IEC 103 Basic Electronic Circuits Lab

Experiment 1

Objective: Familiarisation with basic test equipments and passive devices.

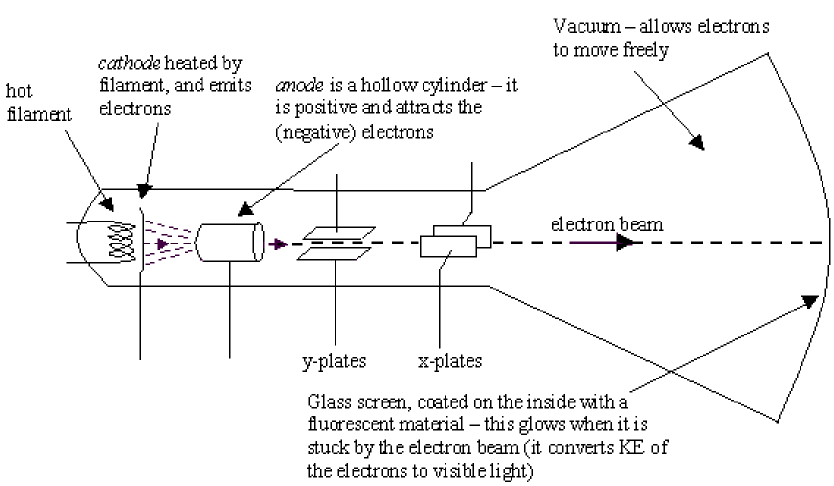
Equipments Required: Regulated Power Supply, CRO, CRO-Probes, Digital Multimeter and Function Generator.

Components Required: Breadboard, Few Resistance, Potentiometer, Few Capacitors, Few Inductors, Diode, Zener Diode, LED, Microphone, Loudspeaker

Theory:

- **Cathode Ray Oscilloscope:**

A CRO consists of a cathode ray tube (CRT) and electronic circuits necessary for generating the voltages required for its proper operation. The electron gun of the CRT generates a focussed electron beam that impinges on the fluorescent screen of the CRT after passing between the horizontal and vertical deflection plates. This creates the bright spot on the screen, which can be moved both horizontally and vertically by means of the voltages applied to the respective deflecting plates. If these voltages are periodic functions of time with be sufficiently high frequency, the back and forth movement of the spot on the screen appears as lines by virtue of persistence of vision.



Basic Internal Diagram of CRO

There are two modes of operation in CRO:

1. **Y-T mode** – This mode enables us to obtain a graph of the voltage (y) applied to the vertical plates plotted as the function of time (t). This is achieved by making spot move with a constant velocity from left to right and then returning very fast from right to left, by applying a sawtooth voltage to the horizontal deflection plates. The horizontal axis thus forms a Time Base (TB), with the time scale adjustable in calibrated step by changing the slope of sawtooth waveform. Most of the CRO

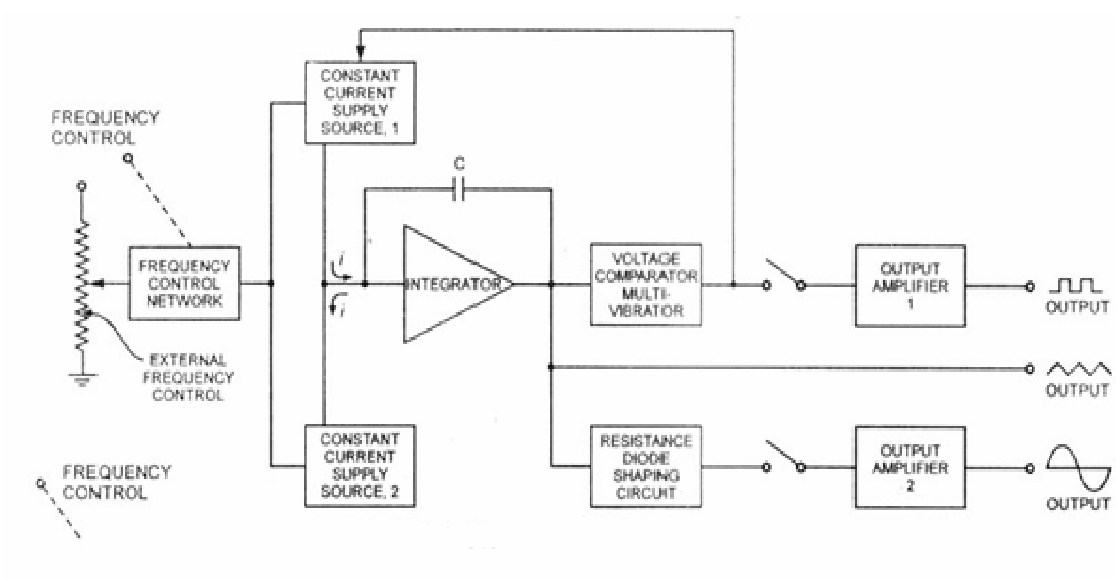
provides dual-trace option, thereby allowing two independent waveform to be displayed simultaneously on two channels CH1 and CH2, using same time base.

2. **X-Y mode –** In this mode, the graph of the y-input against the x-input is obtained by applying these voltages to the vertical and horizontal deflecting plates, after amplifying it by respective horizontal and vertical amplifiers. Their amplification decides the respective deflection sensitivities, adjustable in calibrated steps. This mode gives a stationary display only if the 'x' and 'y' signals are harmonics of the same fundamental frequency. Lissajous' figures are produced if both the voltages are sinusoidal. The component tester (CT) provides the x-y display of I-V characteristics of any component connected between the CT terminals.

- **Function Generator:**

The function generator can generate a number of different waveforms, selectable by two types of push buttons- one chooses function (sine/square/triangular) and other selects range of frequency. The pulse output has an additional control- a knob for adjusting the Duty Cycle.

For all above waveforms we can chose Amplitude and Frequency by setting knobs at required values. The amplitude of the function generator output is governed by two push buttons for providing Attenuation by 20, 40 or 60 dB and a knob for varying the amplitude continuously. It also has a knob to provide continuously variable DC offset upto 10V. The output is taken out by BNC cable.



Circuit Diagram of Function Generator

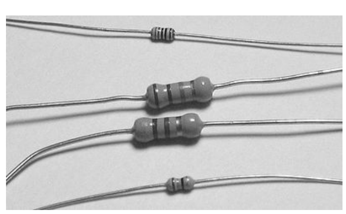
- **Resistance:**

Resistors used in the electronic circuits are usually classified according to the composition (Carbon film, metal film, wire wound, etc.), Tolerance (1%, 5%, etc.) and Power Rating (1/4 W, 1W, 5W, etc.).
Of these three features, the first one has to be found out from the manufacturer's specifications. The value and the tolerance, unless printed on the resistor, are coded by four or five coloured bands. In four band resistor, the value is indicated by three bands the I and II band gives the significant digits, the III band gives the number of zeros after two significant digits, and the tolerance is given by IV band.
In five band resistor, the value is indicated by three bands the I and II band gives the significant digits, the III band gives the number of zeros after two significant digits, the IV band gives the number of zeros after three significant digits and the tolerance is given by V band.

The tolerance band is always placed slightly away from the other bands.

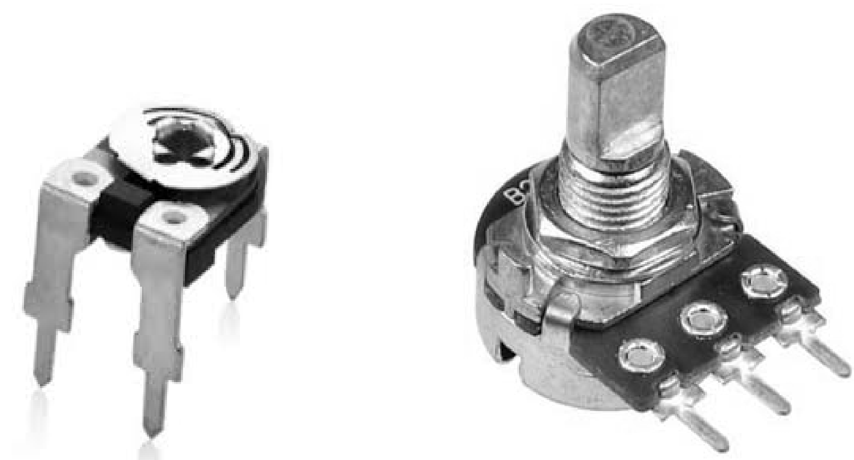
For denoting **value** we use following colour coding:
Black -> 0
Brown -> 1
Red -> 2
Orange -> 3
Yellow -> 4
Green -> 5
Blue -> 6
Violet -> 7
Grey -> 8
White -> 9

For denoting **tolerance** we use following colour coding:
Brown -> 1%
Red -> 2%
Gold -> 5%
Silver -> 10%
No colour -> 20%



Resistors

There is a special resistor whose value can be changed known as potentiometer. The maximum value is found between the two extreme terminals, and the varied resistance is calculated between one extreme terminal and middle terminal.



Potentiometers

- **Capacitors:**

Capacitors used in electronic circuits are classified according to the dielectric material used in the fabrication of type capacitor and the range of values available varies from type to type. Some of the commonly encountered types are listed below:

Electrolytic (>=1uF): Cylindrical body with printed value and polarity indicated by +/-
Polyester (0.001 – 10uF): Modulated body with value either printed or colour coded
Ceramic (<=1uF): Disc-shaped body, with value printed on the body

Capacitor value is printed in the format **abn,** where ab represents a 2-digit number and n represents the exponent, the implied value being (ab) x 10^n pF. These capacitors generally assumed a tolerance of 10% unless indicated otherwise.

Elecrolytic Capacitor

Polyester Capacitor

Ceramic Capacitor

- **<u>Variable Capacitors</u>**

Variable capacitors may have their capacitance changed by mechanical motion. Generally two versions of variable capacitors has to be to distinguished:

Tuning capacitor – variable capacitor for intentionally and repeatedly tuning an oscillator circuit in a radio or another tuned circuit.

Trimmer capacitor – small variable capacitor usually for one-time oscillator circuit internal adjustment

Variable capacitors include capacitors that use a mechanical construction to change the distance between the plates, or the amount of plate surface area which overlaps. They mostly use air as dielectric medium.

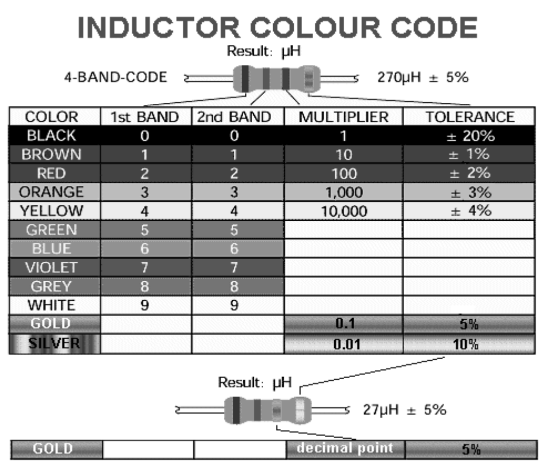
Variable capacitance semiconductor diodes are not capacitors in the sense of passive components but can change their capacitance as a function of the applied reverse bias voltage and are used like a variable capacitor. They have replaced much of the tuning and trimmer capacitors.

- **<u>Inductors:</u>**

Inductors are components that are simple in their construction, consisting of coils of insulated copper wire wound around a former that will have some type of core at its centre. This core might be a metal such as iron that can be easily magnetised; or in high frequency inductors, it will more likely to be just air.

Inductors depend for their action on the magnetic field that is present around any conductor when it is carrying a current. If the wire coil is wound around a core made of a material that is easily magnetised, such as iron, then the magnetic field around the coil is concentrated within the core; this greatly increases the efficiency of the inductor.

Due to the bulky nature of Inductor we preferably don't use them in electronic circuits.



COLOR	1st BAND	2nd BAND	MULTIPLIER	TOLERANCE
BLACK	0	0	1	± 20%
BROWN	1	1	10	± 1%
RED	2	2	100	± 2%
ORANGE	3	3	1,000	± 3%
YELLOW	4	4	10,000	± 4%
GREEN	5	5		
BLUE	6	6		
VIOLET	7	7		
GREY	8	8		
WHITE	9	9		
GOLD			0.1	5%
SILVER			0.01	10%
GOLD			decimal point	5%

<u>Heavy Inductor Coils</u> **<u>Small Axial lead Inductors Colour code</u>**

- **Diodes:**

A diode is a two-terminal electronic component with asymmetric conductance; it has low (ideally zero) resistance to current in one direction, and high (ideally infinite) resistance in the other. A semiconductor diode, the most common type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals.

Diodes are having two terminals namely Cathode (N-type terminal) and Anode (P-type terminal). For device to work in forward bias Anode is connected to positive supply and Cathode to negative supply. In general purpose diodes and Zener diode the Cathode is represented by a 'ring' on the body of diode.

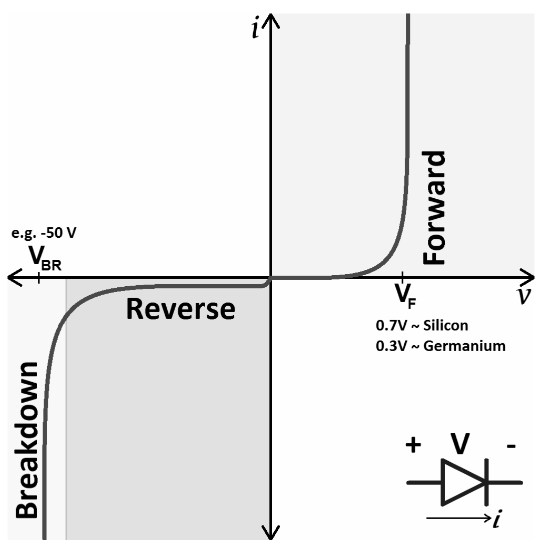
General Purpose Diode

Zener Diode

Light Emitting Diodes

Cathode in the Light emiting dioides are identified by seeing the length of the terminals, the smaller terminal is Cathode.

The general purpose diode is general operated in I quadrant though it can work in III quadrant also but it will burn out in breakdown region. Practically, Zener diode is made to work in breakdown region, it can work in other regions also similar to general diode. LED's only work in forward bias the get burned out in III quadrant.



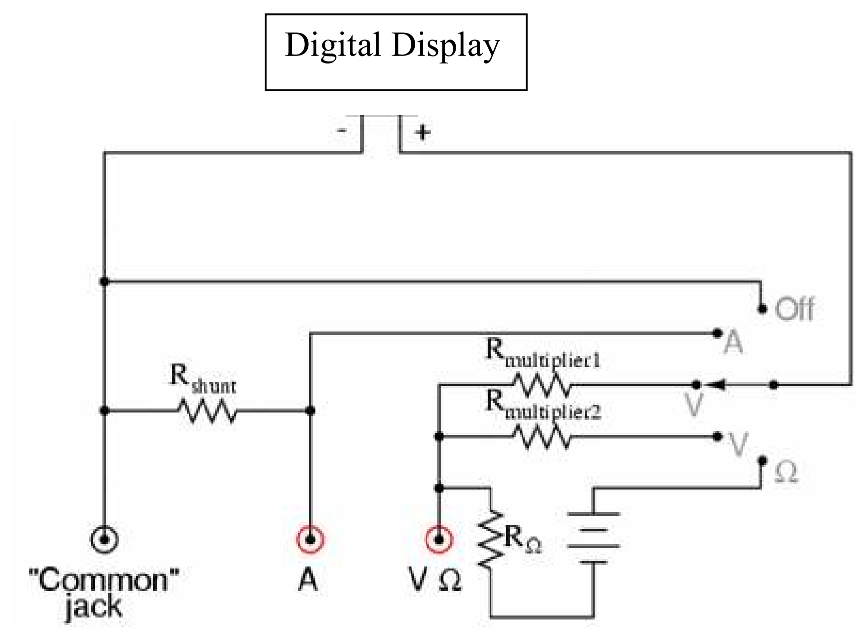
Waveform of Diode

- **Multimeter:**

A multimeter is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter would include basic features such as the ability to measure voltage, current, and resistance. Analog multimeters use a microammeter whose pointer moves over a scale calibrated for all the different measurements that can be made. Digital multimeters (DMM, DVOM) display the measured value in numerals, and may also display a bar of a length proportional to the quantity being measured.

A multimeter is a combination of a multirange DC voltmeter, multirange AC voltmeter, multirange ammeter, and multirange ohmmeter. The range and the quantity to be measured can be selected by rotating the knob and pointing it to the desired location.

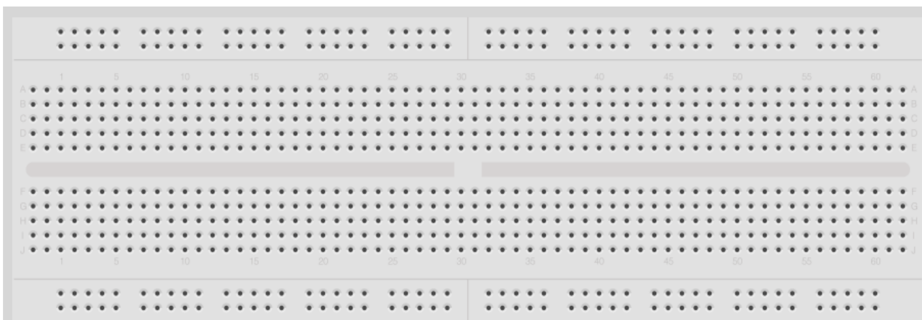
- DC Voltage can be calculated by connecting the probes of multimeter between the two points in parallel with the circuit.
- DC Current can be calculated by connecting the probes of the multimeter between the two points in series with the circuit.
- Resistance measurement can be done by connecting the terminals of the resistance to the probes of the multimeter.
- Connectivity in the circuit as well as h_{fe} of BJT's can also be calculated using multimeter.
- AC voltage and current measurement should be done very carefully as it can harm the device, by setting the desired quantity on the knob, and also by connect probe to proper location in multimeter, and the connection of probes to the circuit in which the voltage or current is calculated should be disconnected after every 10 seconds.



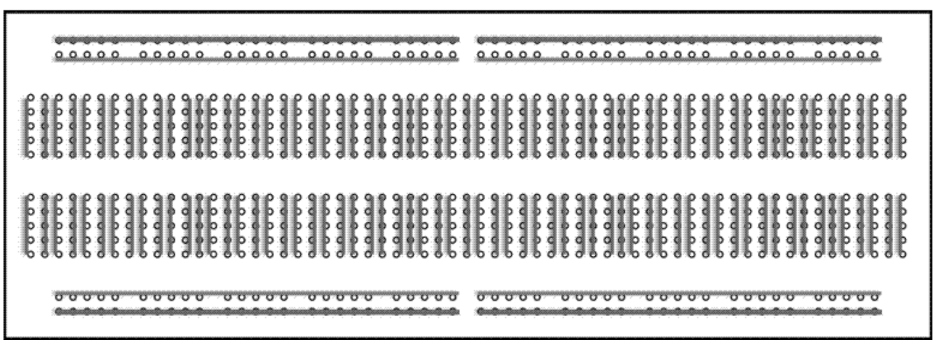
Internal Circuitry of Multimeter

- **Breadboard**

A breadboard (or protoboard) is a construction base for prototyping of electronics. Originally it was literally a bread board, a polished piece of wood used for slicing bread. In the 1970s the solderless breadboard (plugboard, a terminal array board) became available and nowadays the term "breadboard" is commonly used to refer to these. "Breadboard" is also a synonym for "prototype".
Because the solderless breadboard does not require soldering, it is reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design. For this reason, solderless breadboards are also extremely popular with students and in technological education.



Breadboard

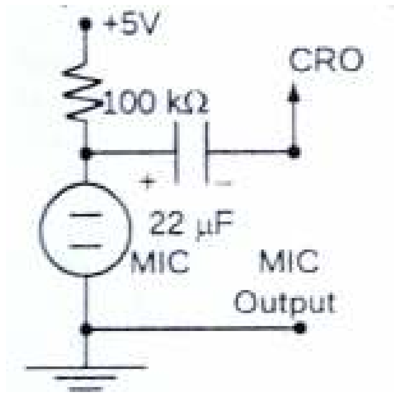


Internal Connection of the Bread board

The above figure shows how the internal connections are done in the breadboard. The lines going through the holes, shows the holes that are shorted to each other.

- **Loudspeaker and Micophone:**

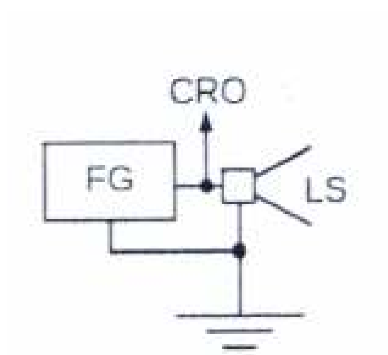
A condensor microphone is just a parallel plate capacitor having one fixed plate and one plate mounted on a diaphragm that can vibrate according to the incident sound waves. It works on the basic principle that the currrent through a capacitor is given by $I_C = C * d(V_C)/dt$ in general.



Circuit for microphone experiment

Setup the biasing circuit for the given condenser microphone as given in above figure and display the microphone output on thr CRO. Speak into the microphone and see your voiceprint on the CRO for different sounds.

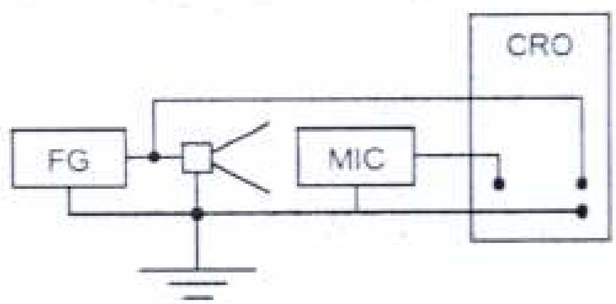
Common loudspeakers are of the electromagnetic type, consisting of a coil wound over a magnetic core, and a diaphragm made of magnetic material placed an the magnetic field of coil. A loudspeaker is normally connected to the output of an audio amplifier that amplfies its input signal to deliver the power required by the loudspeaker. The amplifier output current flows through the coil of the loudspeaker, causing the diaphram tovibrate in accordance with the applied signal, thereby producing sound wave.



Circuit for loudspeaker experiment

Measure the DC resistance of Loudspeaker using Multimeter. Connect the function generator output to the loudspeaker and also to a CRO input channel as shown in figure above. Set the frequency of function generator to 1KHz sinosoidal wave, and gradually increase the amplitude till there is a resonable sound from the loudspeaker. Measure the voltage level V_L.

Without disturbing the Function generator settings, disconnect the Loudspeaker and measure the open-circuit function generator output voltage V_{LO}. Determine the impedence of the loudspeaker at 1KHz from the ratio V_L / V_{LO}, given that function generator output impedence is 50Ω. Compare this value with the value mearured with multimeter.



Audio Test Circuit

Setup the circuit as shown in the figure above. Place a microphone so that it can pick up the sound from the loudspeaker and display the Function genertor and microphone output on the two channels of the CRO. Vary the frequency of the function generator over the entire audio frequency range (20Hz-20KHz) and measure the microphone output voltage at each frequency, ensuring that the function generator output remains at the same level as set before.

Note that the frequency at which your ear can hear the sound from the loudspeaker. Tabulate the ratio of the two voltages aginst frequency. This ratio gives the product of the voltage-to-sound conversion factor of the loudspeaker and the sound-to-voltage conversion factor of the microphone on frequency.

Questions to be answered:

1. Is it possible to measure current directly through CRO, if yes how we should connect CRO in circuit? If no, how we would indirectly calculate it?
2. What is DC-offset and Duty cycle for signal? Can we vary these quantities in function genertor? How can we measure the above quantites in CRO?
3. What is the mechanism followed in Potentiometers and Variable capacitors, for getting variable values of resistances and capacitances?
4. Write the applications of different types of diodes, using circuit diagrams?
5. Explain the mechanism used in multimeter to vary scale of measurment?

Precaution to be taken:

1. All the discrete components should be held with care.
2. Connect all the circuits and check all the connection before switching ON the power supply.
3. Care must be taken while handling AC signal of high amplitude.
4. Before changing any connections ensure that power supply is OFF.