like power rails which are known as metal strips.

While connecting a circuit on a breadboard, we need power in various places, so power rails can provide you easy access wherever you require it within your circuit. Here, power rails (red/black or blue strips) are labeled with positive (+) and negative (-) symbols for indicating the +ve & -ve sides.

It is significant to be alert that the power rails on each side are not connected, thus if you want a similar power source on two sides, then you have to connect the two faces through some jumper wires.

Rows and Columns

In breadboards, we can notice that rows and columns are marked through letters. These are very helpful while designing a circuit on the board. If the component on this board is misplaced by mistake then the circuit can get quickly complicated otherwise it will not work at all. If you identify the row number in the breadboard for the connection then it is very easy to place the component into the board.

On the breadboard, the connection of the circuit doesn't have to be in the correct location as shown in the circuit. Actually, it doesn't even have to look similar. If all the circuit connections are being completed, you can design your circuit in your way.

Terminal Strips

Terminal strips in breadboards occupy most of the place. These are made up of small holes, where you can insert your components. The connection of these strips can be done in a specific way depending on their columns & rows. It is essential to recognize the terminal strip layout on the breadboard. Check the breadboard labeling before inserting components.

Metal Clips

In every breadboard, metal clips will hold an electronic component once it gets plugged in. The arrangement of these clips can be done in lines that respond to the rows as well as columns on the terminal strips of the breadboard. So that you can notice & control which components are inserted on the board

Binding Posts

Some kinds of breadboards are designed on a stand that includes binding posts by attaching to it. These posts permit you to attach all types of power sources to your board. In some types of breadboards, binding posts are used to connect exterior power sources. The primary step to use these posts is to attach them to the board through some jumper wires.

By using these posts, we can simply connect wires toward the posts to attach them to the board. Usually, you have to attach a power as well as the ground wire from the posts toward the breadboard. If you require any additional power source, then you can utilize the alternate post. Once the posts are connected to the breadboard, then you can use several methods to fix the power supply toward the posts as well as toward the breadboard.

Benchtop Power Supplies

Benchtop power supplies mainly used in electronics labs which provide an extensive range of current & voltage to your circuit. A banana connector is used to give a power supply toward the binding posts. The power supply to a breadboard can be supplied with binding posts using banana cables.

On the other hand, you can use IC hooks, alligator clips otherwise any other cables through a banana connection to hook your board up to various supplies. Another advanced technique of utilizing the binding posts is to connect a barrel jack with wires & attach them to the posts but it needs some middle soldering skills.

Connection of ICs on Breadboard (DIP Support)

Generally, connecting electronic components on a breadboard like resistors, capacitors, diodes, etc is quite easy but connecting integrated circuits (ICs) is quite different. When we notice the board, there is a gap line within the two vertical columns. This gap is very helpful in connecting ICs on a breadboard.

We can place any size of integrated circuits onto the breadboard through break rail without shorting its terminals. You can notice the connection of IC in the following image, which includes five holes within a single column. Once an IC is placed then we can have four available holes for each pin of an IC to make interconnection. We can place a wire at any place from these 4 points to acquire a connection through that specific IC pin.

Breadboard Wires

There are different types of wires are used for breadboards based on the requirement. So selection of wires is essential for breadboards to build the projects, so instead of standard wires, different types of wires are used which include the following.

Jumper Wires

Jumper wires are used in making small circuits as they are slightly longer. These wires are harder to track the errors. Jumper wires metal pins connected to the end and are flexible, so it will be simple to insert into the board. In electronics stores, these wires are easily available but at little cost.



Jumper Wire Kit

The jumper wire kit is one kind of plastic box including wires in different sizes, lengths, and colors. Both the ends of these wires are twisted at 90 degrees so that it will be very easy to insert into the breadboard. As compared to lengthy wires, these wires are very perfect & neater. Jumper wires are available with two or more links in several colors, make it difficult to arrange the circuit with standard color code.

Hookup Wires

These wires are also called lead wires which are available in rolls and insulated with single-core. The length and the insulation of this wire can be removed through some tools namely wire strippers to use as a jumper wire. These kinds of wires are available in various colors and at less cost. So we can easily color-code the circuit.

Before choosing these wires, one thing we have to keep in mind that is, you have to purchase solid single core type wire instead of standard wire. Because solid core type wires are designed with a single solid metal part because these are very rigid. So inserting it into the breadboard is very simple. Whereas, standard wires are designed with several separate wires but these wires are very solid to insert into the breadboard.

Alternatives

The alternatives of breadboards which need soldering are veroboards & protoboards. The most similar type of board is the Veroboard which includes holes that are connected through a single axis. Another alternative is protoboards which include similar kinds of holes but none of the holes on the board are connected.

Advantages

The **advantages of breadboard** include the following.

- It is used to make a temporary prototype for the electronics projects
- This is reusable because it doesn't need any soldering.
- These boards are less weight because the material used to make this board is a lightweight plastic material.
- Testing can be done very easily
- The arrangement of these components can be done very simply into the holes on the board to make the design of a circuit.
- It is economical and simple to use
- It does not use any difficult parts.
- Drilling is not necessary to connect the components because the holes on the board are embedded already
- Modifying can be done very quickly
- We can add or remove the components on the breadboard
- These boards are available in different sizes and shapes
- These boards can be adjusted very easily

Disadvantages

The **limitations or disadvantages of breadboards** include the following.

- These boards are not used for high current applications
- For low-frequency applications, low-frequency boards are not used
- For making simple circuits, it needs more physical space.
- The number of connections on the breadboard can make the circuit messy because of several wires.
- The connections on the board can be disturbed once the components are connected or removed.
- Reliable connections are less
- Signaling is limited.

Uses/Applications

The **applications or uses of a breadboard** include the following.

- The main application of a breadboard is to form simple electrical connections among different components so that you can check your circuit before soldering it to the board.
- These boards allow different components to be simply placed or removed or the term prototyping instantly comes to mind permanently.
- If a designer designs a simple circuit or module then they need to check, so this board offers a fast & cheap solution

Different Ways to Power a Breadboard

There are different methods to providing power supply to a breadboard like using Arduino Board, Battery & a Dedicated Power Supply.

Using Arduino Board

If you are an Arduino user, then this technique is very simple for you because, the **Arduino board** gets its power supply from an exterior power supply or a computer, so you can just give power to a board by borrowing its power supply. To protect the board from the Arduino, you need to follow these steps

- First, connect the GND pin of an Arduino using female headers to the power rails of the board
- From the header, the red wire can be connected to the +ve power rail of the board
- Black wire can be connected to the -Ve power rail of breadboard from the GND terminal of Arduino.

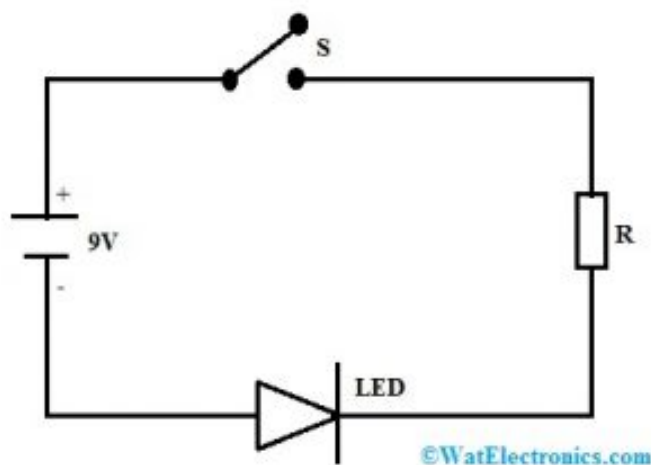
Using a Battery

- The second method to power a breadboard is using a battery like the following.
- Connect the red wire of a battery to a positive bus
- Connect the black wire of the battery to the negative bus

How to Use a Breadboard?

Here is a simple example circuit to know how to use a breadboard. First, we need to connect a simple circuit to the breadboard. Previously, we have discussed the board, connections, and it's working but now we have to start connecting a circuit on a breadboard. Here, a **simple LED circuit** is taken to give connections on the board. This circuit can be built with a resistor, LED, and power supply. To make a circuit with an **LED**, the following steps we have to know.

- A breadboard
- Connecting wires
- 9V battery
- Battery



Basic LED Circuit Diagram

Step-1

Place the LED into the Breadboard by bending the long terminal of the LED. Plug the anode terminal of the LED into the top rail on the breadboard whereas the short terminal is inserted into the main part

Step-2

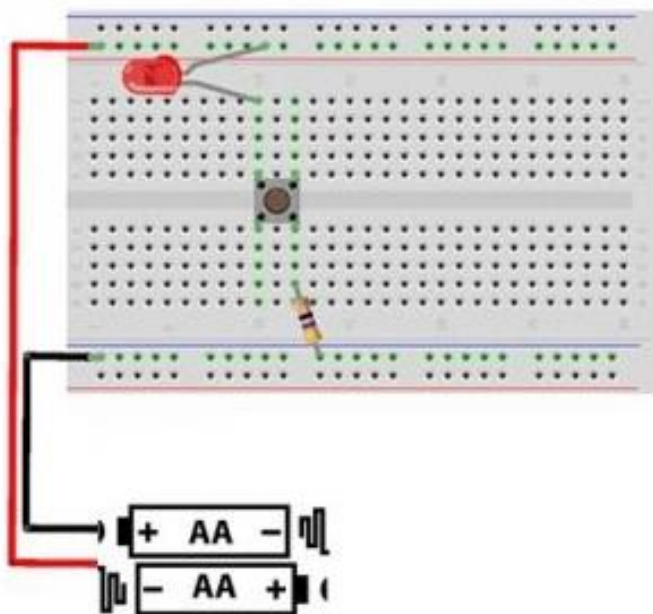
Place the resistor on the breadboard & bend the resistor terminals to plug one of the terminals of a resistor into a hole under the cathode terminal of the diode.

Step-3

Place the connecting wire into the Breadboard under the resistor terminal & the bottom rail.

Step-4

Connect the two terminals of the battery to the Breadboard. In this board, the battery's red wire can be connected to the top rail whereas the black wire can be connected to the bottom rail. Switch on the battery to provide the power supply to the circuit so that the LED will turn ON.



Circuit Connection on Breadboard

Common Mistakes

A common mistake while connecting a circuit on a breadboard is not very important because connections of the board are temporary. So, you can simply reconnect the circuit by changing the components. However, you have to pay attention to some common faults & keep away from them to complete your project easily. The common mistakes are

- Touching terminals
- Forgetting to connect both faces of the board using jumper wires
- Leads connection to incorrect row
- Mixing positive & negative wires
- Reversely connected polarities
- Inadequate contact among leads & clips
- Connecting one component leads within the similar row

Safety Tips for Breadboard

It is very important to connect a circuit systematically & neatly on a breadboard so that one can correct it & get it running simply & rapidly. It also assists once someone else requires knowing and inspecting the circuit. The following tips are very useful for breadboard.

- Use the top & bottom bus rails always for connecting power supply instead of using a direct power supply
- When the jumper wires are coded with color then it will help in reducing the confusion while designing a circuit. For instance, green color wires are used for GND connections, red color wire for +Ve power whereas black color one is for -Ve power connections.
- Jumper wires should be connected lay flat on the board so that the board does not turn cluttered.
- Connect the jumper wires in the region of the ICs but not on the packages so that IC can be changed easily when required.
- Cutting the components leads can lead to insert very closely to the board.
- Be careful when connecting components
- It is significant to be particularly careful while placing ICs into the holes of the board.
- Power supply terminals should not connect otherwise it may cause a short circuit.
- Once the board is connected to the power supply, do not leave it alone

- Do not stroke the IC elements with uncovered hands once the circuit supplies through it because they are sensitive components, so there is a chance to get damage.
- Once the power supply is given to the board, do not connect or remove components
- It is necessary to monitor exact polarity once certain components are connected to the circuit, otherwise, that may break down the dielectric within the component
- If water or liquid dropped onto the board, then right away remove it from the power supply.
- Maintain your surroundings clean and in sequence

Breadboard Sizes

There are different sizes of breadboards are available in the market which is used based on the application.

- Half Size
- Tiny Breadboard
- Little Breadboard Bits
- Large Breadboard

Half Size

The half-size breadboard is applicable for mini-projects. The length and width of this board is 5.5 cm x 8.5 cm including a standard dual strip within the middle & two power rails on two faces. In this breadboard, power rails can be removed simply to make the board thin.

Tiny Breadboard

These breadboards are very small in size. This kind of breadboard does not include power rails however it includes 17 rows. These boards are applicable when you have fewer components to connect.

Little Breadboard Bits

These breadboards are available in different sizes like 4X4, 2X8, and 2X4. The 4x4 type includes four strips with four-pin terminal strips. The 2x8 type includes 8 strips with two-pin terminal strips. The 2x4 boards include 4 strips with two-pin terminal strips.

Large Breadboards

Large breadboards are big in size, very useful for major projects which are located onto a metal plate. These boards are available with four colored posts which can be used through a bench-top supply. These boards include bumpers to maintain the board from slipping in the region of your desk.

How to Choose a Breadboard?

There are several factors need to consider while choosing a breadboard. The following factors need to consider once purchasing a breadboard.

- Spring Contacts
- Construction of Power Rail
- Plastic Housing
- Several Breadboards Mechanical Mating
- Backing of Breadboard
- Metal Plate based Assemblies of Breadboard
- Breadboards Size & Quantity
- Power Supplying to the Breadboard