Practical E-Manual

Department of Physics, B. N. College , Dhubri

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Content

Aim: To determine the coefficient of thermal conductivity of a bad conductor by Lee and Chaltron’s method.

Apparatus: 1. Lee’s apparatus, 2.Two thermometers, 3.Stop watch, 4.Weighing balance, 5.Stand , 6.Heater, 7. Venire and Screw Gauge

Theory: The coefficient of thermal conductivity of a bad conductor by Lee and Chaltron’s method can be determined by the formulae-

$$k = \frac{ms}{A(T_2 - T_1)} \frac{dT}{dt}$$

where

A= Cross sectional area of the Bad Conductivity materials.

d = Thickness of the Bad Conductivity materials.

M= Mass of the bottom metal disc.

s = Specific heat of the material of the bottom metal disc.

T_1= Temperature of the top metal disc.

T_2= Temperature of the bottom metal disc.

$\frac{dT}{dt}$=The amount of heat radiated per second through the bottom disc.

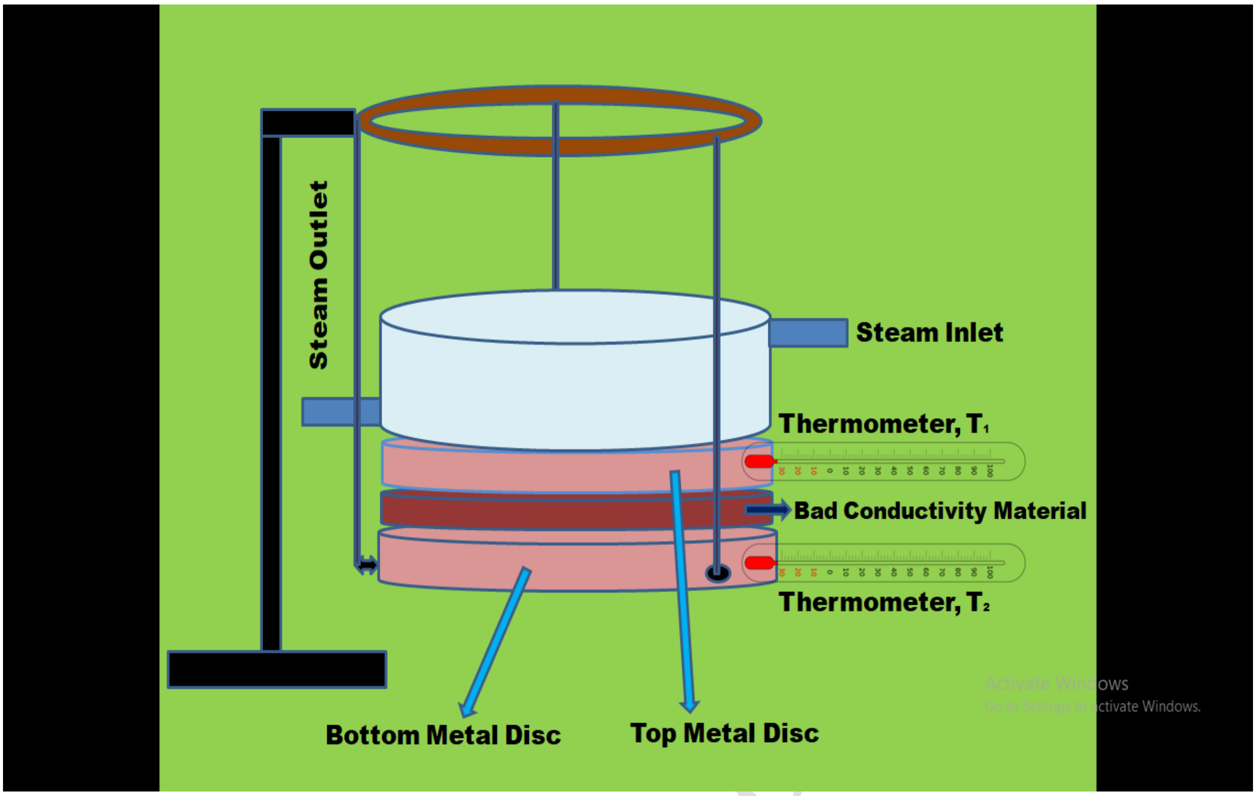


Fig 1

Procedure:

1. Determine the mass “m” of the bottom metal disc by Weighing balance
2. Determine the thickness “d” of the Bad Conductivity materials by screw gauge.
3. Determine diameter and then area “A” of the Bad Conductivity materials by venire scale.
4. Set up the Lee’s apparatus as shown in the fig 1. with disc and thermometer at its proper position
5. Fill the boiler with water nearly half of its volume and starts heating to produce steam.
6. Let the steam flow through the steam chamber until the temperature T1 and T2 become steady.
7. Wait for another 10 min after steady state is reached and then note the steady temperature T1 and T2.

8. Stop the inflow of steam and then remove the Bad Conductivity materials.
9. Again start heating till the temperature become T1+10 (*ie 10 degree greater than steady state temperature*)
10. Remove the steam chamber and top metal disc and place the Bad conductivity material again in its place.
11. Starts recording Decrease of temperature from **T1+10** to **T1-10** at an interval of 30 min.
12. Draw the cooling curve and determine the slope dT/dt at the steady temperature T1 . Fig 2.

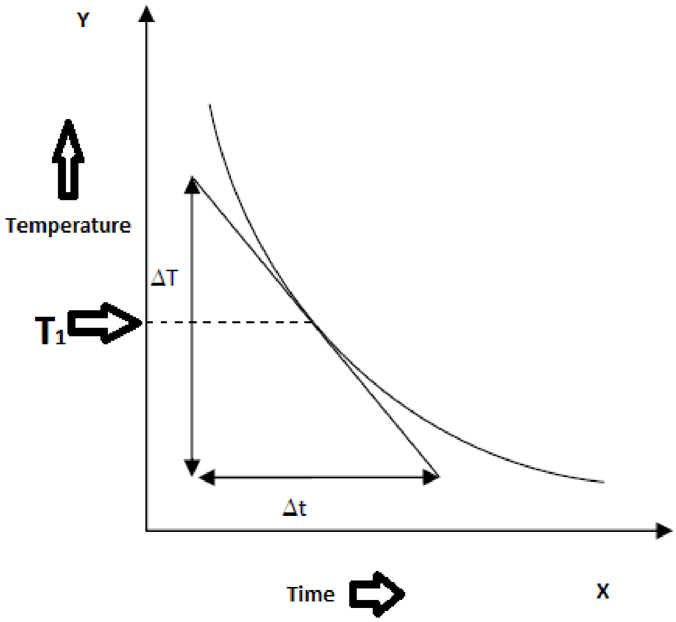


Fig 2

Experimental Data

1. Mean mass of the bottom metal disc , m= (…..+….+…..)/3 { Use Weighing balance }
2. Specific heat of the material of the bottom metal disc , s= ----------- { Given }

3. Table for thickness (d) of the Bad Conductivity materials (By screw Gauge)

Pitch= --------, Least Count =-----------

Sl No	MSR (In cm)	CSR	Value of CSR (In cm)	Total (In cm)	Error (In cm)	Corrected Value (In cm)	Mean, d (In cm)
1							
2							
3							

4. Table for diameter and area (A) of the Bad Conductivity materials (By venire scale).

Venire Constant=--------

Sl. No	MSR (In cm)	VSR	Value of VSR (In cm)	Total (In cm)	Mean Diameter (D) (In cm)	Area, $A = \pi D^2/4$ (In cm)

5. Temperature T1 = (Steady Temperature)

6. Temperature T2= (Steady Temperature)

7. Table for cooling Curve

No. of Obs	1	2	3	4	5	-	-	-	Till **T1-10** (In °C)
Time (In Sec)									
Temperature (In °C)									

$\frac{dT}{dt}$= --------------°C/sec, Corresponding to Temperature T1 (From Graph)

Result: Coefficient of thermal Conductivity of the material of the Bad Conductivity materials

$$k = \frac{ms}{A(T_2 - T_1)} \frac{dT}{dt} d$$

Error Calculation, $\boldsymbol{\Delta k/k}$ **=**

Precautions :

- Safety measure should be taken to avoide any kind of burn due to heat or steam.
- Thermal contact between each disc as well as the thermometer and disc should be proper.
- Reading of T1 and T2 should be taken 10 minute after the steady state.

Aim: To determine J (Mechanical equivalent of heat) by Callender and Barne’s method (continuous flow calorimeter).

APPARATUS USED: A Callender and Barne’s calorimeter, AC mains with a step down transformer, an AC Ammeter and an AC Voltmeter, switch, a rheostat, a stop watch, a measuring jar and two thermometers etc.

DESCRIPTION OF APPARATUS:

A heating coil is mounted axially along a horizontal glass tube. This glass tube is further surrounded by a glass jacket to minimize convection of heat. The coil is made of manganin or nichrome. Small length brass tubes are jointed to the two ends of the glass tube by sealing wax. The ends of the heating coil are brought out for external electrical connection by means of two screws. The free ends of the brass tubes are connected with hollow iron bases which have three extra openings i.e. two vertical and one horizontal. The horizontal openings are used for inlet and outlet of water. In one of the vertical openings on both ends of the glass tube a thermometer is inserted through rubber stopper. The other vertical opening on both sides are used to remove any air bubble which might have crept in while flowing water from the tank.

The water reservoir is a small metal vessel having three openings at the bottom. One of the openings is connected to the tap, the middle one to the sink, and the other to the inlet end of the Callender and Barne’s calorimeter. The height of the reservoir is adjusted and water is allowed to flow through the tube at a constant pressure. The outlet end of the calorimeter is connected to a small glass tube having a nozzle at the free end by means of a rubber tube. The rate of flow of water from the nozzle is controlled by means of the reservoir attached to the input end. The temperature of the inlet and outlet water are given by the respective thermometers T_1 and T_2.

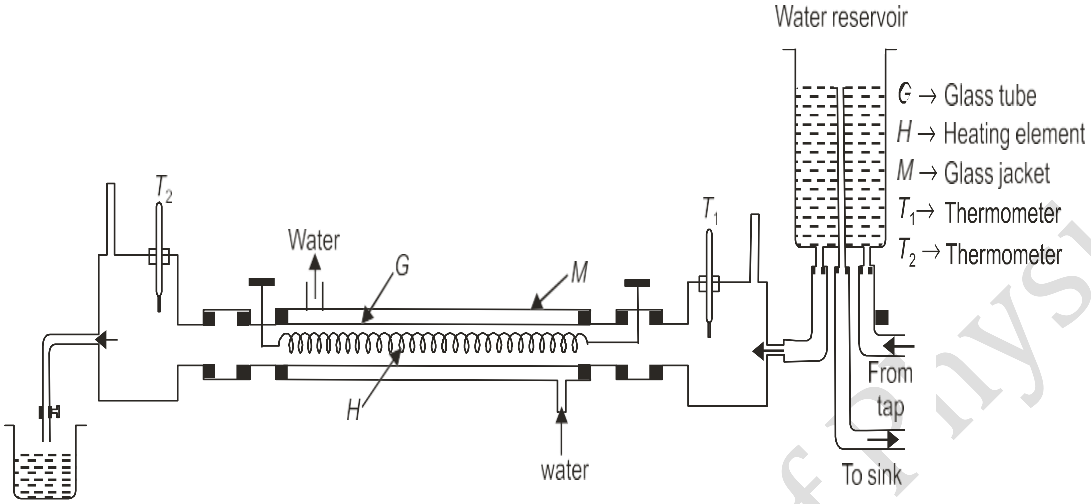


Fig 1

Theory: When a steady electric current flows through the heating coil and a steady flow of water is maintained through the tube, the temperatures at all parts of the apparatus become steady. Under such steady-state conditions, the amount of electrical energy supplied during a known time interval is consumed in heating the amount of water which flows through the tube during the same interval and a small amount of heat is lost by radiation etc., to the surroundings during that interval.

Let the current flowing through the heating coil = I_1 amp

the potential difference between the ends of the coil = V_1 volt

the rate of flow of water through the tube = m_1 gm/sec

the temperature of the inlet water = θ_1°C

the temperature of the outlet water = θ_2°C

the mean specific heat of water between the = s

temperatures θ_1°C and θ_2°C

Therefore, we can write

$$\frac{V^1 I^1}{J} = m_1 s\,(\theta_2 - \theta_1) + h_1 \qquad \text{...(1)}$$

Where, J is the mechanical equivalent of heat (also called Joule's equivalent) and h_1 is the amount of thermal leakage per second from the surface of the tube due to radiation etc.

If V_1, I_1, and m_1 are changed to V_2, I_2, and m_2 while keeping the temperature rise unaltered, then for the same surrounding temperature we can write

$$\frac{V^2 I^2}{J} = m_2 s\,(\theta_2 - \theta_1) + h_2 \qquad \text{...(2)}$$

Subtracting Eq. (1) from Eq.(2), we obtain,

$$\frac{V_2 I_2 - V_1 I_1}{J} = s\,(m_2 - m_1)(\theta_2 - \theta_1) + (h_2 - h_1)$$

For all practical purposes, we may consider $h_1 = h_2$

$$\boxed{J = \frac{V_2 I_2 - V_1 I_1}{s\,(m_2 - m_1)\,(\theta_2 - \theta_1)}}$$

Thus, by measuring V_1, V_2, I_1, I_2, m_1, m_2, θ_1 and θ_2, and knowing s, J can be determined in Joule/Calorie.

PROCEDURE:

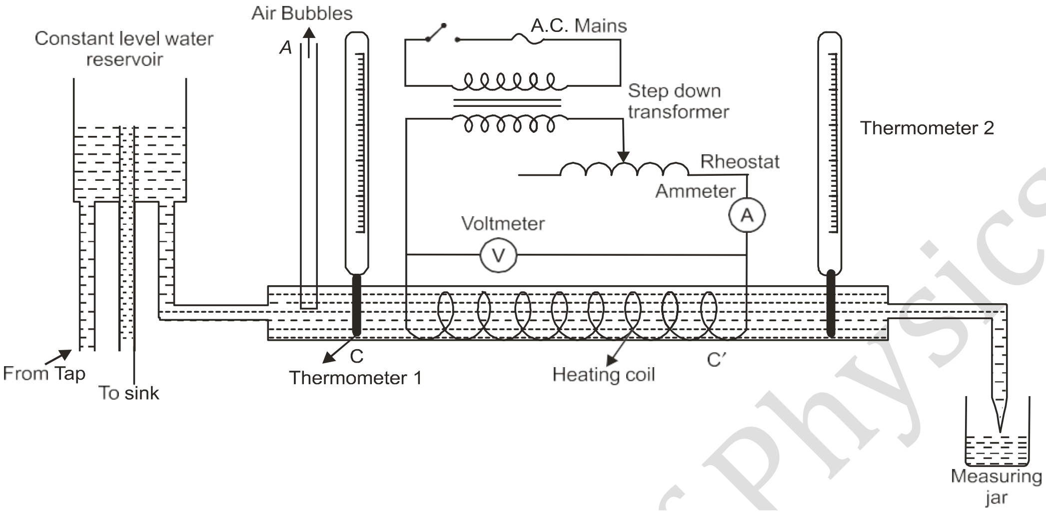


Fig.2

1.Make clean and tight connections shown in fig. 2. Insert thermometer T1 and T2.

2.Connect constant level bath at one end of Callender and Barne's calorimeter and adjust flow of water

3.Adjust the tap and the water reservoir till the rate of flow of water through the tube is about (one) c.c per second. Switch on the current and regulate the rheostat so that the current passing is about 2 amperes.

4.As soon as the temperature of the heated water going out becomes steady. Note the temperature of the two thermometers.

5.Note the ammeter and the voltmeter readings.

6.Measure the rate of flow of water at this moment with the help of measuring Jar.

7.Change the rate of flow of water by varying the height of the reservoir and vary the electric current until the two thermometers again indicate their previous readings. Note the new readings of the ammeter and the voltmeter and measure the new rate of flow of water.

OBSERVATION:

Temperature of the cold water (inlet end) = ……^{0}C

Temperature of the hot water (exit end) =……^{0}C

Mass of empty beaker =………gm

	E (in volts)	C (in amps)	Amount of flow of water per minute unit			
			I	II	III	Mean
I Case						
II Case						

RESULT: Mechanical equivalent of heat ‘ J ‘ = …..ergs / cal.

Standard value 4.18 x 10^7 ergs / cal. Percentage error ………

PRECAUTIONS:

1. The connections must be tight. See that voltmeter and ammeter are connected properly.
2. The flow of water and current should be properly adjusted at both times so that the temperatures θ_1 & θ_2 may remain unaltered.
3. The difference of temperatures (θ_2 - θ_1) should be of the order of 5 to 7^0 C.
4. The thermometers used for temperature measurement must be capable of reading of temperatures up to one – tenth of a degree.
5. The rate of flow of water in the tube should be uniform. To ensure this a number of measurements for the rate of out flow of water should be made.
6. Heating of the water should be uniform throughout tube.
7. Thermometers should be very sensitive.

Aim: To measure time and voltage of an electrical signal using CRO

An introduction to cathode ray oscilloscope:

The Cathode–Ray Oscilloscope (CRO) is a common laboratory instruments that provides accurate time and amplitude measurements of voltage signals over a wide range of frequencies. Its reliability, stability and ease of operation make it suitable as a general purpose laboratory instrument.

Fig: A typical photograph of a CRO.

Working principle

The CRO is a very sophisticated instrument and its working is based on a number of physical principles well known to us:

Thermionic emission: Electrons are ejected from the surface of a cathode due to thermionic emission.

<u>Effect of an accelerating potential:</u> The electrons emitted from the cathode can be accelerated by applying a positive potential along their direction of travel.

<u>Effect of a deflecting potential:</u> The electron beam will suffer sideways deflection if a transverse electric field is applied to their path.

<u>Conversion of electron KE to light energy:</u> Wherever the electron beam hits the screen, the electron comes to rest and delivers its kinetic energy to the molecules of the phosphor on the screen. The Phosphor is excited and light is emitted from that point.

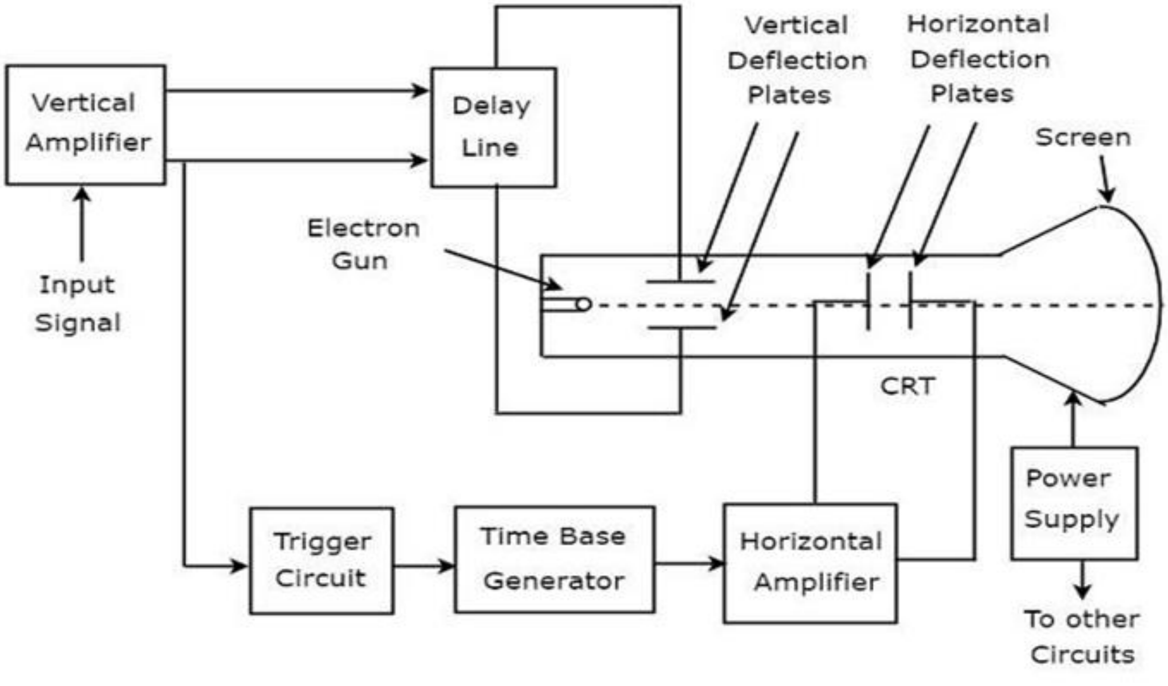


Fig: Block diagram of CRO.

Design of CRO:

CRO is consists of a set of blocks which are vertical amplifier, delay line, trigger circuit, time base generator, horizontal amplifier, cathode ray tube (CRT) and power supply.

The function of each block of CRO is given below-

Vertical amplifier: It amplifies the input signal which is to be displayed on the screen of CRT.

Delay line: It provides some number of delays to the signal, which is obtained at the output of vertical amplifier. This delayed signal is then applied to vertical deflection plates of CRT

Trigger circuit: It produces a triggering signal in order to synchronize both horizontal and vertical deflections of electron beam.

Time Base Generator: It produces a saw-tooth signal, which is useful for horizontal deflections of electron beam.

Horizontal amplifier: It amplifies the saw-tooth signal and then connects it to the horizontal deflection plates of CRT.

Power supply: It produces both high and low voltages. The negative high voltage and positive low voltage are applied to CRT and other circuits respectively.

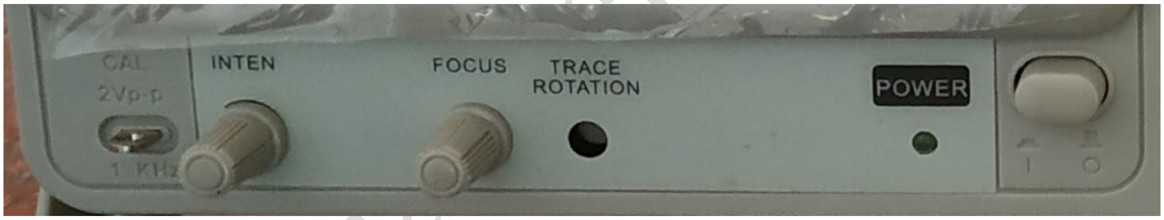
CRT: It is the heart of CRO. It is mainly consisting of four parts- electron gun, vertical deflection plates, horizontal deflection plates and florescent screen.

Control units of CRO.

In oscilloscope, traces are changed by changing the different controls of it. Oscilloscopes are complex instruments with many controls and they require some care to set up and use successfully. It is quite easy to ‘lose’ the trace off the screen if the controls are set wrongly. The front panel comprises of many measurement knobs by which trace can be changed.

There is some variation in the arrangement of the controls for different C.R.Os. The main controls are discussed as follow:-

Display controls:



<u>Intensity control</u>: It is used to adjust the brightness of the waveform. As the sweep speed is increased, there is a need to increase the intensity level.

<u>Focus control</u>: It is used to adjust the sharpness of the waveform.

<u>Trace control</u>: It is used to rotate the trace on the CRO screen.

<u>Calibration point</u>: It is used to calibrate the CRO. It gives a steady square wave at a particular set frequency and voltage. It allows the accurate scaling of the trace. The standard calibration signal is 0V-2V at 1 KHz.

Vertical controls:

Vertical controls are used to position and scale the wave form vertically.

<u>Volts/div:</u> For selecting desired voltage sensitivity of the vertical amplifier to obtain the proper wave form on the screen.

<u>Volts/div. Variable:</u> Provides continuously variable voltage sensitivity. Calibrated position is fully clockwise.

<u>Position:</u> Controls horizontal position of trace on screen.

<u>Vertical Position knob</u>: To move the trace up or down the on the screen.

Horizontal Controls:

Horizontal controls are used to position and scale the wave form horizontally.

Sweep time/cm: For selecting desired sweep rate from calibrated steps or admits external signal to horizontal amplifier.

Sweep time/cm Variable: Provides continuously variable sweep rates. Calibrated position is fully clockwise.

Position: Controls horizontal position of trace on screen.

Horizontal Variable: Controls the attenuation (reduction) of signal applied to horizontal amplifier through External Horizontal connector.

Trigger Controls:

The trigger selects the timing of the beginning of the horizontal sweep.

Slope: Selects whether triggering occurs on a rising or falling edge of trigger signal.

Coupling: Selects whether triggering occurs at a specific amount of DC or AC level.

Level: Selects the voltage point on the triggering signal at which sweep is triggered. It also allows automatic (auto) triggering of allows sweep to run free (free run).

Input Coupling:

Coupling is used to connect an electrical signal from one circuit to another. When the input coupling is the connection from circuit to the oscilloscope. The coupling can be set to DC, AC.

Dual Button:

- The oscilloscope has a capability to display both channel signals on the screen at the same time. This is known as DUAL MODE.

- It is usually used to measure phase difference between two signals.

Alternate and Chop buttons:

i. Multiple channels are displayed using either or chop mode.
ii. Chop mode causes the oscilloscope to draw small parts of each signal back and forth between them; the switching rate is too fast so that waveform looks like a continuous signal.

Use of CRO:

An oscilloscope is an important tool in an electrical field which is used to display the graph of an electrical signal as it varies with respect to time.

Generally, an oscilloscope can measure time-based as well as voltage-based characteristics.

1. Measurement of voltage

CRO displays the voltage signal as a function of time on its screen. The amplitude of that voltage signal is constant, but we can vary the number of divisions that cover the voltage signal in vertical direction by varying volt/division knob on the CRO panel. Therefore we get the amplitude V_0 of the signal, which is present on the screen of CRO by using following formula

$$V_0 = V_d \times N_v$$

Where, V_d is the volt per division and N_v is the number of divisions that cover the signal in vertical direction.

2. Measurement of time period

CRO displays the voltage signal as a function of time on its screen. The time period of that periodic voltage signal is constant, but we can vary the number of divisions that cover one complete cycle of voltage signal in horizontal direction by varying time/division knob on the CRO panel. Therefore, we will gwt the time period T_0 of the signal, which is present on the screen of CRO by using the following formula.

$$T_0 = T_d \times N_v$$

Where, T_0 is the time per division and N_h is the number of division that cover one complete cycle of the periodic signal in horizontal direction.

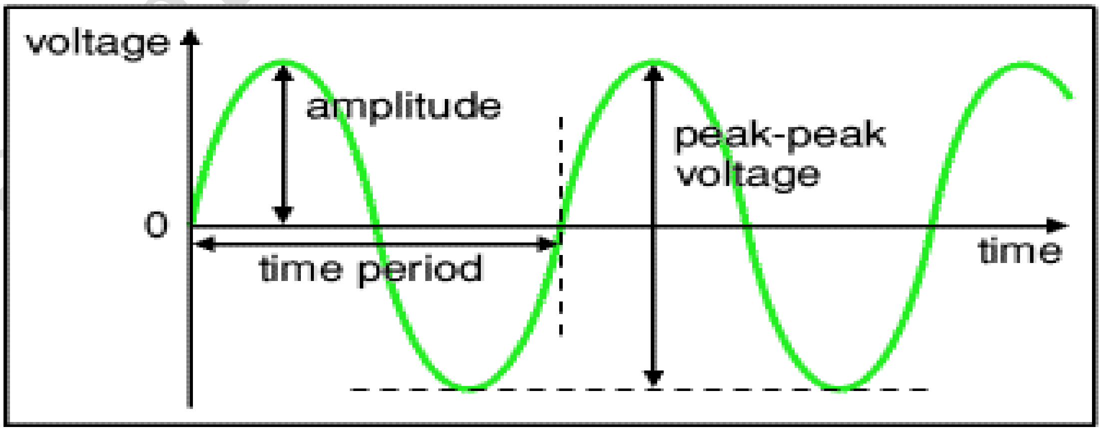


Fig: Measuring voltage and time period.

3. Measurement of frequency

The frequency f_0 of a periodic signal is the reciprocal of time period T_0. Mathematically, it can be represented as $f_0 = \frac{1}{T_0}$ so to determine frequency of the signal using CRO, we can measure the time period and take reciprocal to get the frequency.

References:

1. Digital System and applications by Dr. Gouri Goutam Borthakur.

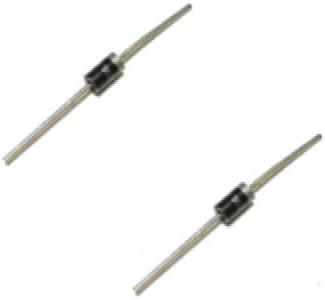
Aim: To test a Diode and Transistor using a Multimeter.

Apparatus required

PN junction Diode, transistor, multimeter

Description of the apparatus

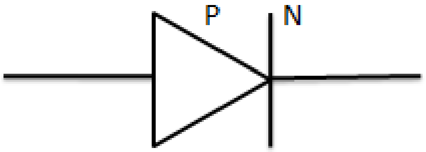
Diode is a two terminal semiconductor device that conducts current when forward biased but does not conduct when reversed biased.



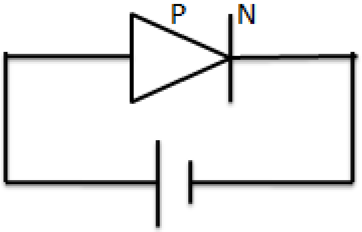
Physical appearance

It has two terminal / legs. White side is N. Black side is P

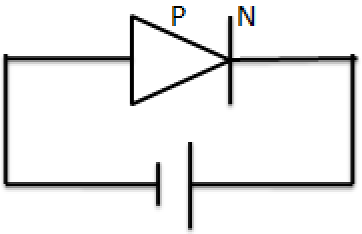
Circuit symbole



Circuit Diagram



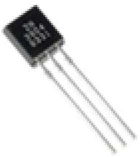
Forward bias



Reverse bias

Principle of diode testing

A diode in good condition has finite minimum resistance (500 to 1000 ohm) in forward bias while it has very high resistance (of the order of mega ohm) in reversed bias.



Test of Diode

1. The multimeter knob is turned to 2000 ohm resistance range.

2. Connect the red and black terminal of the multimeter to the black/P and white/N terminal of Diode respectively. It will gives some finite (~ 600 to 800 ohm) resistance.

3. Connect the red and black terminal of the to the white / N and black / P terminal of Diode respectively. It will show no reading (infinite resistance).

4. If the Diode shows above two properties then it is functional, otherwise it is nonfunctional

Transistor: It is a three terminal electronic component. Generally the middle terminal is Base (B). One end terminal is Emitter (E) and the other terminal is Collector (C)

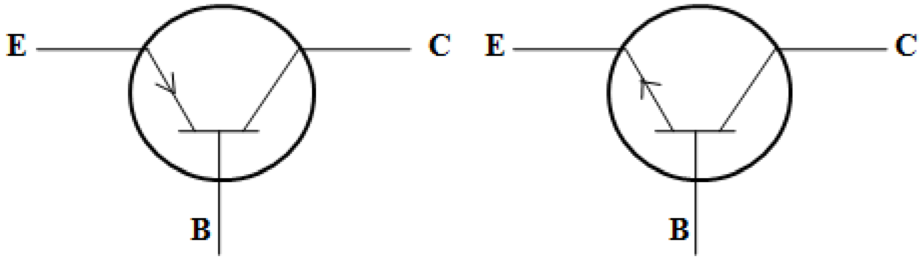
Types

(i) PNP (ii) NPN

Physical appearance

It has three terminal / legs

Circuit symbol



PNP **NPN**

Here the arrow Sign indicates direction of flow of current.

Test of Transistor

(i) To identify Base

1. The multimeter knob is turned to 2000 ohm resistance range.

2. Connect the black lead to one terminal leg (3) and red lead to other terminal leg (1) of the transistor (Fig.2). Note the multimeter reading (resistance). Interchange black and Red lead and repeat the observation. If multimeter shows no reading (infinite resistance) then middle leg (2) is base.

3. In the above case if multimeter shows finite resistance (600 to 900 ohm) in one direction and no reading (infinite resistance) in other direction then one terminal leg will be base.

4. Connect the black lead to one terminal leg (3) and red lead to the leg (2) of the transistor, note the multimeter reading (resistance). Interchange black and Red lead and repeat the observation. If multimeter shows no reading (infinite resistance) then leg (1) is base.

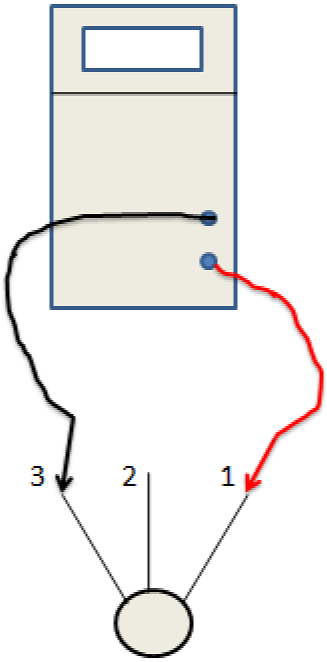


Fig. 2

To identify Emitter and Collector.

1. The multimeter knob is turned to 2000 ohm resistance range.
2. Connect the black/Red lead to the identified base terminal and red/black lead to one leg of the transistor, note the multimeter reading (resistance). Repeat the observation with red/black lead to other leg of the transistor, note the multimeter reading (resistance).
3. The leg showing more resistance is emitter, while the leg showing less resistance is collector.

To identify PNP or NPN

1. The multimeter knob is turned to 2000 ohm resistance range.
2. Connect the black lead to the identified base and red terminal to one leg of the transistor, if multimeter gives finite resistance, then it is PNP.
3. Connect the Red lead to the identified base and black terminal to other leg of the transistor , if multimeter gives finite resistance , then it is NPN.

Aim: To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus

Apparatus Required

Searle's Thermal Conductivity Apparatus, four Thermometers, Steam Boiler, beaker, Constant Water Level Tank, Pinch cock, Stop watch, Rubber tube and Hot Plate, Slide calipers.

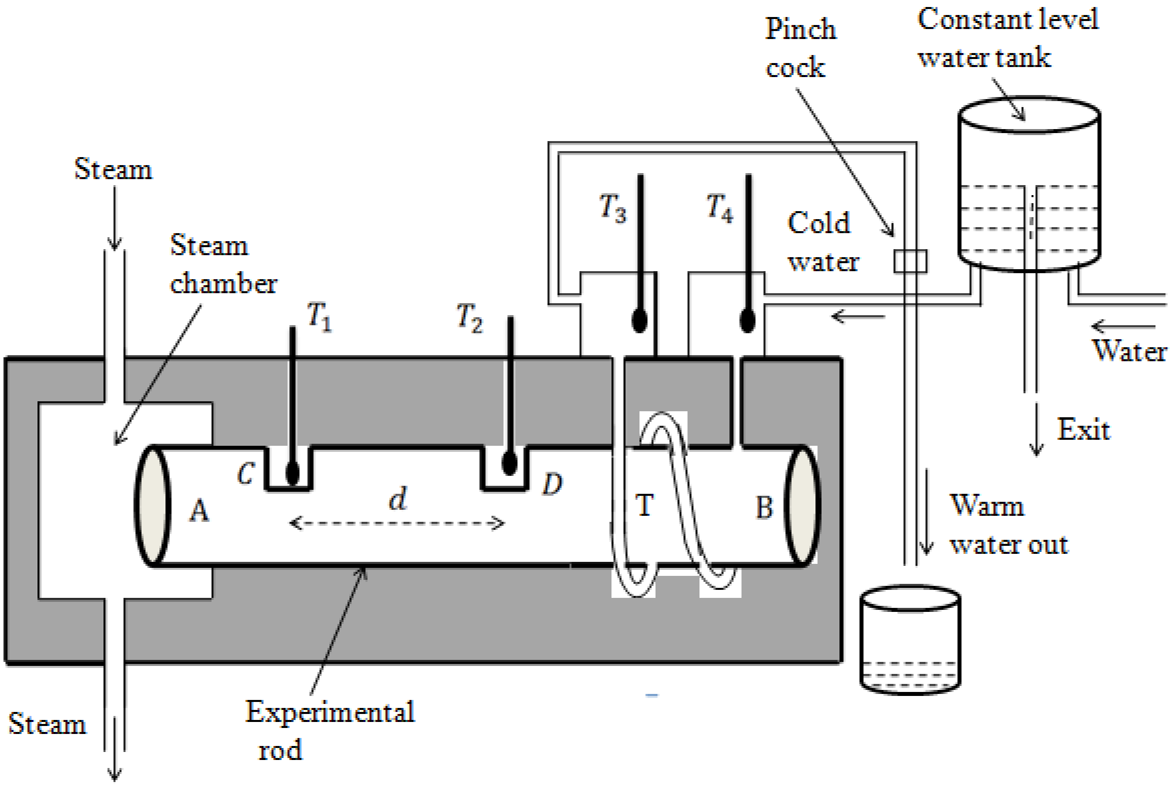


Fig.1: Searle's apparatus for conductivity determination

Description of the apparatus

Fig.1 shows Searle's apparatus to measure the thermal conductivity of Copper. Copper is taken in the form of a cylindrical rod AB. One end A of the rod is inside a steam chamber through which steam is passed from a boiler. A Copper tube T is coiled around the other end B of the rod. This end B is cooled by circulating a steady flow of water maintained in the Copper tube by constant water level tank. The flow of water is adjusted using pinch cock such that water comes drop by drop from the exit side. Water enters the tube at the end away from the steam chamber and it leaves at the end nearer to it. Thermometers T_3 and T_4 shows the temperatures of the outgoing and incoming water. Temperature gradient along the rod is measured by two thermometers T_1 and T_2 which are placed on two holes C and D drilled in the rod. The experimental rod is covered properly with layers of an insulating material like wool or felt and put inside a box, to reduce heat loss.

Theory

In steady state if the temperature of two layers of the Copper rod having cross sectional area A separated by a distance d be θ_1°C and θ_2°C then the quantity of heat Q flowing through them in time t second is given by

$$Q = \frac{KA(\theta_1 - \theta_2)t}{d} \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(i) \text{ where } K = \text{Thermal conductivity of Cu rod}$$

Again if this amount of heat (Q) raises the temperature of m gms of water flowing through the Copper tube in time t second from θ_4°C to θ_3°C then

$$Q = m(\theta_3 - \theta_4) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

From equations (i) and (ii) we have

$$\frac{KA(\theta_1 - \theta_2)t}{d} = m(\theta_3 - \theta_4)$$

$$\Rightarrow \boxed{K = \frac{md(\theta_3 - \theta_4)}{A(\theta_1 - \theta_2)t} \ cal/°C/cm/s}$$

From this expression K can be calculated.

Procedure

1. The experimental Cu rod is taken out from the box and the distance between the two holes C and D is measured by a meter scale.

2. Diameter of the rod is measured by slide calipers at a number of places in two mutually perpendicular directions and mean diameter is determined as shown in table I.

3. Now put the rod in the given box. Get steam ready by heating water in a steam heater. Put all the thermometers at positions as shown in fig.1.

4. Connect the steam chamber to the rod through the rubber pipe.

5. Wait for about half an hour when steady state is obtained. This is confirmed when all the four thermometers give constant readings and there should not be any further increase of temperature. To confirm the steady state go on noting the temperatures of all the four thermometers at an interval of 2 minutes (Table II).

6. When steady state is confirmed, Put water in the constant water level tank and adjust the flow by the pinch cock. Place a beaker/measuring cylinder below the water outflow pipe and collect water for some time. Measure the time of collection of water by stop watch. Find mass of the water collected per unit time (Table III).

7. Change the rate of flow of water by pinch cock and repeat operations 6 to get 2nd and 3rd sets of readings.

Experimental data

(i) The distance $\boldsymbol{d}$ between the two holes of the copper rod or between the thermometer $\boldsymbol{T_1}$ and $\boldsymbol{T_2}$

$d = \ldots\ldots..cm.$

(ii) Determination of cross sectional area $(\boldsymbol{A})$the experimental rod

VC = $\ldots\ldots\ldots\ldots\ldots cm$

Table I

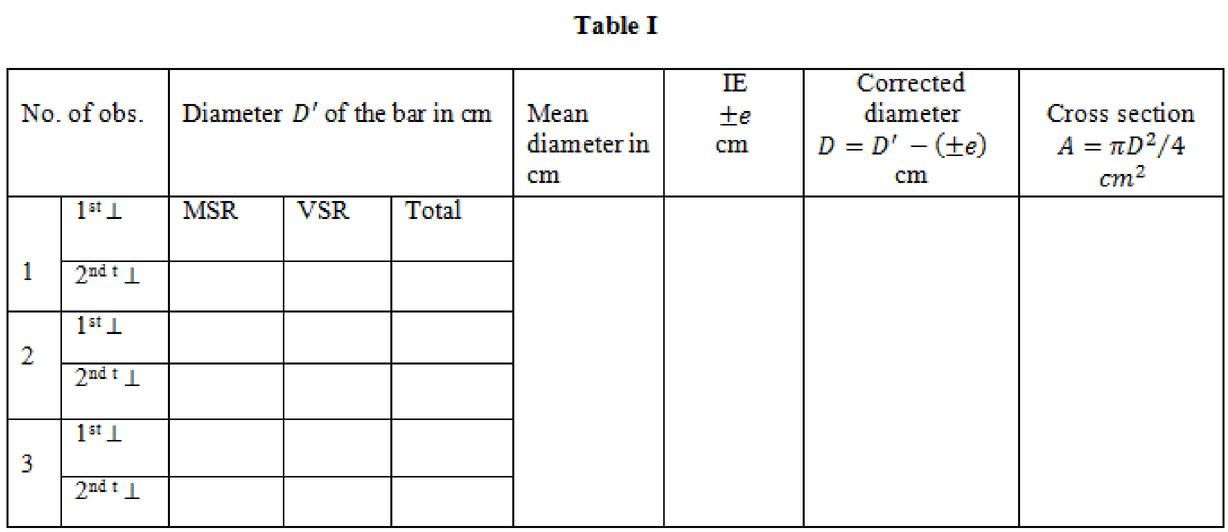


Table I

No. of obs.		Diameter D' of the bar in cm			Mean diameter in cm	IE $\pm e$ cm	Corrected diameter $D = D' - (\pm e)$ cm	Cross section $A = \pi D^2/4$ cm^2
		MSR	VSR	Total				
1	$1^{st} \perp$							
	$2^{nd\ t} \perp$							
2	$1^{st} \perp$							
	$2^{nd\ t} \perp$							
3	$1^{st} \perp$							
	$2^{nd\ t} \perp$							

(iii) Determination of steady state temperatures

Table II

No. of Obs.	Time in minutes	Thermometer readings				$(\theta_1 - \theta_2)$ °C	$(\theta_3 - \theta_4)$ °C
		θ_1 °C	θ_2 °C	θ_3 °C	θ_4 °C		
SET I	2	....	....	....	....	Steady	Steady
	4	....	....	....	....		
	....	....	....	....	....		
	....	Steady	Steady	Steady	Steady		
	....	Steady	Steady	Steady	Steady		
SET II	2	....	....	....	....	Steady	Steady
	4	....	....	....	....		
	....	....	....	....	....		
	....	Steady	Steady	Steady	Steady		
	....	Steady	Steady	Steady	Steady		
SET III	2	....	....	....	....	Steady	Steady
	4	....	....	....	....		
	....	....	....	....	....		
	....	Steady	Steady	Steady	Steady		
	....	Steady	Steady	Steady	Steady		

(iv) Determination of time of flow (t) and mass (m) of water collected.

Table III

Set No.	Mass of empty beaker $m_1\ gm$	Mass of beaker and water collected in $t\ sec.$ $m_2\ gm$	Mass of water collected in $t\ sec.$ $m = (m_2 - m_1)gm$	Time of collection $t\ sec.$	m/t gm/s
Set I					
Set II					
Set III					

(v) Calculation of K

$$K = \left(\frac{m}{t}\right)\frac{d(\theta_3 - \theta_4)}{A(\theta_1 - \theta_2)}\ \ Cal/g/{}^\circ C/s$$

$$= \dots\dots\dots\ cal/{}^\circ C/cm/s$$

(vi) Result

The Thermal conductivity K of Copper obtained experimentally $= \dots\dots\dots\ cal/{}^\circ C/cm/s$

Error calculation

$$K=\frac{md(\theta_3-\theta_4)}{A(\theta_1-\theta_2)t}, \qquad A=\pi D^2/4$$

$$\Rightarrow \frac{\delta K}{K}=\frac{\delta d}{d}+\frac{\delta m}{m}+2\frac{\delta D}{D}+\frac{\delta t}{t}+\frac{2\delta\theta}{\theta_1-\theta_2}+\frac{2\delta\theta}{\theta_3-\theta_4}$$

where $\delta d = 0.2cm$ [2 divisions of meter scale]

$\delta D = 0.01cm$ [v.c. of slide calipers]

$\delta m =$ minimum weight available

$\delta t = 1$ division of stop watch

$\delta\theta = 1$ division of thermometer scale

P. C of error = $\frac{\delta K}{K}$X100%

Precautions:

1. At room temperature all the four thermometers should give same reading. If they differ in readings then necessary correction is to be done.

2. For steady state the temperature of all the four thermometers should remain constant for at least 5 to 6 minutes.

3. Water should be collected only after the rod has attained steady state temperature.

4. Time or collection of water should be such so as to fill about 3/4 th of the beaker.

5. The temperature difference $(\theta_3-\theta_4)$should be maintained within 5°C to 6°C to minimise radiation loss.

6. Care should be taken so that there is no leakage of water through any pipe.

An introduction to Digital multimeter:

Digital multimeter is an instrument that measures current (ac/dc), voltage (ac/dc) and resistance. It is also used for testing diode, transistor, LED, continuity of wire etc. It gives digital output on a LCD screen. Fig.1 shows physical appearance of a digital multimeter.

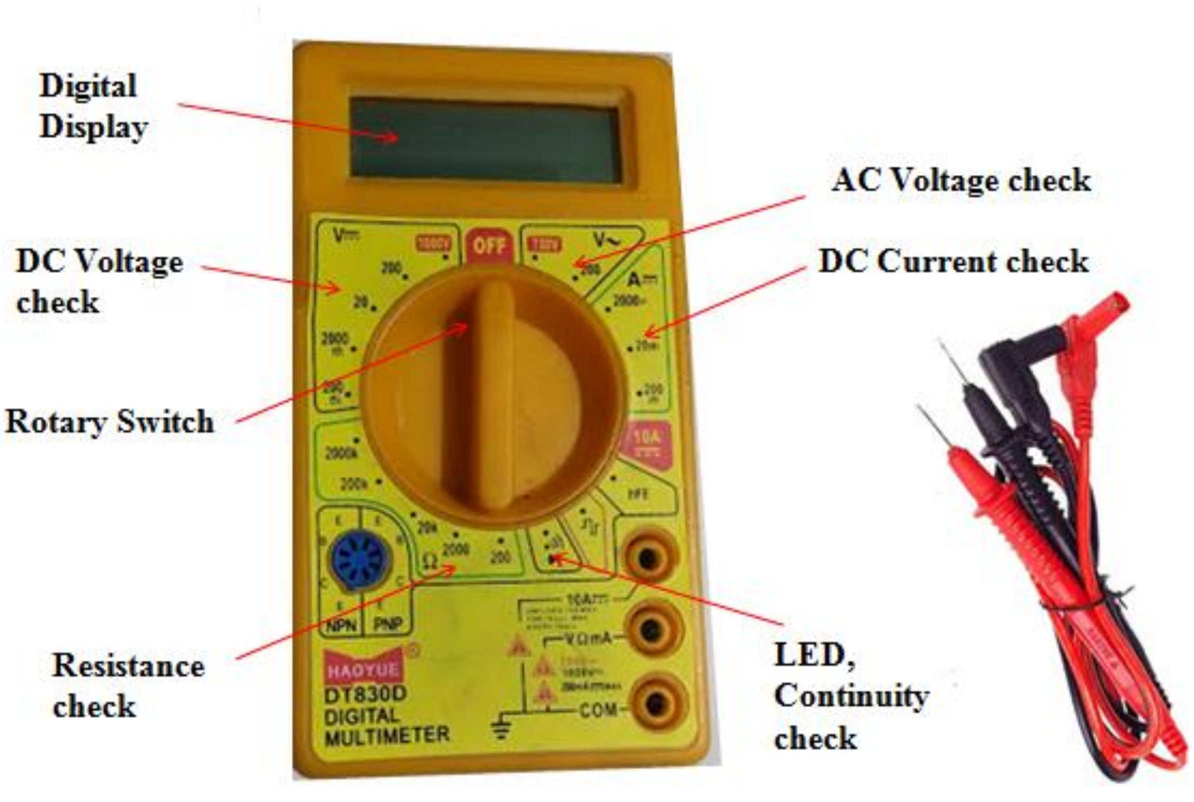


Fig.1: Digital Multimeter

It s main parts are -

1. Display unit

It shows the output of the measured quantity in digital form.

2. Selector knob

The selector/rotary switch is rotated to the appropriate position measure resistance, ac voltage, ac current, dc current and dc voltage (Fig.1)

3. Probe

It has two probes. One is black and the other is red. One end of the black probe is connected to common terminal while one end of the Red probe is connected to $V\Omega mA$ terminal of the multimeter for voltage & resistance measurement and to $10A$ for high current measurement. The other ends of black and red probe are connected to the terminals of the voltage, resistance or to the terminals of any other electronic components.

Fig.2 shows the block diagram of a digital multimeter

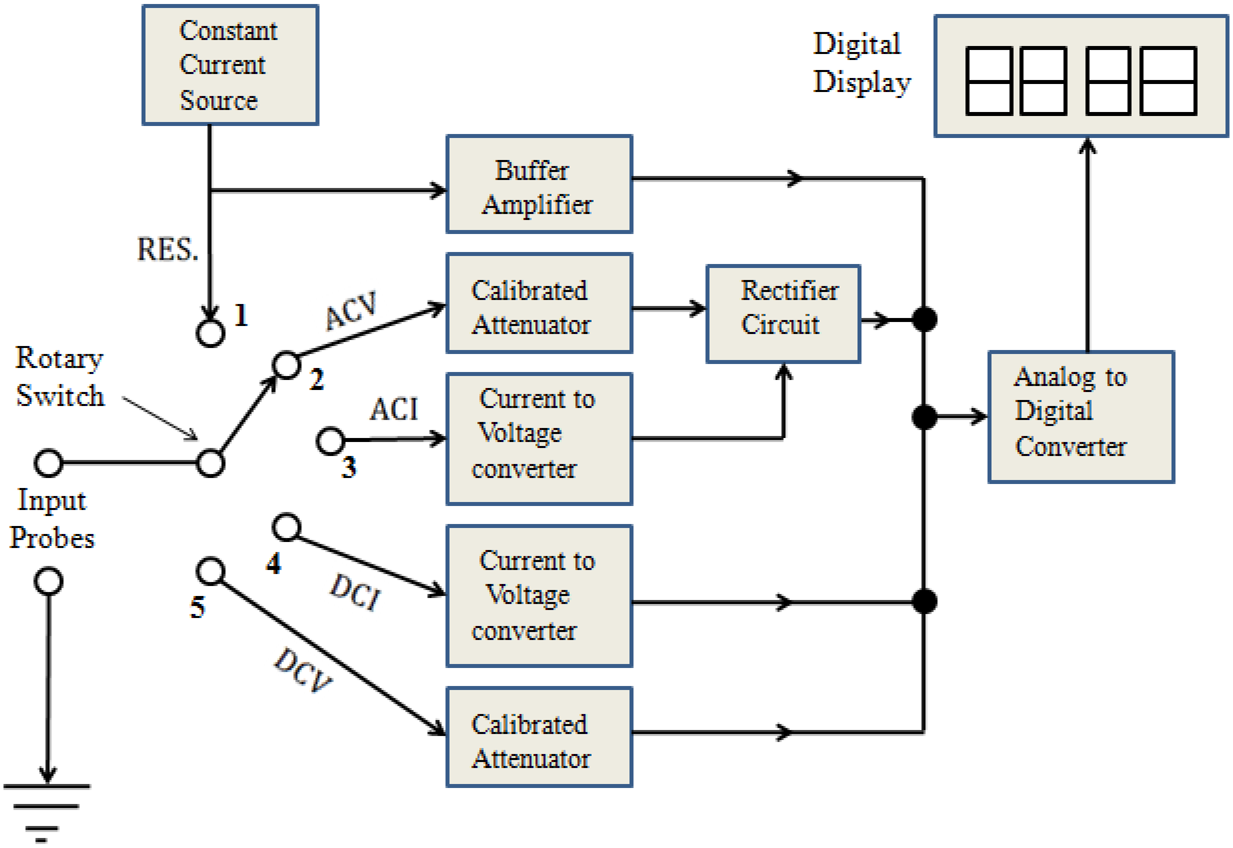


Fig.2: Block diagram of a Digital Multimeter