EXPERIMENT MANUAL

FOR
ANALOG ELECTRONICS - I
BASED EXPERIMENTS

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ANALOG ELECTRONICS- I LAB

List of Experiments

BREADBOARD

What is Breadboard?

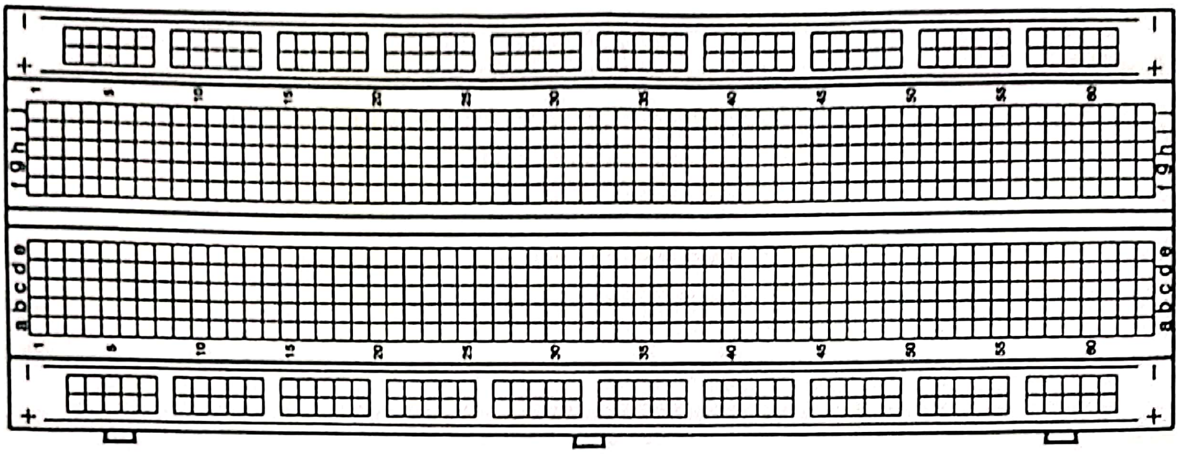
A breadboard is a circuit board that is used to make temporary circuits. It is a device having electronics and test circuit designs. The electronic elements inside the electronic circuits can be interchanged by inserting the terminals and leads into holes and later connecting it with the help of appropriate wires. The device has stripes of metal below the board that connects the holes placed on the top of the board. The connections of the breadboard are mostly temporary and the elements can further be reassembled and reused without any damage. Breadboards are generally used in electrical engineering. Engineers make use of breadboards in order to test different products made by them. Using breadboard is the most efficient way of testing and also they are cost effective. They can be reused again and again for the purpose of testing.

Today, starting from tiny analog, digital circuits to big complicated CPU's everything can be tested with the help of this.

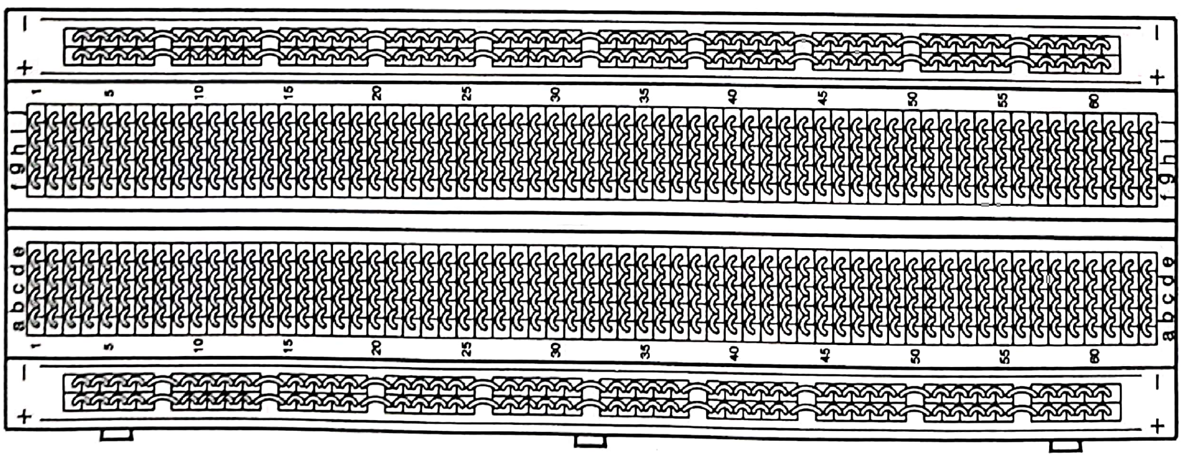
Breadboards earlier were made of copper wires or terminal strips. These days it is made up of white plastic and is a breadboard that can be plugged. Breadboards are solder less and they are made of two kinds of strips i.e. terminal and bus strips. Terminal strips help in holding the electronic elements while the bus strip is used to power electric power to all the electronic components. You can find manufacturers selling solder less breadboards very easily, some manufactures sell the bust and terminal strips separately and some sell it together.

Breadboard Basics:

A breadboard is a circuit which if of a temporary nature used for the purpose of testing and prototyping circuits. It is easy to prototype circuits with the help of breadboards because it is fast and easy. Breadboards are generally used to test circuits. As this device have holes in it. In order to form a circuit, wires are inserted simply inside the holes. An advantage of using a breadboard is that the positions of the wires can be changed if they are placed in a wrong order. In the below diagram you can see alphabets are used in order to identify vertical columns and numbers are used in order to identify vertical columns.



Breadboard Connections:
A breadboard as mentioned before is used to make temporary circuit for testing and other purposes. The advantage of using a breadboard for testing is that connection can be changed if they are wrong. Also the parts of the circuit do not get damaged and can easily be reused. A breadboard generally consists of lots of holes so that wires can easily be pushed in. testing for almost every electronic projects starts from the breadboard. The breadboard has many tiny sockets likes holes arranged in a 0.1 grid. The leads that most elements have can easily be pushed inside these holes. The ICs are pushed inside across to the gap with their dot on the left. Standard wires cannot be used for breadboard as they get damaged easily and hence they require single core plastic coated wires that have 0.6mm diameter. Standard wires if used can also lead to damage of the board.



The above diagram shows how the holes of a breadboard are connected. The bottom and the top rows are connected horizontally. The power supply is connected to both the bottom and the top rows. The other rows are connected in a vertical manner which consists of five rows each without any links to the across the centre. In this way there are separate blocks of connections to each of the ICs pin. Now this was the connection in a small breadboard.

In case of large breadboards, there are breaks half way in the top and the bottom rows of the power supply. It is always better to link across the gap before you start building circuit. If you do not link it then that part of the circuit will not have any power supply.

REGULATED POWER SUPPLY

There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function. For example a 5V regulated supply:

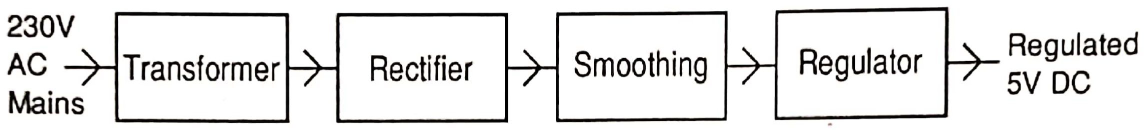


Fig1- Block Diagram of Regulated Power Supply

Each of the blocks is described in more detail below:

- Transformer: Step down high voltage AC mains to low voltage AC.
- Rectifier: Converts AC to DC, but the DC output is varying.
- Smoothing: Smooth the DC form varying greatly to a small ripple.
- Regulator: Elimination ripple by setting DC output to a fixed voltage.

Dual Supplies: Some electronic circuits require a power supply with positive and negative outputs as well as zero volts (0V). This is called a 'dual supply' because it is like two ordinary supplies connected together as shown in the diagram. Dual supplies have three outputs, for example a ±9V supply has +9V, 0V and -9V outputs.

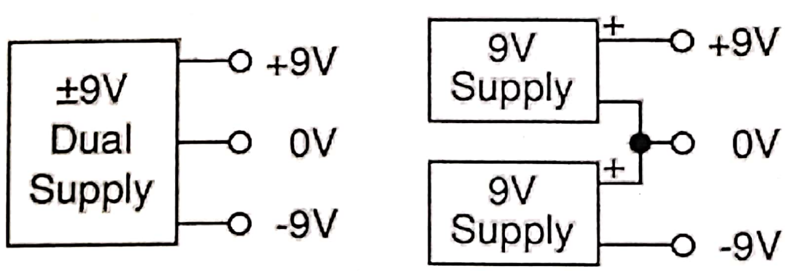


Fig2- Dual Supply

MULTIMETER

Multimeters are very useful test instruments. By operating a multi- position switch on the meter they can be quickly and easily set to be used as a **voltmeter**, an **ammeter** or an **ohmmeter**. Some meters have additional features used to measure capacitance and frequency as well. They have several settings called "ranges" for each type of meter and the choice of either alternating or direct current measurements.

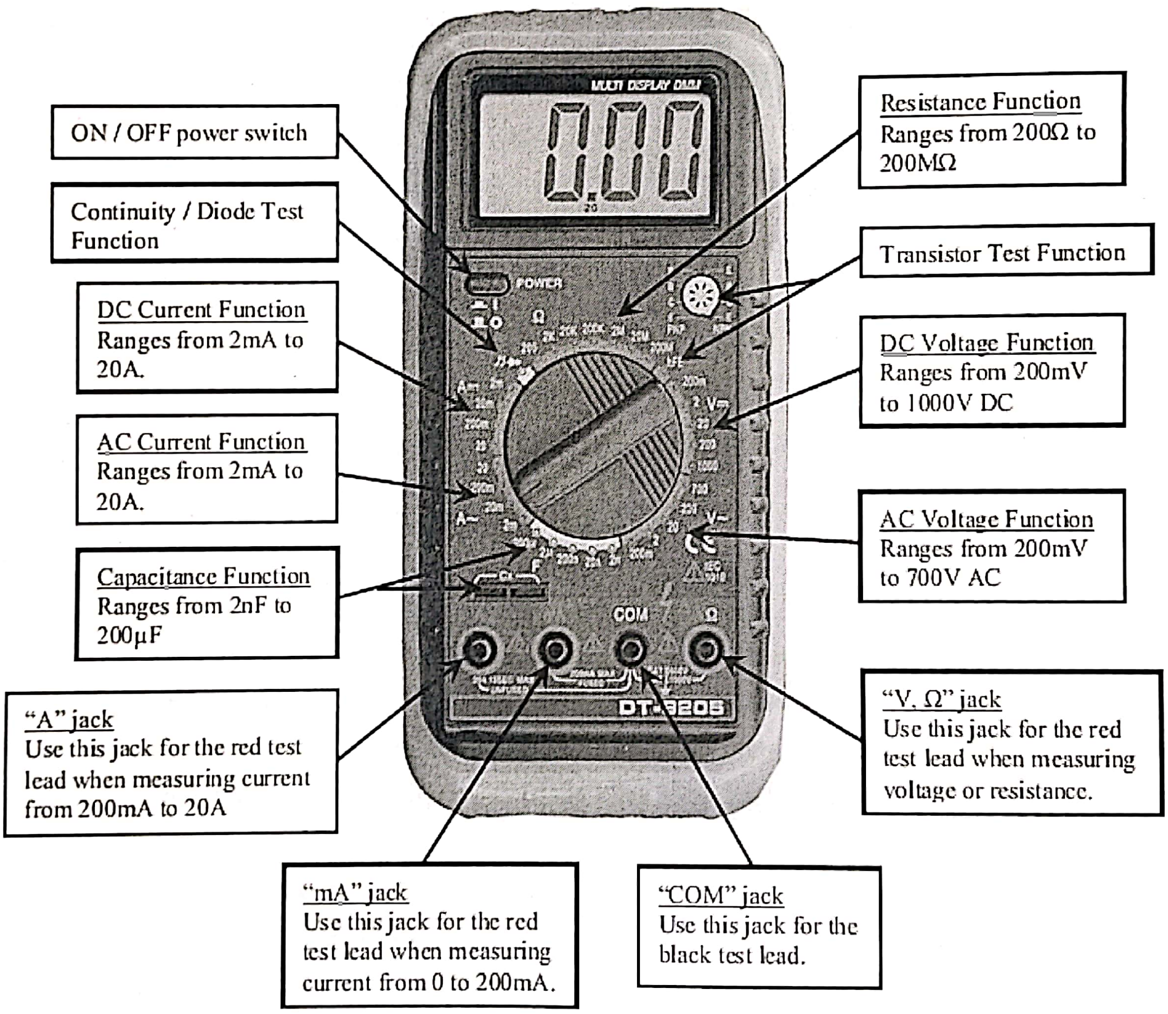


Fig1- Digital Multimeter

Voltmeter

To test for voltage, first determine whether the application you're testing uses AC or DC voltage. Then set the dial to the appropriate function and plug the red test lead into the correct jack used to measure voltage.

Like all test procedures, when testing voltage, set the meter to the range just higher than the expected voltage and decrement it down as needed to increase the accuracy of the reading. If you don't know the expected range, set the range to the highest one available. Take the black test lead and place it on the negative polarity point of the circuit you want to measure. The red test lead will go on the more positive polarity point. When measuring voltage, the test leads of the meter must always be connected in **parallel** or "across" the component or circuit to be measured as in Figure-2.

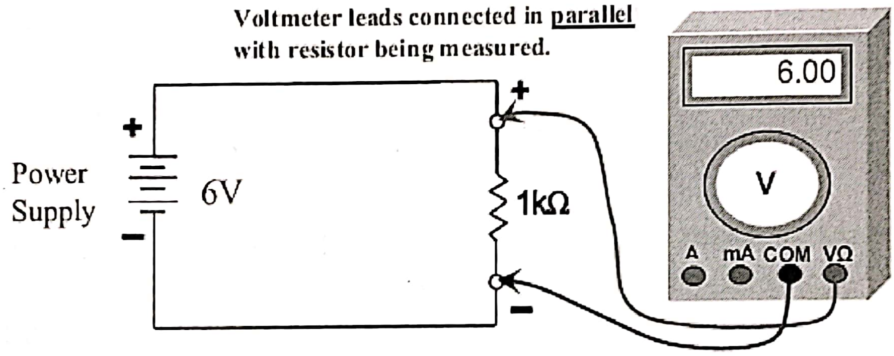


Fig2- Multimeter as a voltmeter

Ammeter

To measure current, break the circuit where you want to take the reading. Set the meter to AC or DC current depending on the source being tested. Plug the test lead into the correct jack to measure the expected current.

Note: Most meters have a separate jack that needs to be used to measure current from 0 to 200mA and from 200mA to 10A or sometimes 20A.

Insert the meter in **series** or "in line" with the circuit to be measured by placing the red test lead on the positive polarity point and the black lead on the negative polarity point (see Figure- 3). Similar to the voltage, the correct current range needs to be selected. Start by selecting the next range higher than the expected reading. If the meter ever reads "0" when an actual reading should be present, check the fuse for the 200mA port.

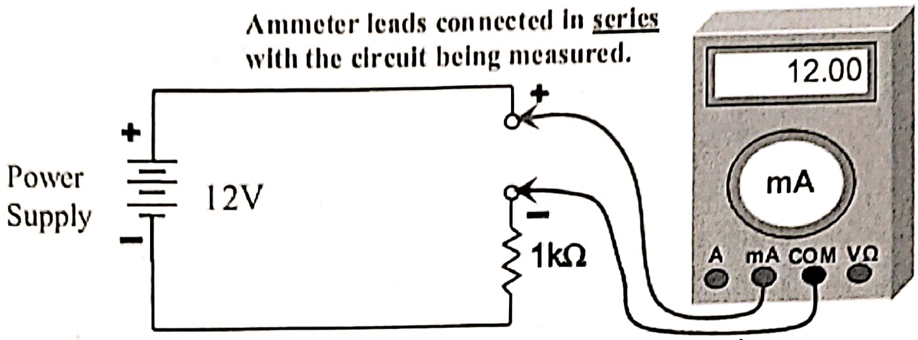


Fig3- Multimeter as an Ammeter

Ohmmeter

To test for resistance, first remove the power from the circuit component to be tested. This prevents the meter from becoming damaged by the source. After ensuring that all power is off, set the dial to the resistance function. Select the appropriate range on the dial. Remove the component to be measured from the circuit (This prevents false readings from any other components in the circuit). Make sure the test leads are plugged into the correct jack to measure resistance. Connect your test leads to the component and take the reading.

It's important that you have good contact between the test leads and the component being tested. Dirt, oil and poor test lead connection can undesirably alter resistance readings.

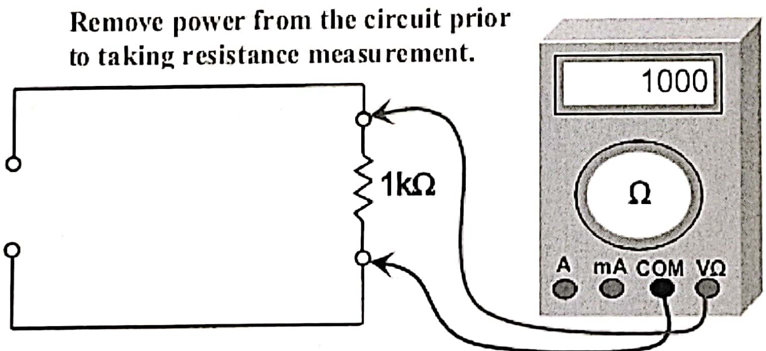


fig4- Multimeter as a ohmmeter

CATHODE RAY OSCILLOSCOPE

An oscilloscope is a test instrument which allows us to look at the 'shape' of electrical signals by displaying a graph of voltage against time on its screen. It is like a voltmeter with the valuable extra function of showing how the voltage varies with time. A graticule with a 1cm grid enables us to take measurements of voltage and time from the screen.

The graph, usually called the trace, is drawn by a beam of electrons striking the phosphor coating of the screen making it emit light, usually green or blue. This is similar to the way a television picture is produced.

Oscilloscopes contain a vacuum tube with a cathode (negative electrode) at one end to emit electrons and an anode (positive electrode) to accelerate them so they move rapidly down the tube to the screen. This arrangement is called an electron gun. The tube also contains electrodes to deflect the electron beam up/down and left/right.

The electrons are called cathode rays because they are emitted by the cathode and this gives the oscilloscope its full name of cathode ray oscilloscope or CRO.

A dual trace oscilloscope can display two traces on the screen, allowing us to easily compare the input and output of an amplifier for example. It is well worth paying the modest extra cost to have this facility.

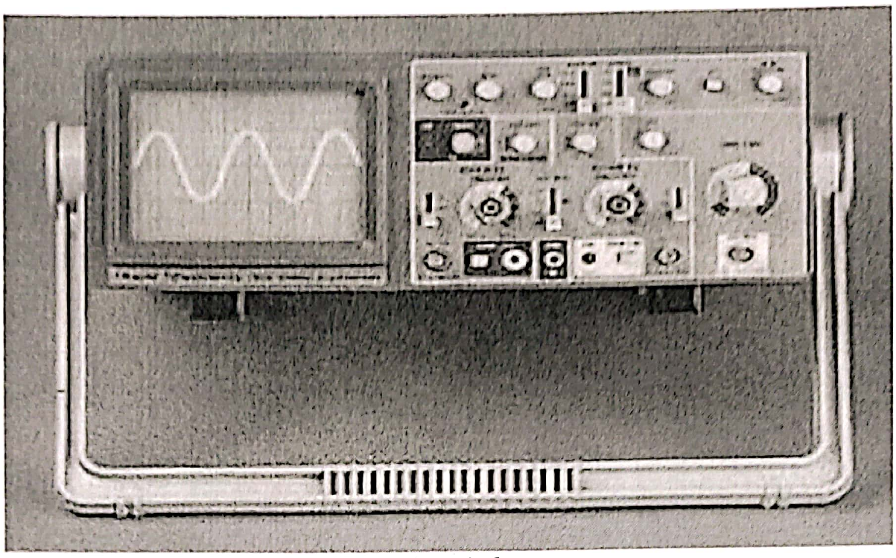


Fig1- Front Panel of CRO

BASIC OPERATION:

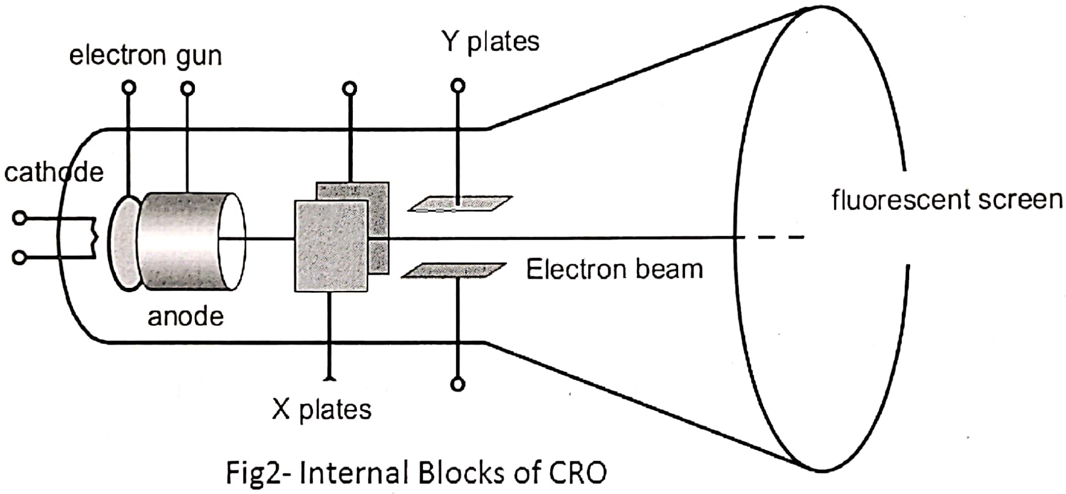


Fig2- Internal Blocks of CRO

Setting up an oscilloscope:

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 controls are set wrongly.

There is some variation in the arrangement and labeling of the many controls. So, the following instructions may be adapted for this instrument.

1. Switch on the oscilloscope to warm up (it takes a minute or two).
2. Do not connect the input lead at this stage.
3. Set the AC/GND/DC switch (by the Y INPUT) to DC.

4. Set the SWP/X-Y switch to SWP (sweep).
5. Set Trigger Level to AUTO.
6. Set Trigger Source to INT (internal, the y input).
7. Set the Y AMPLIFIER to 5V/cm (a moderate value).
8. Set the TIMEBASE to 10ms/cm (a moderate speed).
9. Turn the time base VARIABLE control to 1 or CAL.
10. Adjust Y SHIFT (up/down) and X SHIFT (left/right) to give a trace across the middle of the screen, like the picture.
11. Adjust INTENSITY (brightness) and FOCUS to give a bright, sharp trace.

The following type of trace is observed on CRO after setting up, when there is no input signal connected.

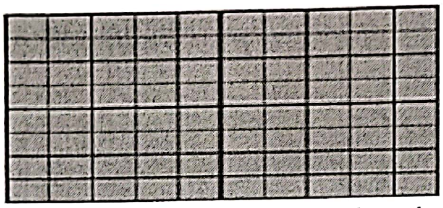


Fig3- Absence of Input Signal

Connecting an oscilloscope:

The Y INPUT lead to an oscilloscope should be a co-axial lead and the figure 4 shows its construction. The central wire carries the signal and the screen is connected to earth (0V) to shield the signal from electrical interference (usually called noise).

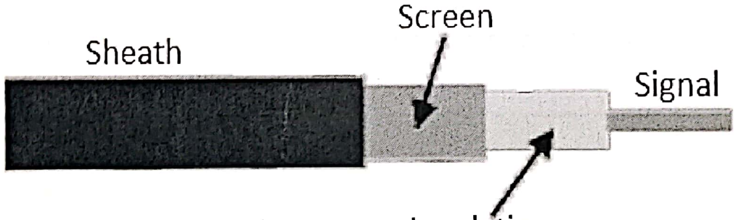


Fig4- Construction of Co- axial lead

Most oscilloscopes have a BNC socket for the y input and the lead is connected with a push and twist action, to disconnect we need to twist and pull. Professionals use a specially designed lead and probes kit for best results with high frequency signals and when testing high resistance circuits, but this is not essential for simpler work at audio frequencies (up to 20 kHz).

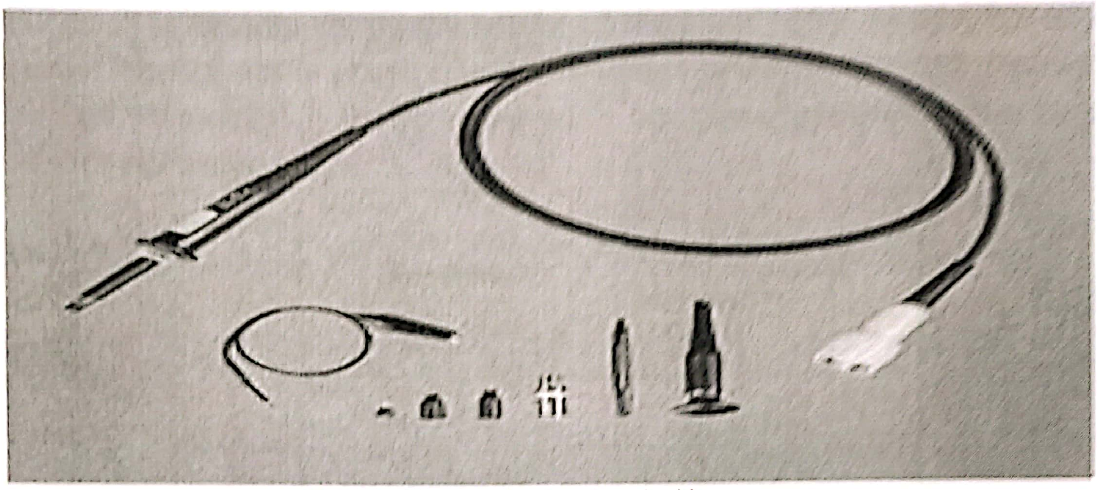


Fig5- Oscilloscope lead and probe kit

Obtaining a clear and stable trace:

Once if we connect the oscilloscope to the circuit, it is necessary to adjust the controls to obtain a clear and stable trace on the screen in order to test it.

- The Y AMPLIFIER (VOLTS/CM) control determines the height of the trace. Choose a setting so the trace occupies at least half the screen height, but does not disappear off the screen.
- The TIMEBASE (TIME/CM) control determines the rate at which the dot sweeps across the screen. Choose a setting so the trace shows at least one cycle of the signal across the screen. Note that a steady DC input signal gives a horizontal line trace for which the time base setting is not critical.
- The TRIGGER control is usually best left set to AUTO.

The trace of an AC signal with the oscilloscope controls correctly set is as shown in Figure 6.

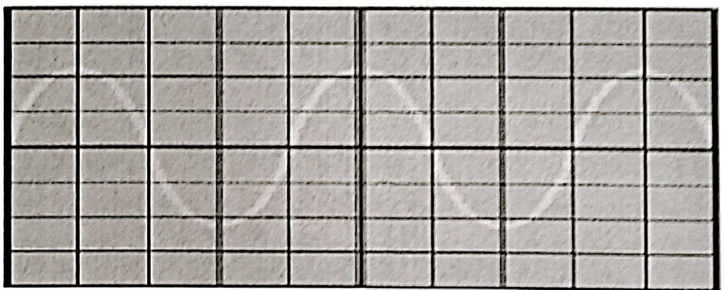


Fig6- Stable Waveform

Measuring voltage and time period

The trace on an oscilloscope screen is a graph of voltage against time. The shape of this graph is determined by the nature of the input signal. In addition to the properties labeled on the graph, there is frequency which is the number of cycles per second. The diagram shows a sine wave but these properties apply to any signal with a constant shape

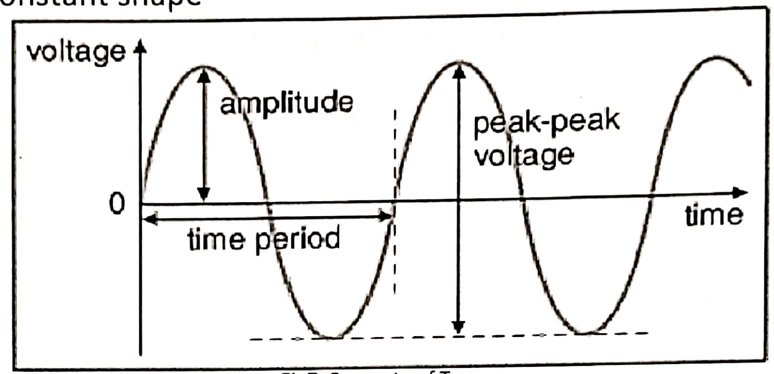


Fig7- Property of Trace

- **Amplitude** is the maximum voltage reached by the signal. It is measured in volts. **Peak voltage** is another name for amplitude.
- **Peak-peak voltage** is twice the peak voltage (amplitude). When reading an oscilloscope trace it is usual to measure peak-peak voltage.
- **Time period** is the time taken for the signal to complete one cycle. It is measured in seconds (s), but time periods tend to be short so milliseconds (ms) and microseconds (µs) are often used. 1ms = 0.001s and 1µs = 0.000001s.
- **Frequency** is the number of cycles per second. It is measured in hertz (Hz), but frequencies tend to be high so kilohertz (kHz) and megahertz (MHz) are often used. 1kHz = 1000Hz and 1MHz = 1000000Hz

A) **Voltage:** Voltage is shown on the vertical y-axis and the scale is determined by the Y AMPLIFIER (VOLTS/CM) control. Usually peak-peak voltage is measured because it can be read correctly even if the position of 0V is not known. The amplitude is half the peak-peak voltage.

Voltage = distance in cm × volts/cm

B) **Time period:** Time is shown on the horizontal x-axis and the scale is determined by the TIMEBASE (TIME/CM) control. The time period (often just called period) is the time for one cycle of the signal. The frequency is the number of cycles per second, frequency = 1/time period.

Time = distance in cm × time/cm

FUNCTION GENERATOR

A function generator is a device that can produce various patterns of voltage at a variety of frequencies and amplitudes. It is used to test the response of circuits to common input signals. The electrical leads from the device are attached to the ground and signal input terminals of the device under test.

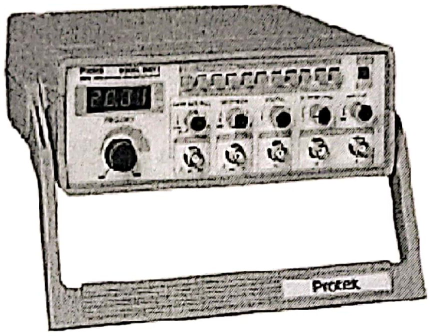


Fig1- A low cost Function Generator

Features and controls:
Most function generators allow the user to choose the shape of the output from a small number of options.

- Square wave - The signal goes directly from high to low voltage

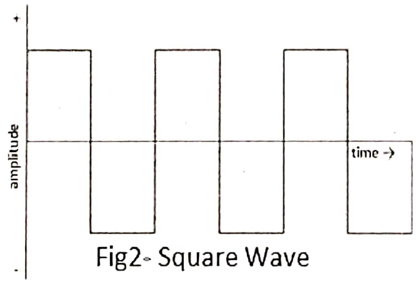


Fig2- Square Wave

The duty cycle of a signal refers to the ratio of high voltage to low voltage time in a square wave signal.

- Sine wave - The signal curves like a sinusoid from high to low voltage.

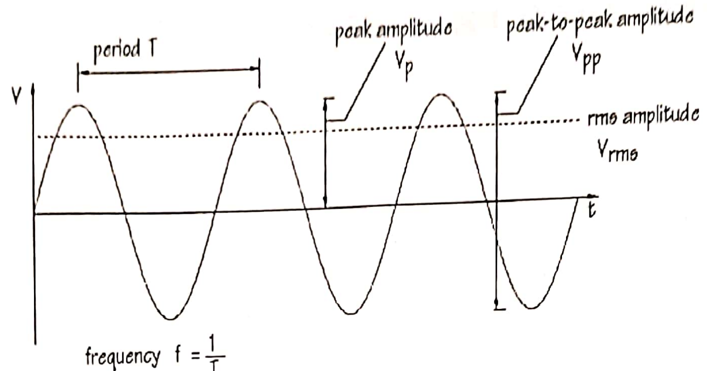


Fig3- Sine Wave

- Triangle wave - The signal goes from high to low voltage at a fixed rate

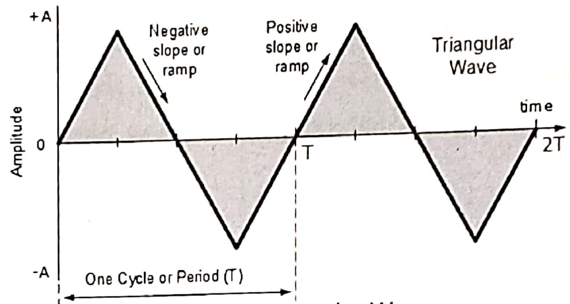


Fig4- Triangular Wave

The amplitude control on a function generator varies the voltage difference between the high and low voltage of the output signal. The direct current (DC) offset control on a function generator varies the average voltage of a signal relative to the ground.

The frequency control of a function generator controls the rate at which output signal oscillates. On some function generators, the frequency control is a combination of different controls. One set of controls chooses the broad frequency range (order of magnitude) and the other selects the precise frequency. This allows the function generator to handle the enormous variation in frequency scale needed for signals.

How to use a function generator

After powering on the function generator, the output signal needs to be configured to the desired shape. Typically, this means connecting the signal and ground leads to an oscilloscope to check the controls. Adjust the function generator until the output signal is correct, then attach the signal and ground leads from the function generator to the input and ground of the device under test. For some applications, the negative lead of the function generator should attach to a negative input of the device, but usually attaching to ground is sufficient.

ACTIVE AND PASSIVE ELECTRONIC COMPONENTS

Passive Components:
The electronic components which are not capable of amplifying or processing an electrical signal are called PASSIVE COMPONENTS.
Such as Resistors, Capacitors and Inductors.

1.1. RESISTOR

A **Resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. The current through a resistor is in direct proportion to the voltage across the resistor's terminals. This relationship is represented by Ohm's law:

Where *I* is the current through the conductor in units of amperes, *V* is the potential difference measured across the conductor in units of volts, and *R* is the resistance of the conductor in units of ohms.

The ratio of the voltage applied across a resistor's terminals to the intensity of current in the circuit is called its resistance, and this can be assumed to be a constant (independent of the voltage) for ordinary resistors working within their ratings.

1.2. COLOUR CODING OF RESISTOR

Colour Codes are used to identify the value of resistor. The numbers to the Colour are identified in the following sequence which is remembered as **BBROY GREAT BRITAN VERY GOOD WIFE (BBROYGBVGW)** and their assignment is listed in following table.

Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Grey	White
0	1	2	3	4	5	6	7	8	9

Table 1: Colour codes of resistor

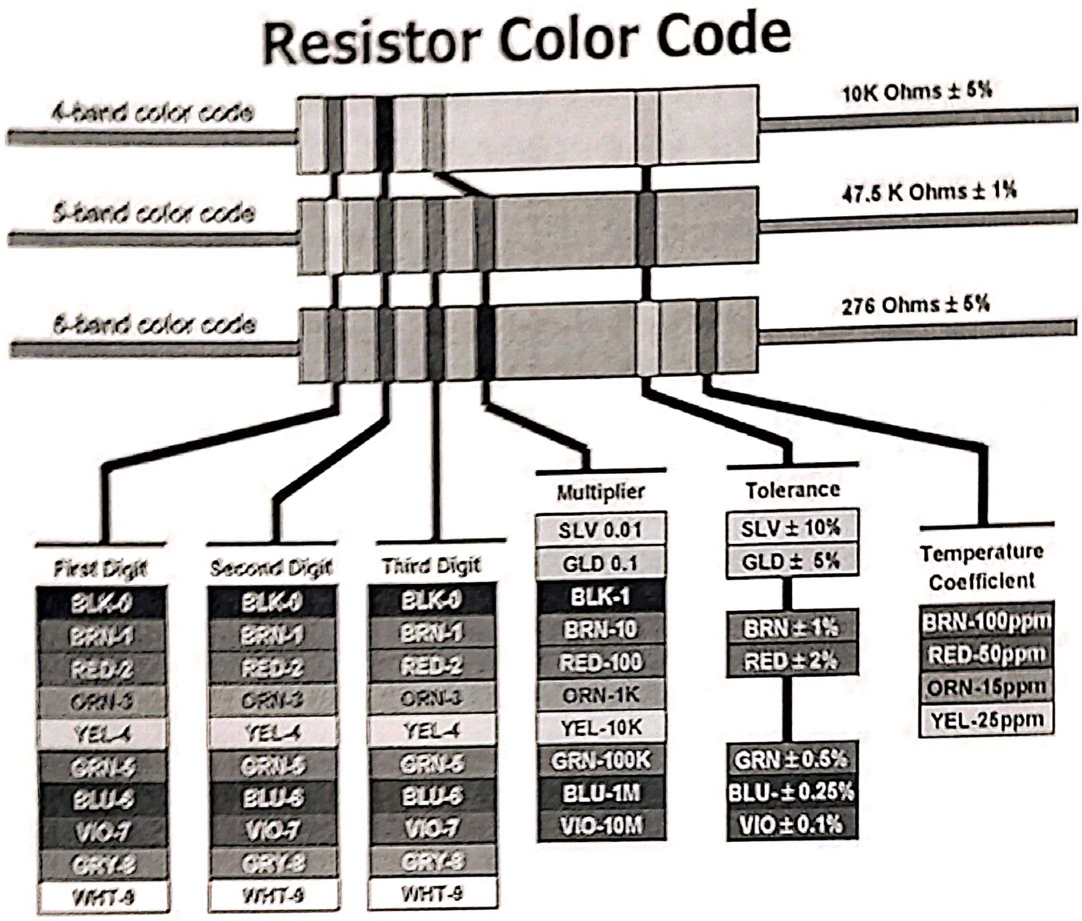


Figure 1: Procedure to find the value of Resistor using Colour codes

Resistor Color Codes: Resistors are devices that limit current flow and provide a voltage drop in electrical circuits. Because carbon resistors are physically small, they are color-coded to identify their resistance value in Ohms. The use of color bands on the body of a resistor is the most common system for indicating the value of a resistor. Color-coding is standardized by the Electronic Industries Association (EIA).

Use the **Resistor Color Code Chart** (above) to understand how to use the color code system. When looking at the chart, note the illustration of three round resistors with numerous color code bands. The first resistor in the chart (with 4 bands) tells you the minimum information you can learn from a resistor. The next (a 5-band code) provides a little more information about the resistor. The third resistor (a 6-band) provides even more information. Each color band is associated with a numerical value.

How to read a typical 4-band, 5-band and 6-band resistor: 4-Band: Reading the resistor from left to right, the first two color bands represent *significant digits* , the third band represents the decimal *multiplier*, and the fourth band represents the *tolerance*. **5-Band:** The first three color bands represent *significant digits*, the fourth band represents the decimal *multiplier*, and the fifth band represents the *tolerance*. **6-Band:** The first three color bands represent *significant digits*, the fourth band represents the decimal *multiplier*, the fifth band represents the *tolerance*, and the sixth band represents the *temperature coefficient*.

Definitions of color bands: The color of the *multiplier* band represents multiples of 10, or the placement of the decimal point. For example: ORANGE (3) represents 10 to the third power or 1,000. The *tolerance* indicates, in a percentage, how much a resistor can vary above or below its value. A gold band stands for +/- 5%, a silver band stands for +/-10%, and if there is no fourth band it is assumed to be +/- 20%. For example: A 100-Ohm 5% resistor can vary from 95 to 105 Ohms and still be considered within the manufactured tolerance. The *temperature coefficient* band specifies the maximum change in resistance with change in temperature, measured in parts per million per degree Centigrade (ppm/°C).

1.3. TYPES OF RESISTORS

1. Carbon Resistors
2. Wire wound Resistors

Carbon Resistors

There are many types of resistors, both fixed and variable. The most common type for electronics use is the carbon resistor. They are made in different physical sizes with power dissipation limits commonly from 1 watt down to 1/8 watt. The resistance value and tolerance can be determined from the standard resistor color code.

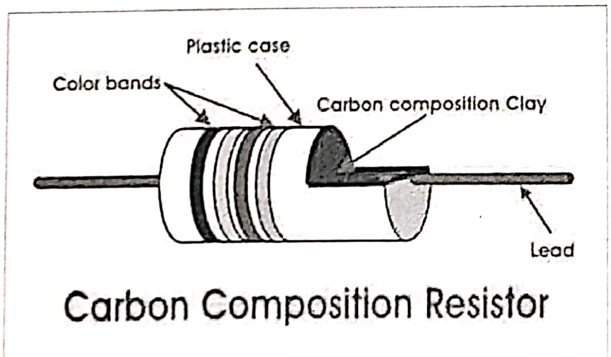


Figure 2: Images of Carbon Resistors

A variation on the color code is used for precision resistors which may have five colored bands. In that case the first three bands indicate the first three digits of the resistance value and the fourth band indicates the number of zeros. In the five band code the fifth band is gold for 1% resistors and silver for 2%.

Wire Wound Resistors

Wire wound resistors are commonly made by winding a metal wire, usually nichrome, around a ceramic, plastic, or fiberglass core. The ends of the wire are soldered or welded to two caps or rings, attached to the ends of the core. The assembly is protected with a layer of paint, molded plastic, or an enamel coating baked at high temperature. Because of the very high surface temperature these resistors can withstand temperatures of up to +450 °C.[6] Wire leads in low power wire wound resistors are usually between 0.6 and 0.8 mm in diameter and tinned for ease of soldering. For higher power wire wound resistors, either a ceramic outer case or an aluminum outer case on top of an insulating layer is used. The aluminum-cased types are designed to be attached to a heat sink to dissipate the heat; the rated power is dependent on being used with a suitable heat sink, e.g., a 50 W power rated resistor will overheat at a fraction of the power dissipation if not used with a heat sink. Large wire wound resistors may be rated for 1,000 watts or more.

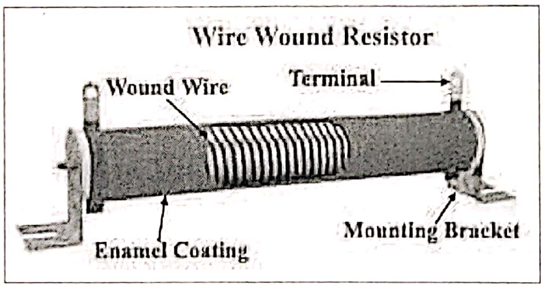


Figure 2: Images of WireWound Resistors

Because wire wound resistors are coils they have more undesirable inductance than other types of resistor, although winding the wire in sections with alternately reversed direction can minimize inductance. Other techniques employ bifilar winding, or a flat thin former (to reduce cross-section area of the coil). For the most demanding circuits, resistors with Ayrton-Perry winding are used.

Applications of wire wound resistors are similar to those of composition resistors with the exception of the high frequency. The high frequency response of wire wound resistors is substantially worse than that of a composition resistor

1.4. CAPACITOR

A **capacitor** (originally known as a **condenser**) is a passive two-terminal electrical component used to store energy electro statically in an electric field. By contrast, batteries store energy via chemical reactions. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator); for example, one common construction consists of metal foils separated by a thin layer of insulating film. Capacitors are widely used as parts of electrical circuits in many common electrical devices.

When there is a potential difference (voltage) across the conductors, a static electric field develops across the dielectric, causing positive charge to collect on one plate and negative charge on the other plate. Energy is stored in the electrostatic field. An ideal capacitor is characterized by a single constant value, capacitance. This is the ratio of the electric charge on each conductor to the potential difference between them. The SI unit of capacitance is the farad, which is equal to one coulomb per volt.

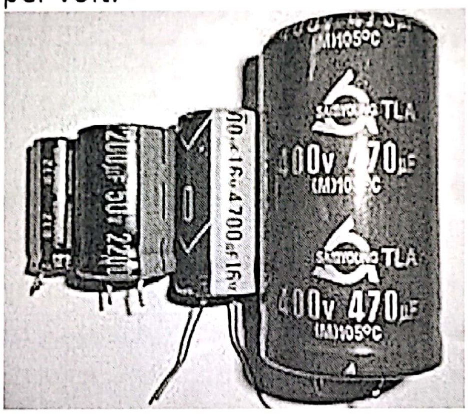


Figure 4: Electrolytic capacitors of different voltages and capacitance

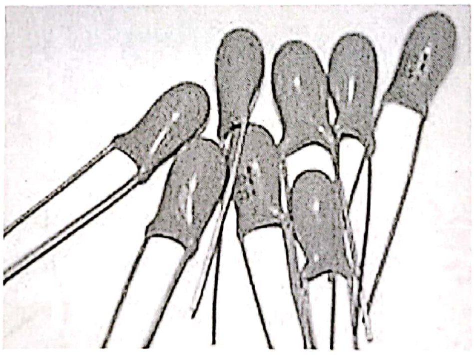


Figure 5: Solid-body, resin-dipped 10 µF 35 V Tantalum capacitors.

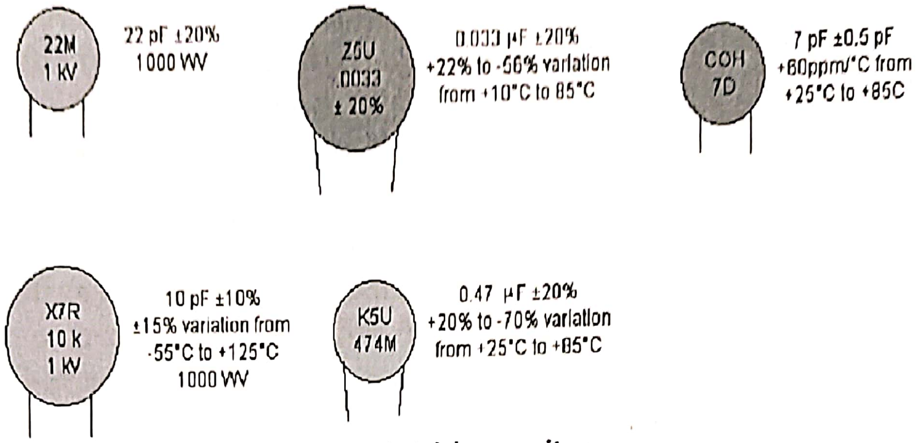


Figure 8: Ceramic Disk capacitor

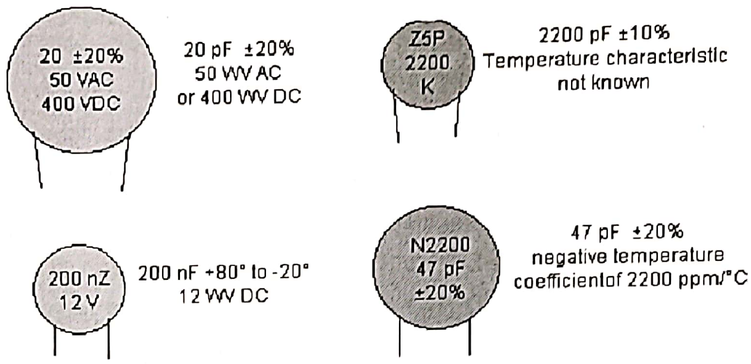


Figure 9: Miscellaneous Capacitors

- **Electrolytic capacitor properties**

There are a number of parameters of importance beyond the basic capacitance and capacitive reactance when using electrolytic capacitors. When designing circuits using electrolytic capacitors it is necessary to take these additional parameters into consideration for some designs, and to be aware of them when using electrolytic capacitors

ESR Equivalent series resistance: Electrolytic capacitors are often used in circuits where current levels are relatively high. Also under some circumstances and current sourced from them needs to have low source impedance, for example when the capacitor is being used in a power supply circuit as a reservoir capacitor. Under these conditions it is necessary to consult the manufacturers" datasheets to discover whether the electrolytic capacitor chosen will meet the requirements for the circuit. If the ESR is high, then it will not be able to deliver the required amount of current in the circuit, without a voltage drop resulting from the ESR which will be seen as a source resistance.

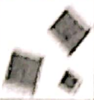
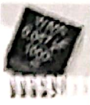
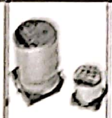
Type ⊕ = polarized	Pic	Cap Range	ESR	Leakage	Voltage Rating	Temp Range	Gen Notes
Ceramic		pF - µF	low	med	high	-55° to +125°C	Multipurpose Cheap
Mica (silver mica)		pF - nF	low 0.01-0.1Ω	low	high	-55° to +125°C	For RF filters Expensive Very stable
Plastic Film (polyethylene polystyrene)		few µFs	med	med	high	varies	For low freq Cheap
Tantalum ⊕		µFs	high 0.5-5.0Ω	low	lowest	-55° to +125°C	Expensive Nonlinear (bad for audio)
OSCON ⊕		µFs	low 0.01-0.5Ω	low	low	-55° to +105°C	Best quality Highest price
Aluminum Electrolytic ⊕		high µFs	high 0.05-2.0Ω	med	low	-40° to +85°C	For low-med frequencies Cheap Hold charge for long time – not for production test

Table2- Common Capictor specifications and Trade- offs

1.5. COLOUR CODING OF CAPACITORS

In general, a capacitor consists of two metal plates insulated from each other by a dielectric. The capacitance of a capacitor depends primarily upon its shape and size and upon the relative permittivity ε_r of the medium between the plates. In vacuum, in air, and in most gases, ε_r ranges from one to several hundred..

One classification of capacitors comes from the physical state of their dielectrics, which may be gas (or vacuum), liquid, solid, or a combination of these. Each of these classifications may be subdivided according to the specific dielectric used. Capacitors may be further classified by their ability to be used in alternating-current (ac) or direct-current (dc) circuits with various current levels.

- **Capacitor Identification Codes:** There are no international agreements in place to standardize capacitor identification. Most plastic film types (Figure1) have printed values and are normally in microfarads or if the symbol is n, Nanofarads. Working voltage is easily identified. Tolerances are upper case letters: M = 20%, K = 10%, J = 5%, H = 2.5% and F = ± 1pF.

Frequency response: One of the problems with electrolytic capacitors is that they have a limited frequency response. It is found that their ESR rises with frequency and this generally limits their use to frequencies below about 100 kHz. This is particularly true for large capacitors, and even the smaller electrolytic capacitors should not be relied upon at high frequencies. To gain exact details it is necessary to consult the manufacturer"s data for a given part.

Leakage: Although electrolytic capacitors have much higher levels of capacitance for a given volume than most other capacitor technologies, they can also have a higher level of leakage. This is not a problem for most applications, such as when they are used in power supplies. However under some circumstances they are not suitable. For example they should not be used around the input circuitry of an operational amplifier. Here even a small amount of leakage can cause problems because of the high input impedance levels of the op-amp. It is also worth noting that the levels of leakage are considerably higher in the reverse direction

Ripple current: When using electrolytic capacitors in high current applications such as the reservoir capacitor of a power supply, it is necessary to consider the ripple current it is likely to experience. Capacitors have a maximum ripple current they can supply. Above this they can become too hot which will reduce their life. In extreme cases it can cause the capacitor to fail. Accordingly it is necessary to calculate the expected ripple current and check that it is within the manufacturer's maximum ratings.

Tolerance: Electrolytic capacitors have a very wide tolerance. Typically this may be -50% + 100%. This is not normally a problem in applications such as decoupling or power supply smoothing, etc. However they should not be used in circuits where the exact value is of importance.

Polarization: Unlike many other types of capacitor, electrolytic capacitors are polarized and must be connected within a circuit so that they only see a voltage across them in a particular way.

The physical appearance of electrolytic capacitor is as shown in Figure 5.The capacitors themselves are marked so that polarity can easily be seen. In addition to this it is common for the can of the capacitor to be connected to the negative terminal.

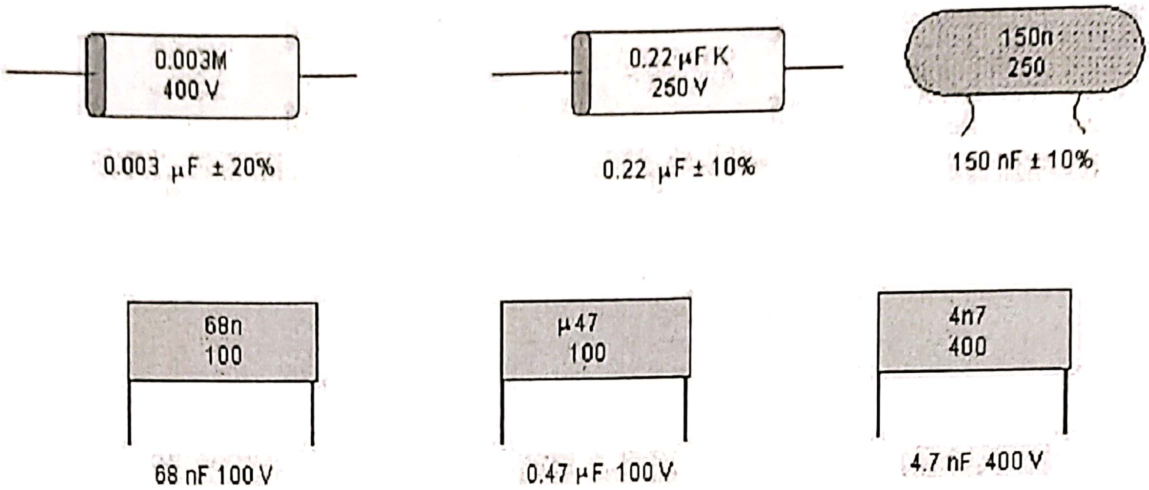


Figure 6: Plastic Film Types

A more difficult scheme is shown in Figure 2 where K is used for indicating Picofarads. The unit is picofarads and the third number is a multiplier. A capacitor coded 474K63 means 47 × 10000 pF which is equivalent to 470000 pF or 0.47 microfarads. K indicates 10% tolerance. 50, 63 and 100 are working volts.

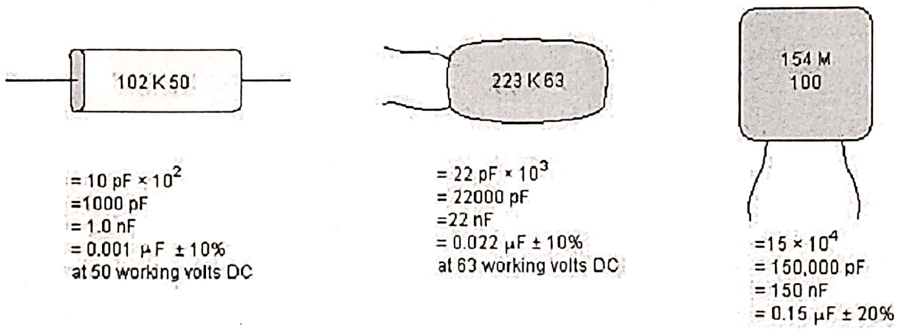


Figure 7: Pico Farads Representation

Ceramic disk capacitors have many marking schemes. Capacitance, tolerance, working voltage and temperature coefficient may be found. Capacitance values are given as number without any identification as to units. (uF, nF, pF) Whole numbers usually indicate pF and decimal numbers such as 0.1 or 0.47 are microfarads. Odd looking numbers such as 473 is the previously explained system and means 47 nF.

Figure 10: Electrolytic capacitor

It is absolutely necessary to ensure that any electrolytic capacitors are connected within a circuit with the correct polarity. A reverse bias voltage will cause the centre oxide layer forming the dielectric to be destroyed as a result of electrochemical reduction. If this occurs a short circuit will appear and excessive current can cause the capacitor to become very hot. If this occurs the component may leak the electrolyte, but under some circumstances they can explode. As this is not uncommon, it is very wise to take precautions and ensure the capacitor is fitted correctly, especially in applications where high current capability exists.

1.6. COLOUR CODING OF INDUCTORS

Inductor is just coil wound which provides more reactance for high frequencies and low reactance for low frequencies.

Molded inductors follow the same scheme except the units are usually micro henries. A brown-black-red inductor is most likely a 1000 uH. Sometimes a silver or gold band is used as a decimal point. So a red-gold-violet inductor would be a 2.7 uH. Also expect to see a wide silver or gold band before the first value band and a thin tolerance band at the end. The typical Colour codes and their values are shown in Figure 6.

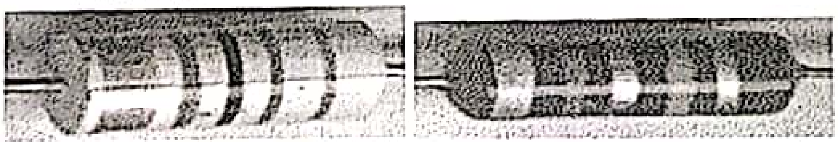


Figure 11: Typical inductors Colour coding and their values.

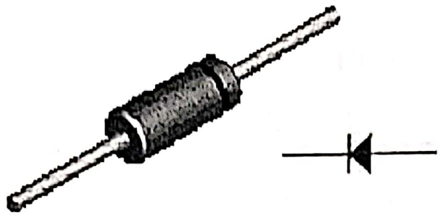
Active Components:

The electronic components which are capable of amplifying or processing an electrical signal are called ACTIVE COMPONENTS.

Such as Vacuum Tubes, Gas Tubes and Semiconductor Devices.

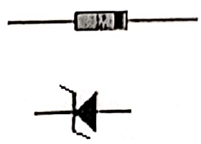
Diode:

A diode is a single junction device made of p and n type materials.. Its main function is to rectify an ac signal although other special purpose diodes like zener and led's are used for other purposes. A normal diode comes in a black casing whereas a zener diode has a transparent casing. Their pictures and symbols are given in figure.



DO-35

(a)



(b)

Fig. (a): A normal diode with DO-35 casing and its symbol.
(b) A zener diode with transparent casing and its symbol

Other diodes may be made by a p type and n type materials or between a semiconductor and a metal. If the junction is made between a metal and semiconductor then it is called a Schottky diode whose application is in rectifying and non-rectifying contacts and Schottky devices. If the pn junction is made between very heavily doped materials then it forms a Zener diode. These are used for voltage regulation in power supplies. and have breakdown voltages which are very low. The normal diode has a breakdown voltage of greater than 100 V.

Some of the diode specifications are: Maximum reverse voltage (V_{br}), rated forward current (I_f) , maximum forward voltage drop (V_f) and package style. Table 3 gives some of the most commonly used diodes with their specifications.

Table- 3

Device Number	Material used.	I_F (mA)	V_F(V)	V_{BR} (V)
OA91	Ge	50	2.1	115
In 4148	Si	100	1.0	75
In 4149	Si	100	1.0	75
IN 4007	Si	1000	1.6	1000

To test whether a given diode is O.K. or not, a simple multimter test can be performed which is given later in this unit.

Light Emitting Diode (LED)

Led'sare pn junction devices which emit light radiation when biased in the forward direction. The semiconductor material used for these junctions is a compound semiconductor like AlGaAs whose band gap corresponds to a particular wavelength according to equation $E_g = 1.24 / \lambda$ where E_g is the band gap in ev and λ is the wavelength in microns. (e.g. red ~ 0.7 μ hence corresponding $E_g = 1.24 / 0.7 = 1.77$ ev). When the pn junction is forward biased, the electrons are excited to conduction band and when they fall to the valence band, they give out energy in the form of radiation corresponding to the Eg of the material Conventional led's are made from the materials like AlGaAs, GaAlP, GaAsP, GaP and GaN which emit Red, green, orange, yellow and blue colours respectively. Led's come in a special transparent casing as shown in fig 8..Dual colour led's are also available where two junctions are encapsulated on the same chip. It has three leads where cathode is common whereas normal leds' have two leads one for cathode and other for anode. A very important precaution while using an led is the amount of current being passed through it. For most leds the maximum allowable current is 20 mA beyond which the led can burn out. Hence in most of the circuits a resistor is used to limit the current. Some important specifications before using an led are: LED colour, peak wavelength, viewing angle, optical power output, luminous intensity, forward current and forward voltage.

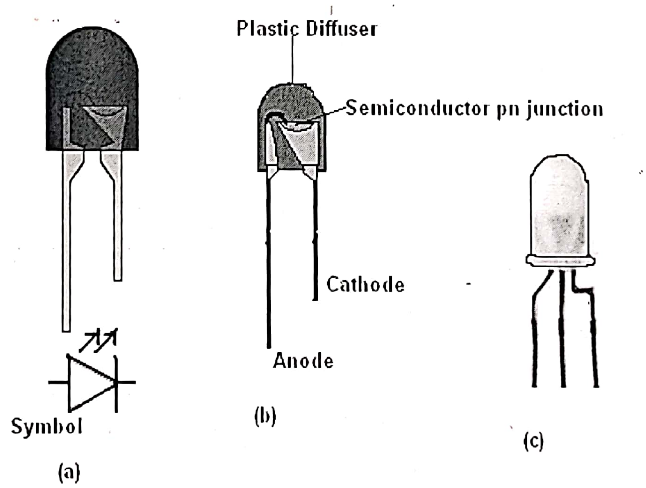


Fig (a) An led with its symbol, (b) Internal structure of led (c) Dual colour led

Transistors

Transistors are semiconductor devices used for applications like amplification of voltages, current and are also used in oscillator circuits and switches. It's a two junction and 3 terminal device made of three layers of n and p type materials. The three regions are emitter, base and collector. They are of 2 types (i) pnp and (ii) npn. Their most important specifications are Ic, Vce, hfe and Power rating. They come in different casings like TO18, TO92C, and TO39 etc Given below is a table of most commonly used transistors with their specifications (approximate) and casings. Datasheets from the companies can be referred to to know the exact specifications.

Code	Structure	Case style	I_C max.	V_{CE} max.	h_{FE} min.	P_{tot} max.	Category (typical use)	Possible substitutes
BC107	NPN	TO18	100mA	45V	110	300mW	Audio, low power	BC182 BC547
BC108	NPN	TO18	100mA	20V	110	300mW	General purpose, low power	BC108C BC183 BC548
BC108C	NPN	TO18	100mA	20V	420	600mW	General purpose, low power	
BC109	NPN	TO18	200mA	20V	200	300mW	Audio (low noise), low power	BC184 BC549
BC182	NPN	TO92C	100mA	50V	100	350mW	General purpose, low power	BC107 BC182L
BC182L	NPN	TO92A	100mA	50V	100	350mW	General purpose, low power	BC107 BC182
BC547B	NPN	TO92C	100mA	45V	200	500mW	Audio, low power	BC107B
BC548B	NPN	TO92C	100mA	30V	220	500mW	General purpose, low power	BC108B
BC549B	NPN	TO92C	100mA	30V	240	625mW	Audio (low noise), low power	BC109
2N3053	NPN	TO39	700mA	40V	50	500mW	General purpose, low power	BFY51
BFY51	NPN	TO39	1A	30V	40	800mW	General purpose, medium power	BC639
BC639	NPN	TO92A	1A	80V	40	800mW	General purpose, medium power	BFY51
TIP29A	NPN	TO220	1A	60V	40	30W	General purpose, high power	
TIP31A	NPN	TO220	3A	60V	10	40W	General purpose, high power	TIP31C TIP41A
TIP31C	NPN	TO220	3A	100V	10	40W	General purpose, high power	TIP31A TIP41A
TIP41A	NPN	TO220	6A	60V	15	65W	General purpose, high power	
2N3055	NPN	TO3	15A	60V	20	117W	General purpose, high power	
BC177	PNP	TO18	100mA	45V	125	300mW	Audio, low power	BC477
BC178	PNP	TO18	200mA	25V	120	600mW	General purpose, low power	BC478

BC179	PNP	TO18	200mA	20V	180	600mW	Audio (low noise), low power	
BC477	PNP	TO18	150mA	80V	125	360mW	Audio, low power	BC177
BC478	PNP	TO18	150mA	40V	125	360mW	General purpose, low power	BC178
TIP32A	PNP	TO220	3A	60V	25	40W	General purpose, high power	TIP32C
TIP32C	PNP	TO220	3A	100V	10	40W	General purpose, high power	TIP32A

Next Figure gives some of the transistors with the symbols for npn and pnp.

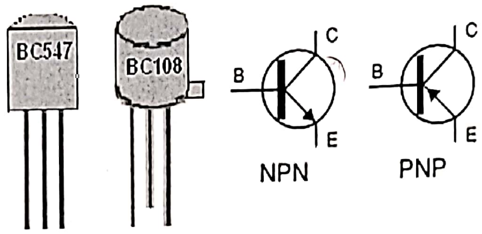


Fig. Transistors BC 108 and BC547

And Following figure illustrates some of the casings with the configurations for emitter , base and collector leads

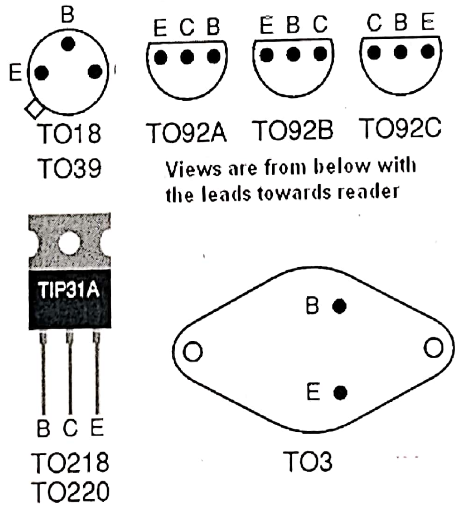


Fig Emitter, base and collector leads for some case styles.

EXPERIMENT NO – 3

OBJECTIVE: To plot Forward and Reverse Bias Characteristics of P-N Junction Diode and to calculate the resistance of Diode from their characteristics curves.

APPARATUS REQUIRED:-

1.	Bread Board	01 No.
2.	P-N Junction Diode	01 No.
3.	Resistance- 1KΩ	01 No.
4.	Multimeter	02 Nos.
5.	Variable DC Power Supply	01 No.
6.	Connecting Wires	

CIRCUIT DIAGRAM:-

1. Forward Biasing:-

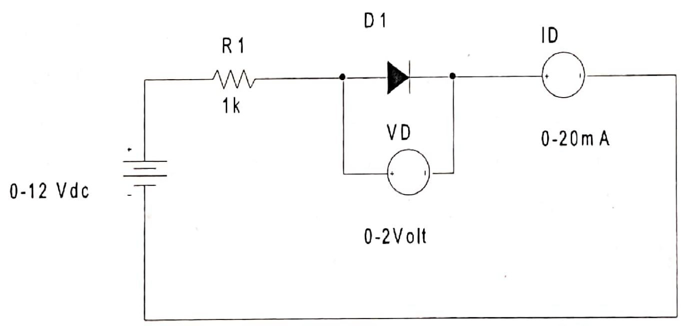


Figure- A

2. Reverse Biasing:-

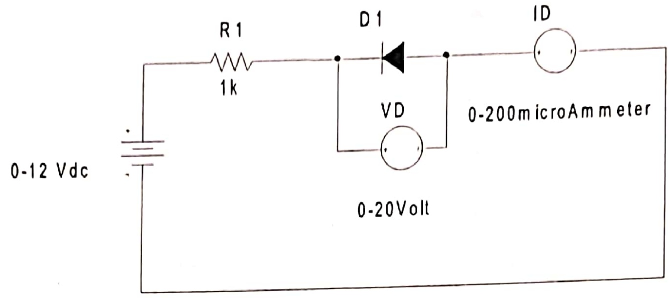


Figure- B

THEORY:-

The diode is a device formed from a junction of n-type and p-type semiconductor material. The lead connected to the p-type material is called the anode and the lead connected to the n-type material is the cathode. In general, the cathode of a diode is marked by a solid line on the diode. The primary function of the diode is rectification. When it is forward biased (the higher potential is connected to the anode lead), it will pass current. When it is reversed biased (the higher potential is connected to the cathode lead), current flow is blocked. In the simplest form, the diode is modeled by a switch. The switch is closed when the diode if forward biased and open when the diode is reversed biased. Immediately after the diode is switched to reverse bias, the depletion region is still full of carriers. Therefore, a large negative current will flow until all of the excess carriers are washed out. As the carriers are removed, the reverse current decays exponentially to approximately zero. The other characteristic is reverse bias breakdown. In a normal diode, breakdown can result in damage to the diode. However, the Zener diode is designed to breakdown. In fact, the breakdown voltage is set to a desired point through the construction of the device. This effect can be exploited to perform voltage regulation.

Diode Equation:

$$I_D = I_0 \left(e^{qV/\eta kT} - 1\right)$$

Where

I= Forward (or Reverse) Diode Current

= Reverse Saturation Current

V= External Voltage (It is positive for forward bias & negative for reverse bias)

n= Constant (for Ge= 1 and for Si= 2)

V_T= Volt- Equivalent of Temperature (V_T= T/11600= 26mV)

Forward and Reverse Characteristics of P-N Junction Diode:

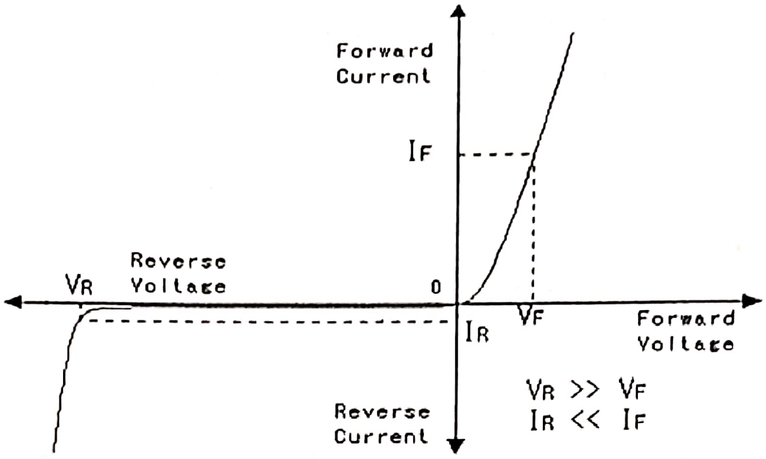


Figure- C

PROCEDURE:-

Using suitable patch cords make connection as shown in Figure- A for forward characteristics and Figure- B for reverse characteristics.

The typical forward and reverse characteristics are shown in Figure- C.

Forward Characteristics:

Using suitable patch cords make connection as shown in figure- A for forward characteristics.

In order to plot forward bias characteristics, perform the following steps :

Vary the. Diode voltage (V_D) in step of 0.1V starting from zero and observe the corresponding value of Diode Current (I_D) in milli- ampere (mA). And finally Plot the graph.

Reverse characteristics:

Using suitable patch cords make connection as shown in figure- B for reverse characteristics.

In order to plot Reverse bias characteristics, perform the following steps:

Vary the Diode voltage (V_D) in step of 1V starting from zero and observe the corresponding value of Diode Current (I_D) in micro- ampere (µA). and finally Plot the graph.

OBSERVATION:

Forward Bias		Reverse Bias	
V_D (Volt)	I_D(mA)	V_D(Volt)	I_D(µA)
0		0	
0.1		1	
0.2		2	
0.3		3	
0.4		4	
0.5		5	
0.6		6	
0.7		7	
0.8		8	
0.9		9	
1.0		10	

CALCULATION:

1. Static Resistance $R_D = V_D/I_D$
2. Dynamic Resistance $Rd = \Delta V_D / \Delta I_D$

RESULT:

1. R_D = ...
2. Rd = ...

PRECAUTIONS:

1. Keep variable power supply in anti-clock wise before the starting the experiment.

2. Do not exceed Diode current beyond the limit i.e. 10 mA.

EXPERIMENT NO - 4

OBJECTIVE: To plot forward and reverse bias characteristics of Zener diode and calculate the Zener voltage.

APPARATUS REQUIRED:-

1.	Bread Board	01 No.
2.	Zener Diode	01 No.
3.	Resistance- 1KΩ	01 No.
4.	Multimeter	02 Nos.
5.	Variable DC Power Supply	01 No.
6.	Connecting Wires	

CIRCUIT DIAGRAM:-

1. **Forward Bias:**

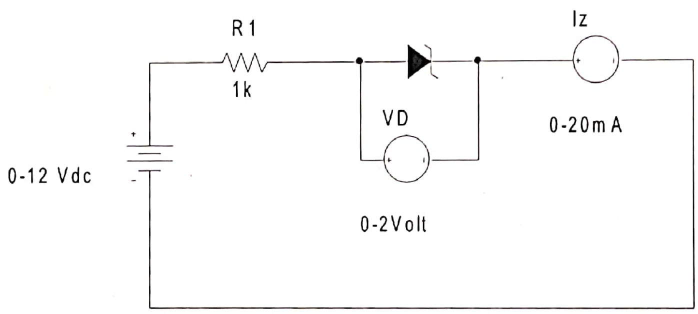


Figure- A

2. **Reverse Biase**

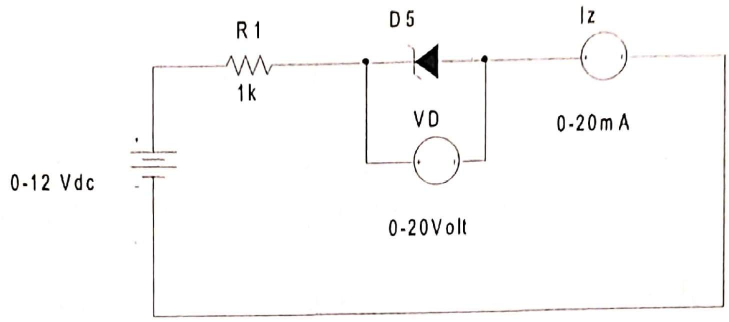


Figure- B

THEORY:-

It is made up of specially doped semiconductor and in reverse bias the breakdown can be made reversible. There are two types of breakdown, one is zener breakdown and the other is the Avalanche breakdown. Zener diodes are used for regulating output voltage.

Forward and Reverse Characteristics of Zener Diode:

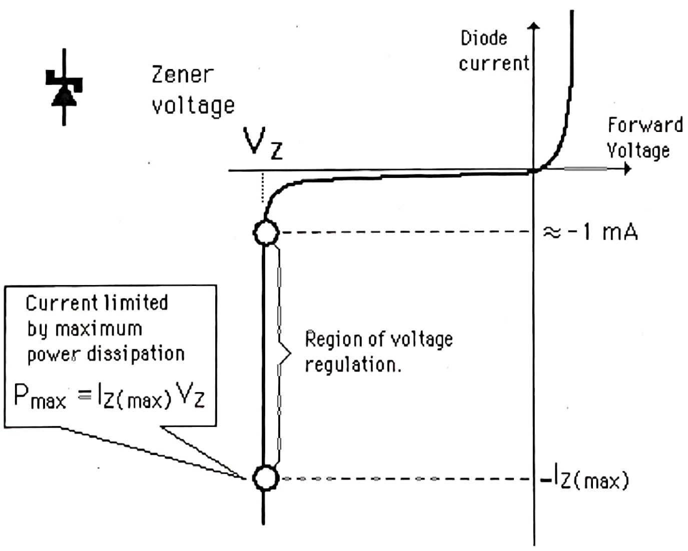


Figure- C

PROCEDURE:-

Forward characteristics for Zener Diode: Using suitable patch cords make connection as shown in figure- A for forward Characteristics of zener diode.

<u>In order to plot forward bias characteristics, perform the following steps</u>:
Vary the Diode voltage (V_D) in step of 0.1V starting from zero and observe the corresponding value of Diode Current (I_D) in mili ampere (mA).

Reverse characteristics for Zener Diode: Using suitable patch cords make connection as shown in fig. b for reverse Characteristics.

<u>In order to plot the reverse bias characteristics, perform the following steps:</u>
Vary the Diode voltage (V_z) in steps of 1V starting from zero and observe the corresponding value of Zener Diode Current (I_z) in mili ampere (mA) and observe the point where small change of zener voltage shows the great change in Zener Diode current (I_z) that is breakdown zener voltage. And finally plot the graph.

OBSERVATION:

Forward Bias		Reverse Bias	
V_Z (Volt)	I_D(mA)	V_z(Volt)	I_D(μA)
0		0	
0.1		1	
0.2		2	
0.3		3	
0.4		4	
0.5		5	
0.6		6	
0.7		7	
0.8		8	
0.9		9	
1.0		10	

RESULT:
observe the point where small change of zener voltage shows the great change in Zener Diode current (I_z) that is breakdown zener voltage.

PRECAUTIONS:
1. Keep variable power supply in anti-clock wise before the starting the experiment.

2. Do not exceed Diode current beyond the limit i.e. 10 mA.

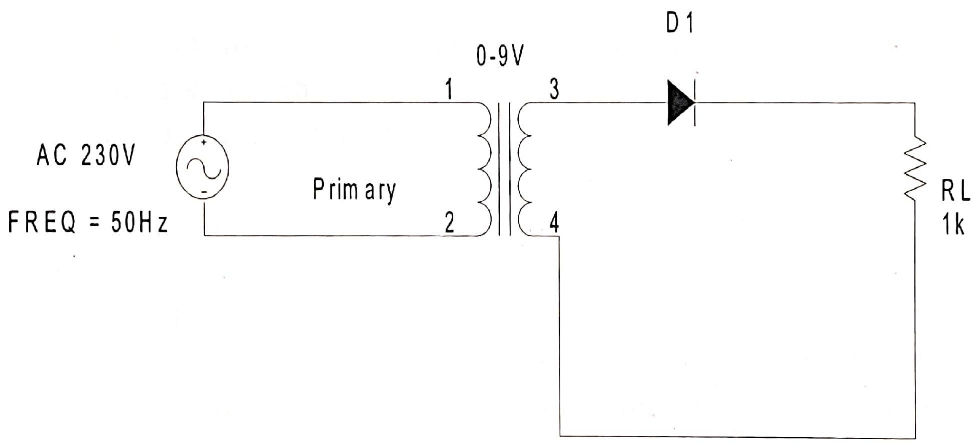
EXPERIMENT NO - 5

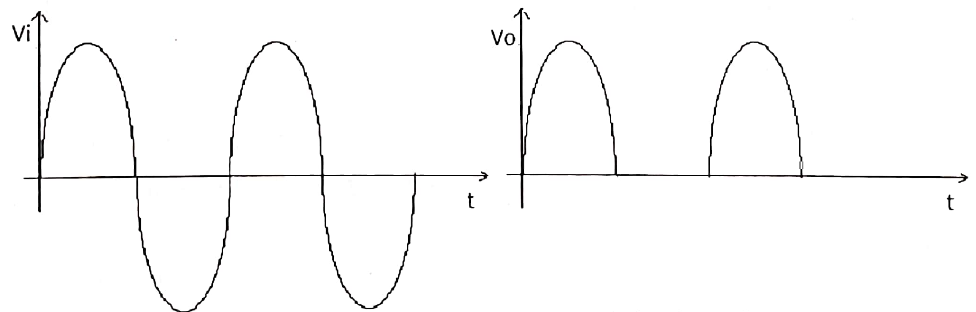
OBJECTIVE: To study of Half Wave Rectifier circuit and find ripple factor using capacitor filter circuit.

APPARATUS REQUIRED:

1.	Bread Board	01 No.
2.	P-N Junction Diode	01 No.
3.	Resistance- 1KΩ	01 No.
4.	Transformer (9-0-9)	01 No.
5.	CRO with CRO Probes	01No.
6.	Electrolytic Capacitor	01No.
7.	Connecting Wires	

CIRCUIT DIAGRAM:

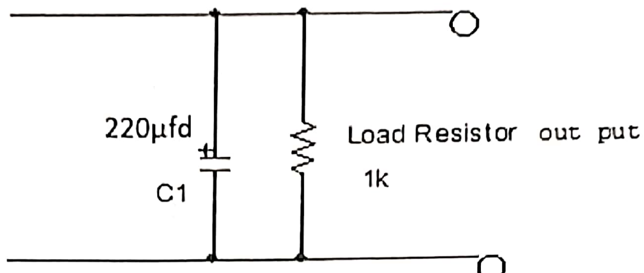




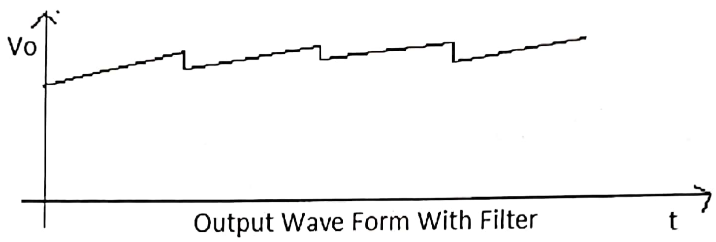
Input Wave Form

Output Wave Form

Filter Circuit



Shunt Capictor Filter



Output Wave Form With Filter

THEORY:

In Half Wave Rectification, When AC supply is applied at the input, only Positive Half Cycle appears across the load whereas, the negative Half Cycle is suppressed. How this can be explained as follows:

During positive half-cycle of the input voltage, the diode D1 is in forward bias and conducts through the load resistor R_L. Hence the current produces an output voltage across the load resistor R_L, which has the same shape as the +ve half cycle of the input voltage.

During the negative half-cycle of the input voltage, the diode is reverse biased and there is no current through the circuit. i.e., the voltage across R_L is zero. The net result is that only the +ve half cycle of the input voltage appears across the load. The average value of the half wave rectified o/p voltage is the value measured on dc voltmeter.

For practical circuits, transformer coupling is usually provided for two reasons.

1. The voltage can be stepped-up or stepped-down, as needed.
2. The ac source is electrically isolated from the rectifier. Thus preventing shock hazards in the secondary circuit.

The efficiency of the Half Wave Rectifier is 40.6%

Theoretical calculations for Ripple factor:
Without Filter:

Ripple Factor = 1.21

With Filter:
Ripple Factor

PROCEDURE:

1. Make connections for half wave rectifier as shown in figure.
2. Observe the input wave from on oscilloscope (Transformer Secondary Voltage i.e 9-0-9 Volt)
3. Observe the output wave form on oscilloscope.
4. Measure the DC voltage V_{DC} across the load.
5. Draw output waveform.
6. Measure r.m.s. value of output voltage.
7. Ripple factor

OBSERVATION:

		T	P	T	P	T	P	T	P
Without Filter									
With Filter									

RESULT: The ripple factors for half wave Rectifier with Filter and without filter have been calculated.

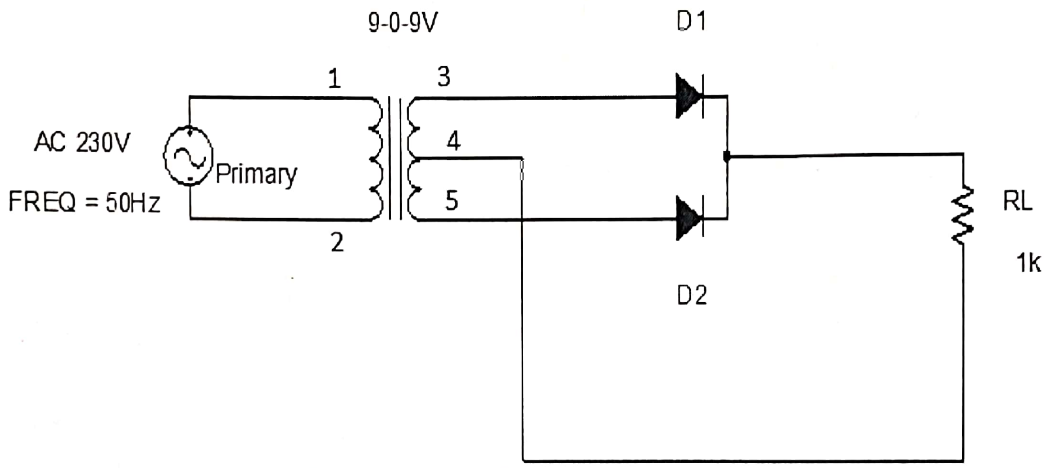
EXPERIMENT NO - 6

OBJECTIVE: **To study of Center- Tapped Full Wave Rectifier circuit and find ripple factor using capacitor filter circuit.**

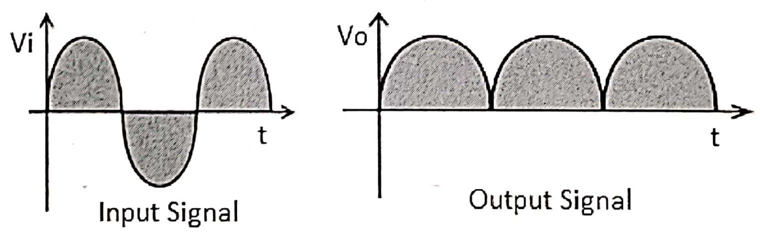
APPARATUS REQUIRED:

1.	Bread Board	01 No.
2.	P-N Junction Diode	02 Nos.
3.	Resistance- 1KΩ	01 No.
4.	C.T. Transformer (9-0-9)	01 No.
5.	CRO with CRO Probes	01No.
6.	Electrolytic Capacitor	01No.
7.	Connecting Wires	

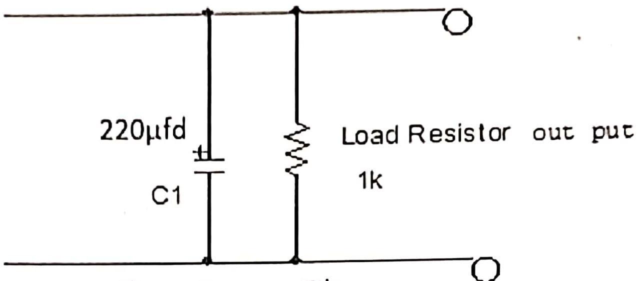
CIRCUIT DIAGRAM:



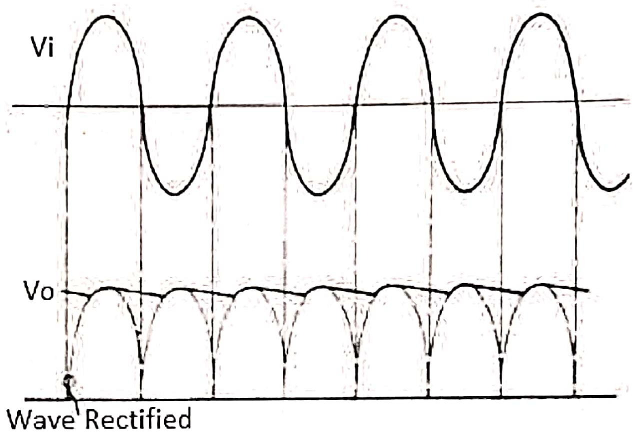
Center- Tapped Full Wave Rectifier



Filter Circuit



Shunt Capictor Filter



Full Wave Rectified

Output Waveform with Capacitor Filter

THEORY:

The circuit of a center-tapped full wave rectifier uses two diodes D1&D2. During positive half cycle of secondary voltage (input voltage), the diode D1 is forward biased and D2is reverse biased. So the diode D1 conducts and current flows through load resistor R_L.

During negative half cycle, diode D2 becomes forward biased and D1 reverse biased. Now, D2 conducts and current flows through the load resistor R_L in the same direction. There is a continuous current flow through the load resistor R_L, during both the half cycles and will get unidirectional current as show in the model graph. The difference between full wave and half wave rectification is that a full wave rectifier allows unidirectional (one way) current to the load during the entire 360 degrees of the input signal and half-wave rectifier allows this only during one half cycle (180 degree).

THEORITICAL CALCULATIONS:
Without Filter:

Ripple Factor = 0.482

With Filter:
Ripple Factor

PROCEDURE:

1. Make connections for full wave rectifier as shown in figure.
2. Observe the input wave from on oscilloscope (Transformer Secondary Voltage i.e 9-0-9 Volt)
3. Observe the output wave form on oscilloscope.
4. Measure the DC voltage V_{DC} across the load.
5. Draw output waveform.
6. Measure r.m.s. value of output voltage.
7. Ripple factor

OBSERVATION:

		T	P	T	P	T	P	T	P
Without Filter									
With Filter									

RESULT: The ripple factors for Full wave Rectifier with Filter and without filter have been calculated.

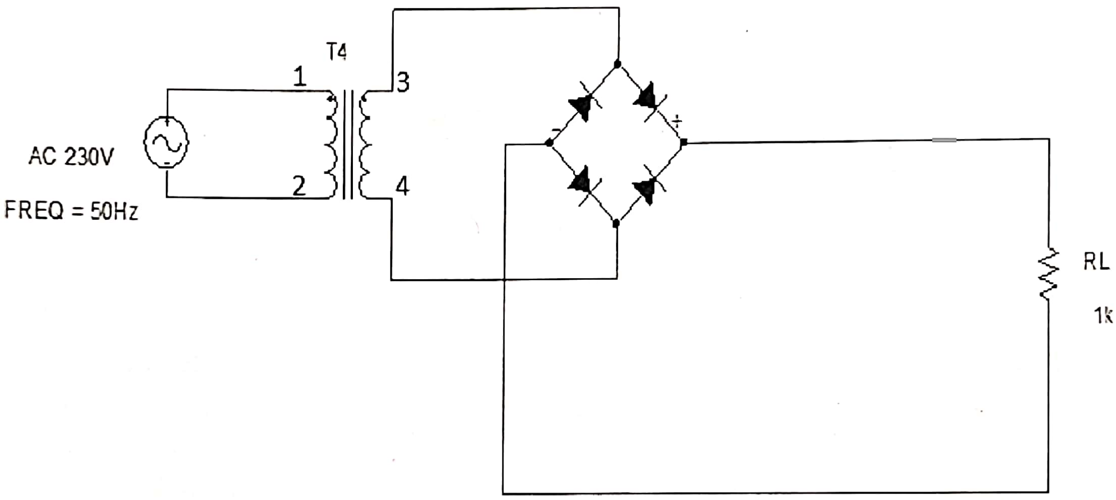
EXPERIMENT NO - 7

OBJECTIVE: To study of Full Wave Bridge Rectifier circuit and find ripple factor using capacitor filter circuit.

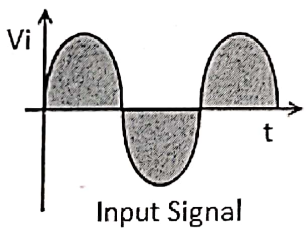
APPARATUS REQUIRED:

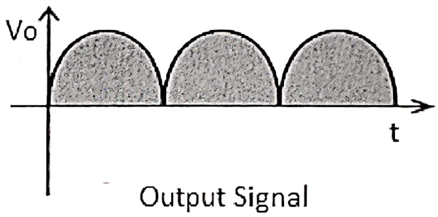
1.	Bread Board	01 No.
2.	P-N Junction Diode	04 Nos.
3.	Resistance- 1KΩ	01 No.
4.	Transformer (9-0-9)	01 No.
5.	CRO with CRO Probes	01No.
6.	Electrolytic Capacitor	01No.
7.	Connecting Wires	

CIRCUIT DIAGRAM:

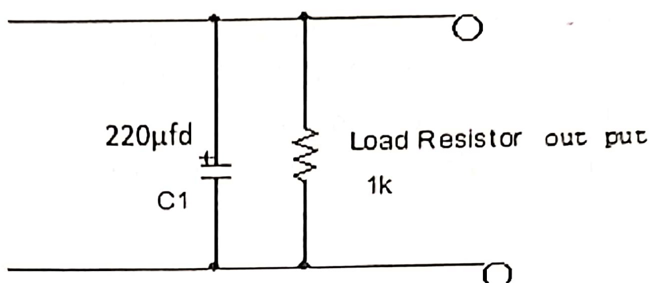


Full Wave Bridge rectifier

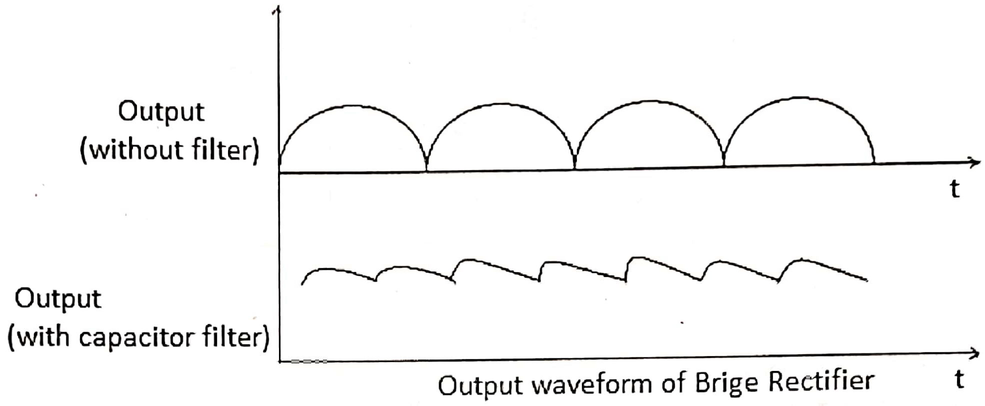




Filter Circuit



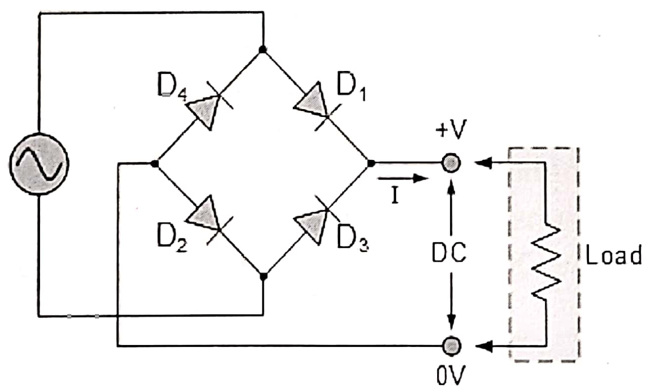
Shunt Capictor Filter



Output waveform of Brige Rectifier

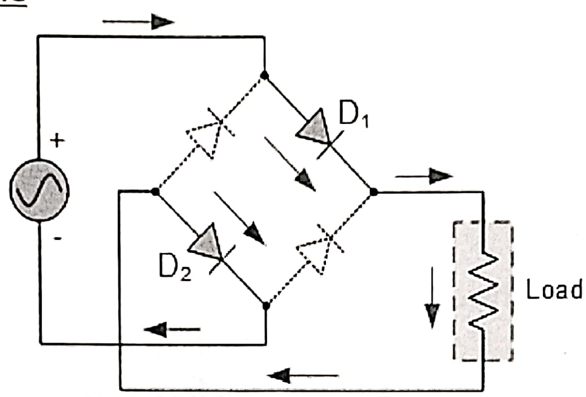
THEORY:

Another type of circuit that produces the same output waveform as the full wave rectifier circuit above is that of the **Full Wave Bridge Rectifier**. This type of single phase rectifier uses four individual rectifying diodes connected in a closed loop "bridge" configuration to produce the desired output. The main advantage of this bridge circuit is that it does not require a special center tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below.



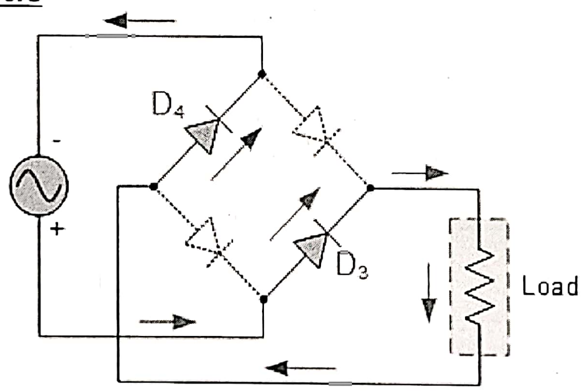
The four diodes labeled D_1 to D_4 are arranged in "series pairs" with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D1 and D2conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below.

The Positive half Cycle



During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 andD2 switch "OFF" as they are now reverse biased. The current flowing through the load is the same direction as before.

The Negative half Cycle



As the current flowing through the load is unidirectional, so the voltage developed across the load is also unidirectional the same as for the previous two diode full-wave rectifier, therefore the average DC voltage across the load is $0.637V_{max}$.

THEORITICAL CALCULATIONS:
Without Filter:

Ripple Factor = 0.482

With Filter:
Ripple Factor

PROCEDURE:

1. Make connections for full wave rectifier as shown in figure.
2. Observe the input wave from on oscilloscope (Transformer Secondary Voltage i.e 9-0-9 Volt)
3. Observe the output wave form on oscilloscope.
4. Measure the DC voltage V_{DC} across the load.
5. Draw output waveform.
6. Measure r.m.s. value of output voltage.
7. Ripple factor

OBSERVATION:

		T	P	T	P	T	P	T	P
Without Filter									
With Filter									

RESULT: The ripple factors for Full wave Bridge Rectifier with Filter and without filter have been calculated.

EXPERIMENT NO - 8

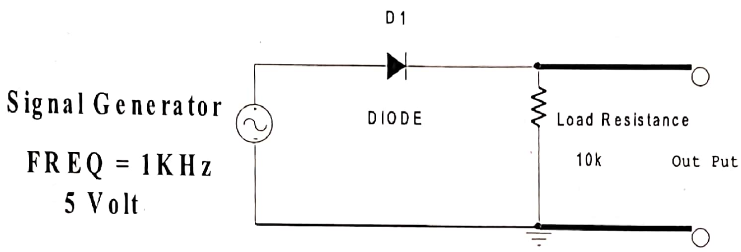
OBJECTIVE: To study of clipping and clamping circuits.

APPARATUS REQUIRED:

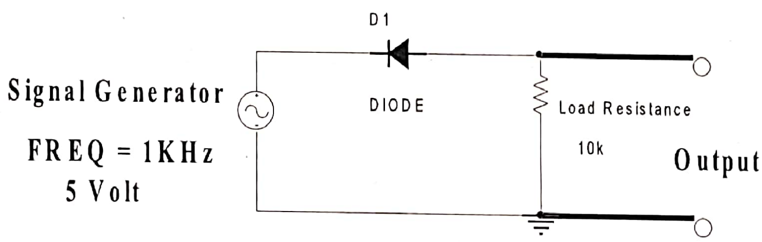
1.	Bread Board	01 No.
2.	P-N Junction Diode	02 Nos.
3.	Resistance- 10KΩ	01 No.
4.	Function Generator	01 No.
5.	CRO with CRO Probes	01No.
6.	Ceramic Capacitor (0.01μfd)	01No.
7.	Power Supply	01 No.
8.	Connecting Wires	

CIRCUIT DIAGRAM:

1. Series Clipper Circuits

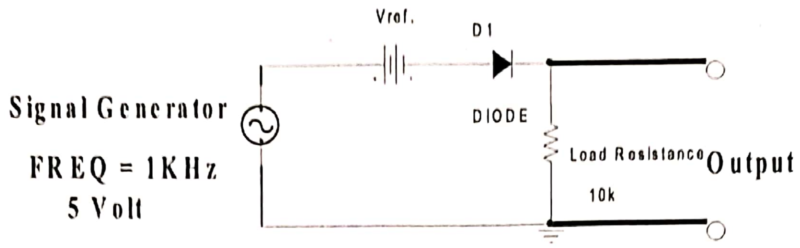


A Series Negative Clipper Circuit



A Series Positive Clipper Circuit

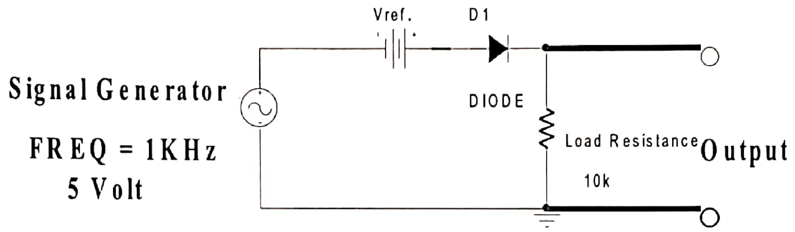
2. Series Clipper Circuits with DC Bias



A Series Clipper Circuit with DC Bias

If $V_{in} \leq Vref.$ $Vo = o$

If $V_{in} > Vref. Vo = V_{in} - Vref.$

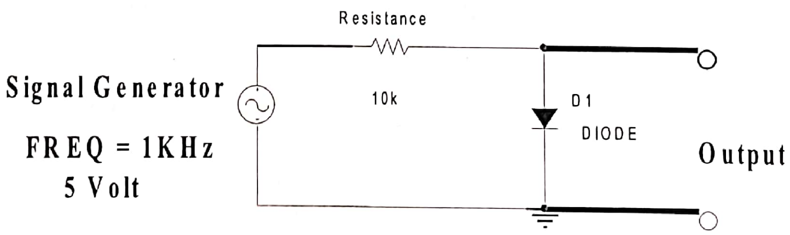


A Series Clipper Circuit with DC Bias

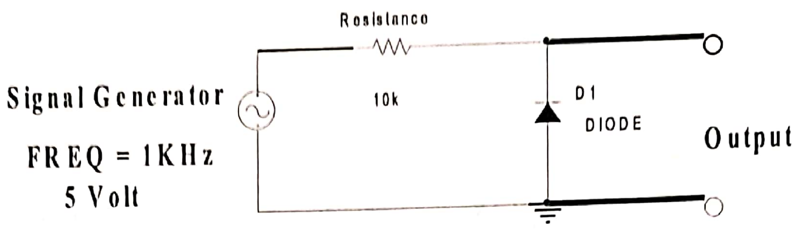
If $V_{in} \geq 0$ $Vo = V_{in}$

For negative value of V_{in} $Vo = 0$

3. Parallel Clipper Circuits

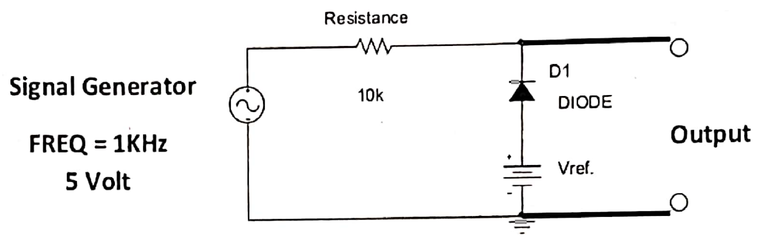


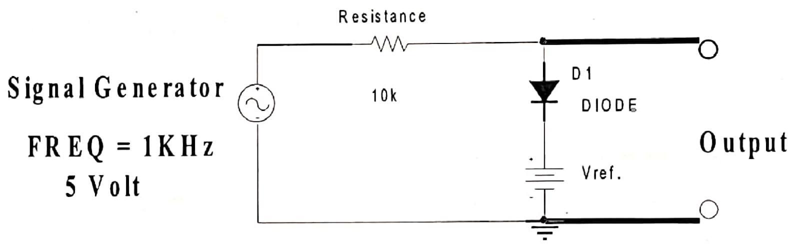
A Parallel Clipper Circuit

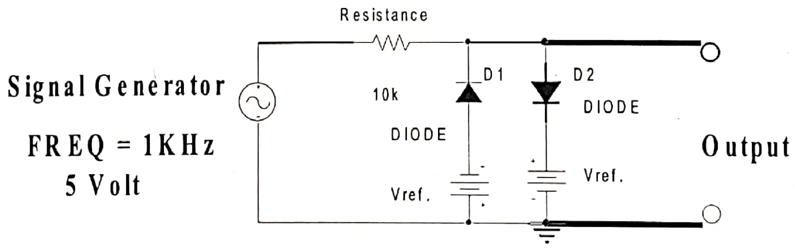


A Parallel Clipper Circuit

4. Parallel Clipper Circuits with DC Bias

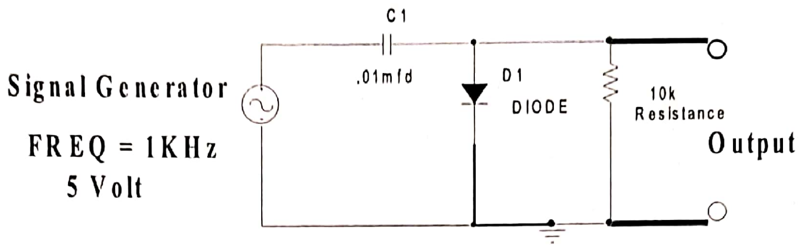


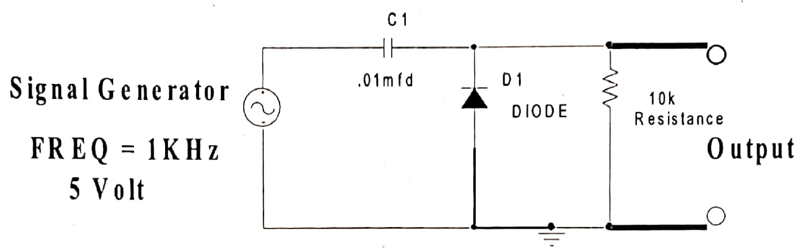




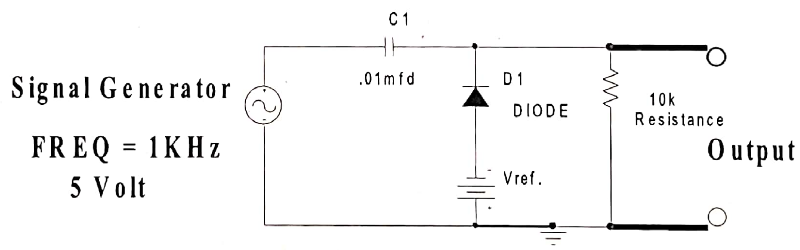
Two Way Parallel Clipper Circuit

5. **Clamper Circuit**





6. **Clamper Circuit with DC Bias**



THEORY:

1. **Clippers:**

Clipping circuits (also known as **limiters**, **amplitude selectors**, or **slicers**), are used to remove the part of a signal that is above or below some defined reference level. We've already seen an example of a clipper in the half-wave rectifier – that circuit basically cut off everything at the reference level of zero and let only the positive-going (or negative-going) portion of the input waveform through.

To clip to a reference level other than zero, a dc source is put in series with the diode. Depending on the direction of the diode and the polarity of the battery,

the circuit will either clip the input waveform above or below the reference level (the battery voltage for an ideal diode; i.e., for Von=0).
Clipping circuit is of various types:

1. Series Clipper
2. Parallel Clipper
3. Series bias clipper
4. Parallel bias clipper

2. Clampers:

Clamping circuits, also known as **dc restorers** or **clamped capacitors,** shift an input signal by an amount defined by an independent voltage source. While clippers limit the part of the input signal that reaches the output according to some reference level(s), the entire input reaches the output in a clamping circuit – it is just shifted so that the maximum (or minimum) value of the input is "clamped" to the independent source.
Clamping circuit is of various types:

1. Positive Clamper
2. Negative Clamper

PROCEDURE:

1. Connect the circuit using suitable patch cord as shown in circuit diagram.
2. Apply a Sinusoidal input of 5 volt and 1 kHz. (Use signal Generator for Sinusoidal input).
3. Observe the input signal on channel 1 on CRO and out put signal from circuit on channel 2 on CRO.
4. Repeat the experiment for different clipping and clamping circuits.

RESULT:

1. Sketch the wave shape and label the Amplitudes.
2. Indicate the type of clipping in each case.
3. Draw transfer characteristics for different clipping and clamping circuits.

EXPERIMENT NO - 9

OBJECTIVE: To study and plot the input and output Characteristics of the given transistor in CB (common base) configuration.

APPARATUS REQUIRED:

1.	Bread Board	01 No.
2.	Transistor (BJT)	01 No.
3.	Resistance- 1KΩ	02 Nos.
4.	Multi-Meter	04 Nos.
5.	Dual Power Supply	01 No.
6.	Connecting Wires	

CIRCUIT DIAGRAM:

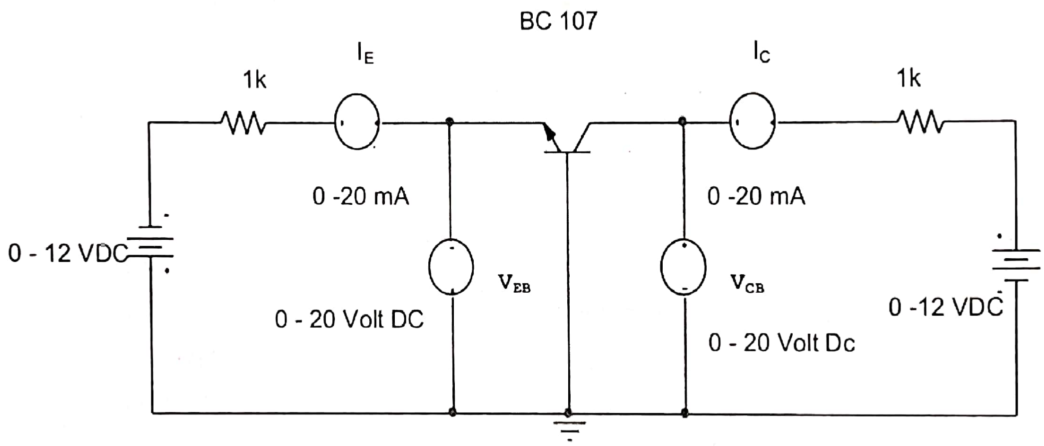


Figure1- CB Configuration for NPN Transistor

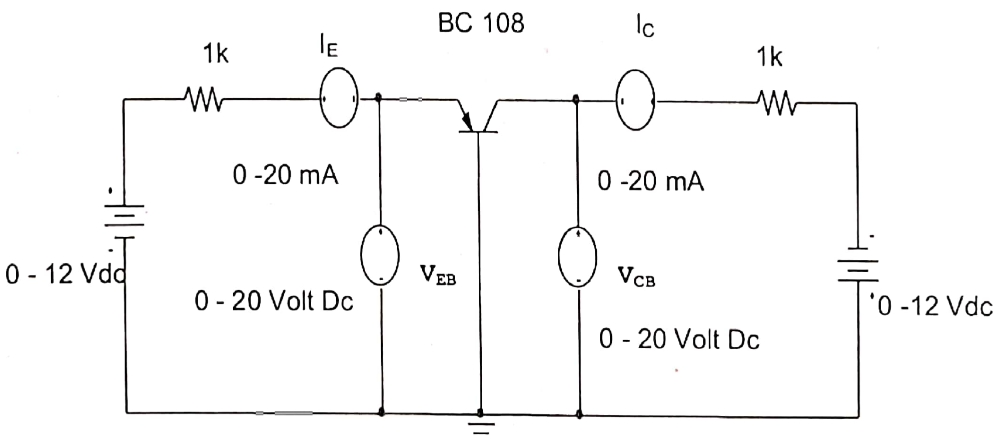


Figure2- CB Configuration for PNP Transistor

THEORY:

A transistor is a three terminal active device. The terminals are emitter, base, collector. In CB configuration, the base is common to both input (emitter) and output (collector). For normal operation, the E-B junction is forward biased and C-B junction is reverse biased. In CB configuration, I_E is +ve, I_C is –ve and I_B is –ve. So,

$$V_{EB} = F1\ (V_{CB}, I_E) \text{ and}$$
$$I_C = F_2\ (V_{EB}, I_B)$$

With an increasing the reverse collector voltage, the space-charge width at the output junction increases and the effective base width „W" decreases. This phenomenon is known as "Early effect". Then, there will be less chance for recombination within the base region. With increase of charge gradient with in the base region, the current of minority carriers injected across the emitter junction increases.

The current amplification factor of CB configuration is given by,

$$\alpha = \Delta I_C / \Delta I_E$$

Input Resistance, $r_i = \Delta V_{BE} / \Delta I_E$ at Constant V_{CB}

Output Résistance, $r_o = \Delta V_{CB} / \Delta I_C$ at Constant I_E

PROCEDURE:

- **Input characteristics.**

1. Using suitable patch cords make connections as shown in figure- 1 for NPN transistor and figure- 2 for PNP transistor.
2. The typical input characteristics for the transistors is shown in figure- 3

   To Plot the Input Characteristics perform the following steps:
   (i) Set the collector voltage, V_{CB} to a certain value, say 1 volt.
   (ii) Now, vary the emitter base voltage, V_{EB} in steps of say 0.1volt starting from zero and observe the corresponding values of emitter current (I_E) .
   (iii) Repeat step (ii) for different values of collector voltages, V_{CB}) : 2V, 5V, collector open.
   (iv) Plot the input characteristics.

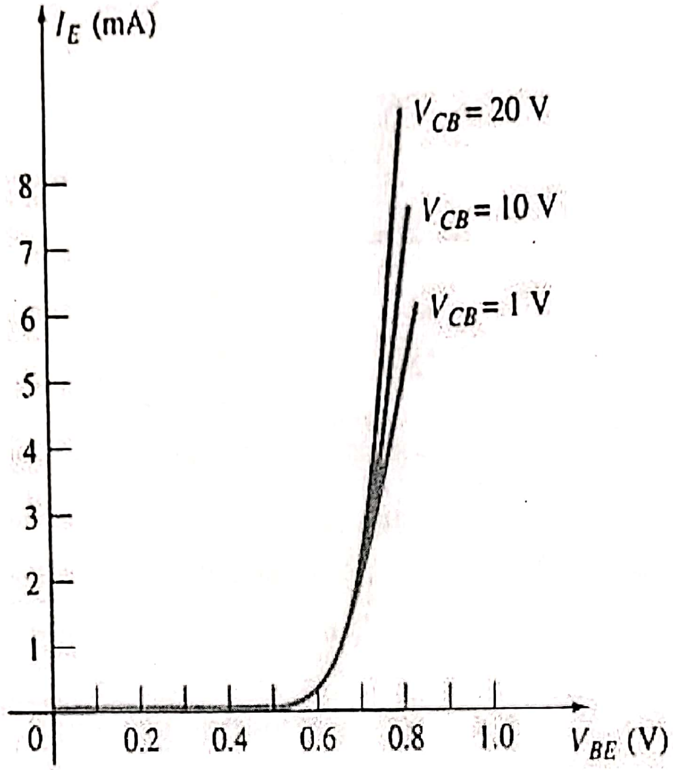


Figure3- Input Characteristics of CB Configuration

- **Output Characteristics**

1. The typical output characteristics for transistors are shown in figure- 4
   To plot Output characteristics, perform the following steps:
   (i) Set the emitter current to a certain value, say 1mA.
   (ii) Now Vary the collector base voltage(V_{CB}) in steps of 1volt starting from zero and observe the corresponding collector currents (Ic)
   (iii) Ensure that the emitter current remains constant, when collector voltage is being raised, by minor adjustment in the emitter-base voltage.
   (iv) Repeat (ii) for different values of emitter currents, say, 2mA, 4mA, 8mA.
   (v) Plot the output characteristics.

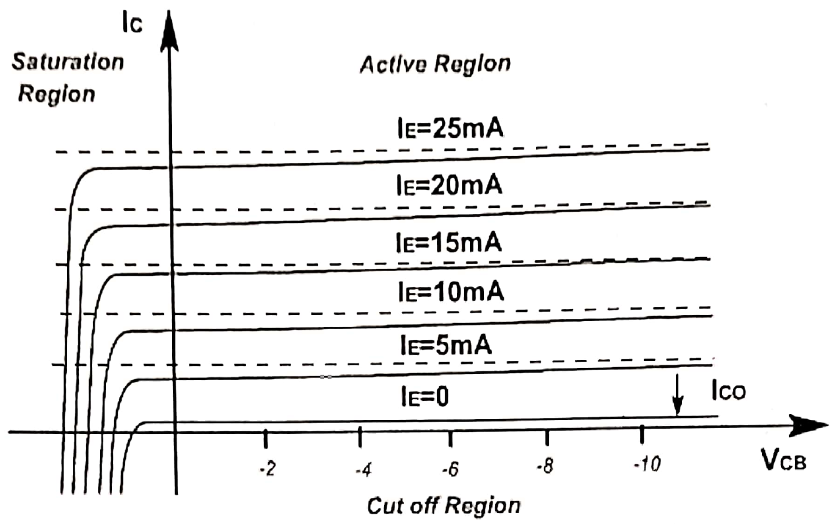


Figure4- Output Characteristics of CB Configuration

- **Saturation region**

1. Reverse the supply connected to the output circuit. This will forward bias the collector junction.(Reverse the voltmeter polarity too).
2. Set the emitter current to a certain value, say 1mA.
3. Now vary the collector Base voltage (V_{CB}), note the corresponding collector current until I_c become zero. Typical value of V_{CB}(Sat.)=0.6Volt

OBSERVATION:

FOR INPUT CHARACTERISTICS

Output voltage Constant (V_{CB}=0 volt)		Output voltage constant (V_{CB}=2 volt)	
Input voltage V_{EB}(Volt)	Input current I_E(mA)	Input voltage V_{EB}(Volt)	Input current I_E(mA)
0		0	
0.1		0.1	
0.2		0.2	
0.3		0.3	
0.4		0.4	
0.5		0.5	
0.6		0.6	
0.7		0.7	
0.8		0.8	
0.9		0.9	
1		1	

FOR OUTPUT CHARACTERISTICS

Input Current Constant (I_E=1 mA)		Input Current constant (I_E=2 mA)	
output voltage V_{CB}(Volt)	output current I_c(mA)	output voltage V_{CB}(Volt)	output current I_c(mA)
0		0	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	

CALCULATION:

1. Input resistance, $R_{in}= V_{EB}/I_E$ for a certain value of V_{CB}.
2. Output resistance, $R_o=V_{CB}/I_C$ for a certain value of I_E.
3. Current gain, $\alpha= I_c/I_E$ for a certain value of V_{CB}.

RESULT:

R_{in} =--------------------

R_o = -------------------

α = -------------------

NOTE: Points to remember

1. The cut-in voltage, V_x is approximately 0.2V for Ge transistor and approx. 0.6V for a Si transistor.
2. The collector current, I_C should be less than emitter current, I_E.
3. The value for current gain α_F is always less than 1.

EXPERIMENT NO - 10

OBJECTIVE: To study and plot the input and output characteristics of the given transistor in C.E. (Common Emitter) Configuration

APPARATUS REQUIRED:

1.	Bread Board	01 No.
2.	Transistor (BJT)	01 No.
3.	Resistance- 1KΩ	01 No.
4.	Resistance- 100KΩ	01 No.
5.	Multi-Meter	04 Nos.
6.	Dual Power Supply	01 No.
7.	Connecting Wires	

CIRCUIT DIAGRAM:

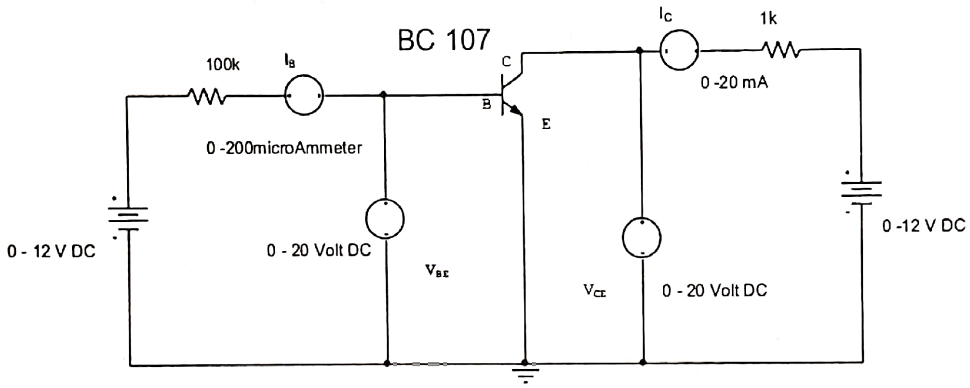


Figure1- CE Configuration for NPN Transistor

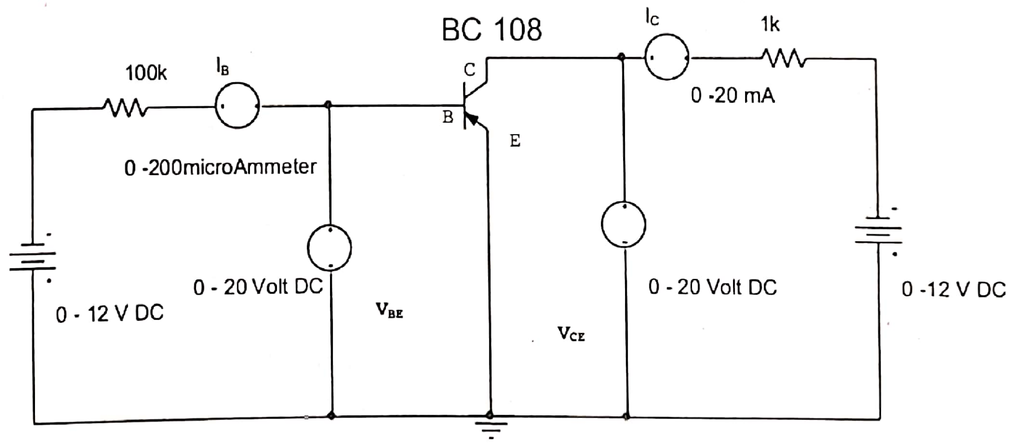


Figure2- CE Configuration for PNP Transistor

THEORY:

In common emitter configuration, input voltage is applied between base and emitter terminals and output is taken across the collector and emitter terminals. Therefore the emitter terminal is common to both input and output.

The input characteristics resemble that of a forward biased diode curve. This is expected since the Base-Emitter junction of the transistor is forward biased. As compared to CB arrangement I_B increases less rapidly with $V_{BE.}$ Therefore input resistance of CE circuit is higher than that of CB circuit.

The output characteristics are drawn between I_c and V_{CE} at constant $I_{B.}$ the collector current varies with V_{CE} upto few volts only. After this the collector current becomes almost constant, and independent of $V_{CE.}$ The value of V_{CE} up to which the collector current changes with V_{CE} is known as Knee voltage. The transistor always operated in the region above Knee voltage, I_C is always constant and is approximately equal to $I_{B.}$The current amplification factor of CE configuration is given by

$$\beta = \Delta I_c/\Delta I_B$$

Input Resistance, $r_i = \Delta V_{BE} / \Delta I_B$ (µA) at Constant V_{CE}

Output Résistance, $r_o = \Delta V_{CE} / \Delta I_C$ at Constant I_B (µA)

PROCEDURE:-

- **Input Characteristics**

1. Using suitable patch cords make connections as shown in figure- 1 for NPN transistor and figure- 2 for PNP transistor.
2. The typical input characteristics of PNP and NPN transistors in CE configurations are shown in figure- 3

   To plot Input characteristics, perform the following steps:

   (i) Set the collector voltage V_{CE} to a constant voltage of 1Volt.

   (ii) Now vary the base voltage V_{BE} in steps of 0.1V and observe the corresponding base current (I_B). Do not exceed the base current from 200µA. (The maximum base current varies from transistor to transistor.)

   (iii) Repeat step (ii) for different values of collector voltages, $V_{CE:}$ 2V, 5V, and Open collector.

   (iv) Plot the input characteristics.

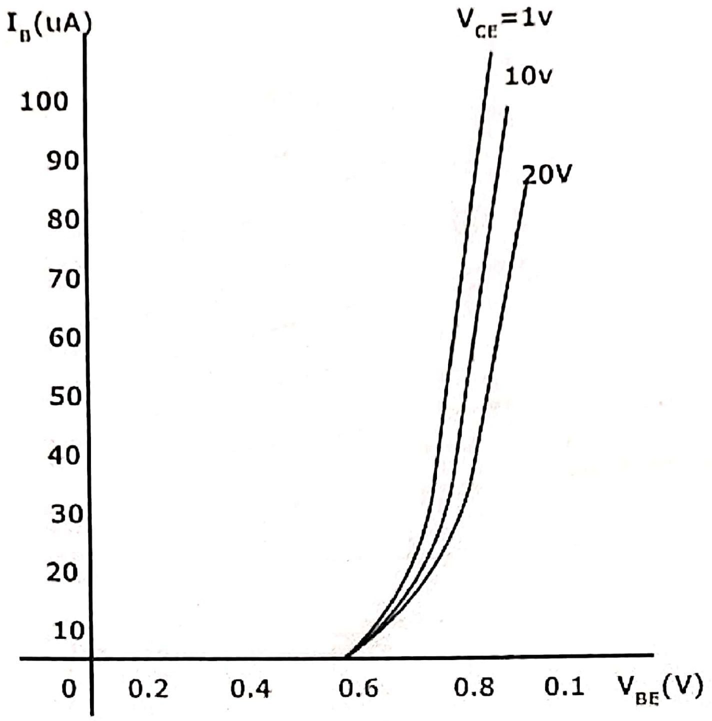


Figure3- Input Characteristics of CE Configuration

- **Output Characteristics**

1. The typical output characteristics for some transistors are shown in fig.4
   To plot Input characteristics, perform the following steps:
   (i) Set the base current (I_B) to say 25µA with the help of 0-12V variable supply in the input circuit.
   (ii) Now vary the collector voltage (V_{CE}) from 0 to 12 Volts in steps of say 1 Volt and observe the corresponding values of collector current (I_c).
   (iii) Repeat step (ii) for different values of base current, say 35µA, 50µA,
   (iv) Plot the output characteristics.

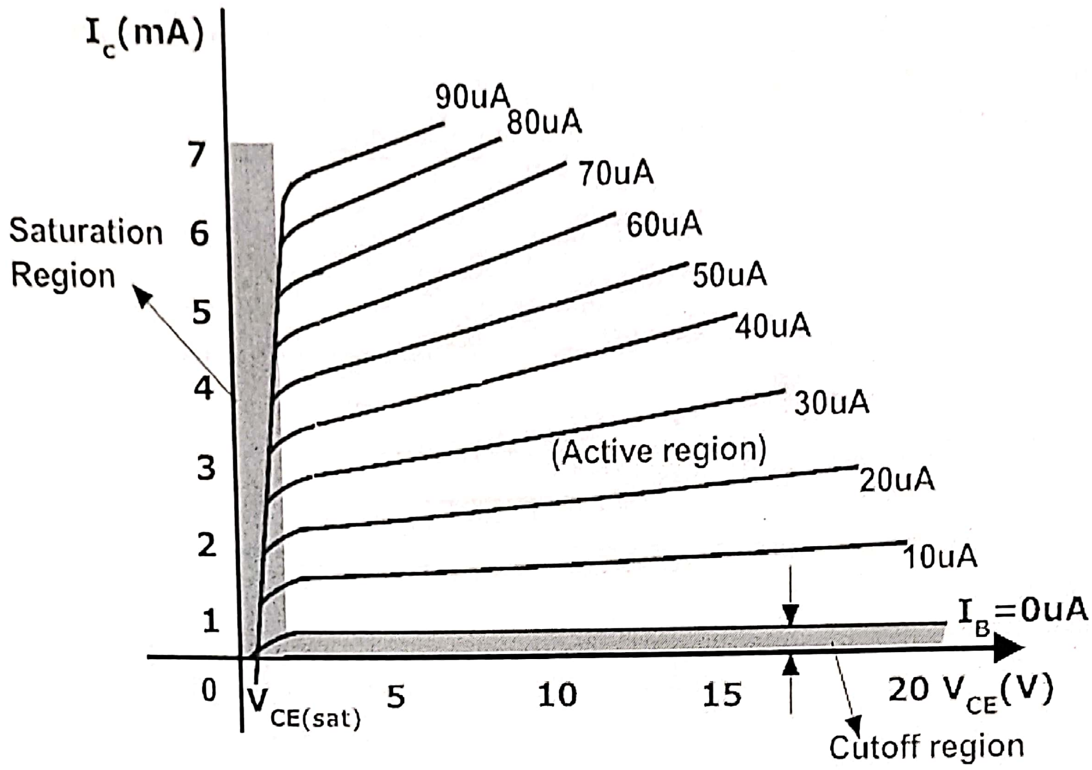


Figure4- Output Characterstics of CE Configuration

OBSERVATION:

FOR INPUT CHARACTERISTICS

Output voltage Constant (V_{CE}=0 volt)		Output voltage constant (V_{CE}=2 volt)	
Input voltage V_{BE}(Volt)	Input current I_B(μA)	Input voltage V_{BE}(Volt)	Input current I_B(μA)
0		0	
0.1		0.1	
0.2		0.2	
0.3		0.3	
0.4		0.4	
0.5		0.5	
0.6		0.6	
0.7		0.7	
0.8		0.8	
0.9		0.9	
1		1	

FOR OUTPUT CHARACTERISTICS

Input Current Constant (I_B=25µA)		Input Current constant (I_B=35µA)	
output voltage V_{CE}(Volt)	output current I_c(mA)	output voltage V_{CE}(Volt)	output current I_c(mA)
0		0	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	

CALCULATION:

1. Input resistance, $R_{IN} = V_{BE} / I_B$ at certain value of V_{CE}.
2. Output resistance $R_o = V_{CE}/I_C$ at certain value of I_B
3. DC forward current gain $\beta_F = I_c/I_B$

RESULT:

Input resistance, R_{IN} = -------------
Output resistance R_o = ---------------
DC forward current gain β_F =-------

Important Note:-

As soon as, the collector voltage is changed, the base current also gets varied. For the new collector voltage, set the base current to the earlier fixed value. This must be done for every change in collector voltage to ensure that the base current is constant.

Points to note:-

1. The cut-in voltage for a Ge transistor is about 0.2 Volt and about 0.6 volt for a Si transistor.
2. Observe the 'saturation' and 'active' and cut-off regions in the output characteristics.
3. The transistor gives current gain β_F in the range of 100 to 300 general purpose transistors.
4. Keep the knobs of both the 0-10 V D.C. supplies to fully anticlockwise position before switching on the mains supply.

EXPERIMENT NO - 11

OBJECTIVE: To draw the Drain characteristics and Transfer characteristics Of N-channel junction field effect transistor

APPARATUS REQUIRED:

1.	Bread Board	01 No.
2.	Transistor (FET)	01 No.
3.	Resistance- 1KΩ	02 No.
4.	Multi-Meter	03 Nos.
5.	Dual Power Supply	01 No.
6.	Connecting Wires	

CIRCUIT DIAGRAM:

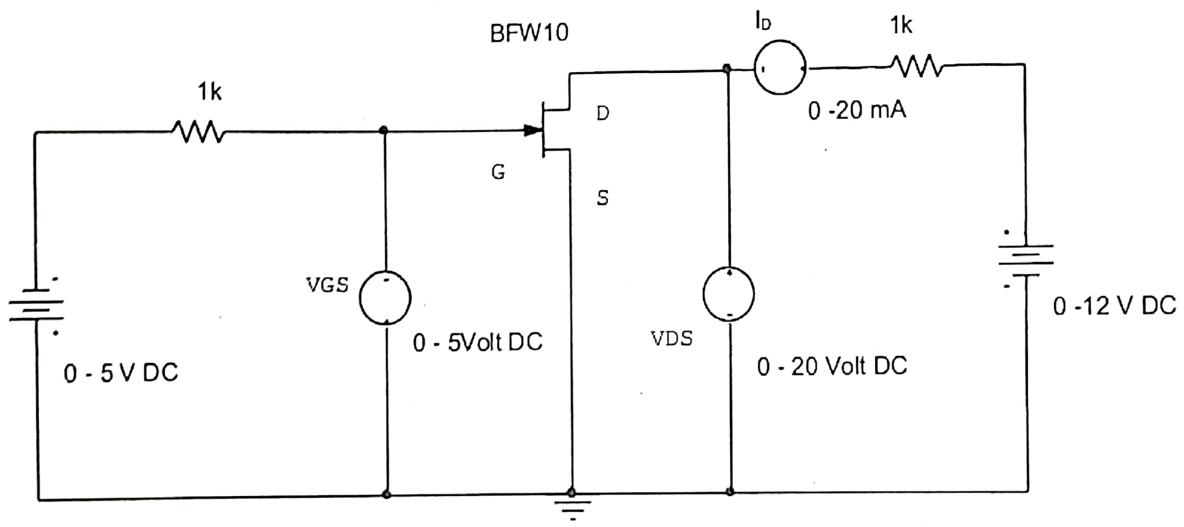


Figure1- N- Channel JFET

THEORY:

A FET is a three terminal device, in which current conduction is by majority carriers only. The flow of current is controlled by means of an Electric field. The three terminals of FET are Gate, Drain and Source. It is having the characteristics of high input impedance and less noise, the Gate to Source junction of the FETs always reverse biased. In response to small applied voltage from drain to source, the n-type bar acts as sample resistor, and the drain current increases linearly with V_{DS}. With increase in I_D the ohmic voltage drop between the source and the channel region reverse biases the junction and the conducting position of the channel begins to remain constant. The V_{DS} at this instant is called "pinch of voltage". If the gate to source voltage (V_{GS}) is applied in the direction to provide additional reverse bias, the pinch off voltage ill is decreased.

In amplifier application, the FET is always used in the region beyond the pinch-off.

FET parameters:

AC Drain Resistance,

$$r_d = \Delta V_{DS} / \Delta I_D \quad \text{at constant } V_{GS}$$

Trans conductance,

$$g_m = \Delta I_D / \Delta V_{GS} \quad \text{at constant } V_{DS}$$

Amplification,

$$\mu = \Delta V_{DS}/\Delta V_{GS} \quad \text{at constant } I_D$$

Relation between above parameters

$$\mu = rd * g_m$$

The drain current is given by

$$I_D = I_{DSS} (1 - V_{GS}/V_P)^2$$

CHARACTERISTICS:

- **Drain Characteristics**

  The typical Drain characteristics are shown in figure- 2.

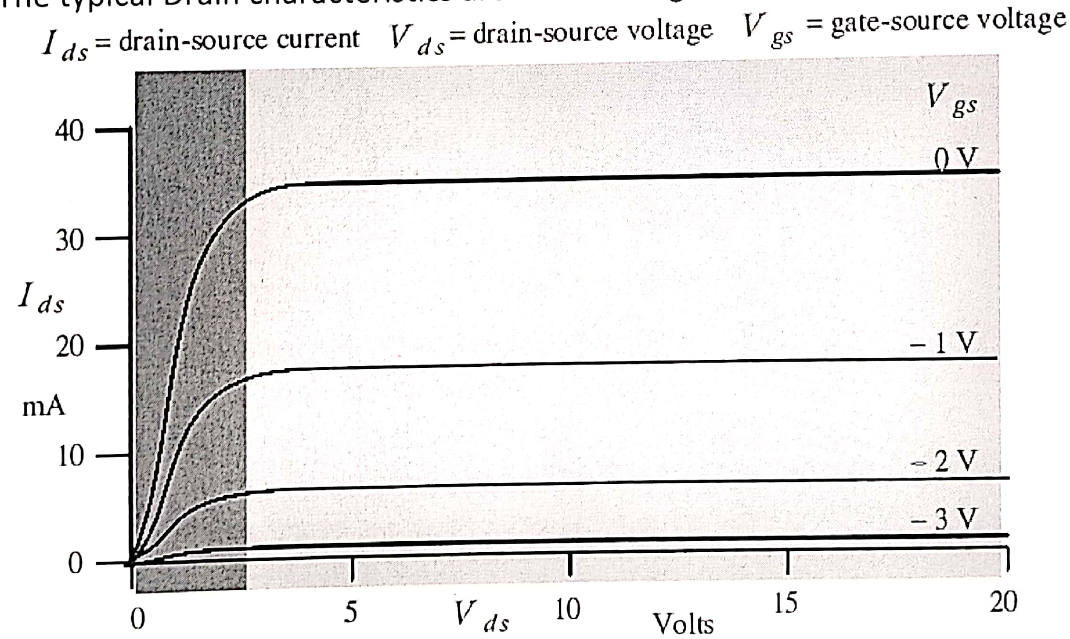


Figure2- Drain Characteristics for a Typical N- Channel JFET

In order to draw the above characteristics perform following steps:

PROCEDURE:

1. Connect the circuit as shown in fig.
2. Set V_{GS} = 0Volt. Keep 0-5Volt variable power supply at anti-clock wise direction for making V_{GS} = 0Volt.
3. Now increase the V_{DS} in step say 1volt starting from zero and observe the corresponding Drain Current (I_D) in milli-ammeter.
4. Repeat step 2 for different V_{GS} value say -0.5V,-1V, -1.5, -2V
5. Plot the graph between V_{DS} vs I_D

- **Transfer Characteristics**

  The typical Drain characteristics are shown in figure- 3.

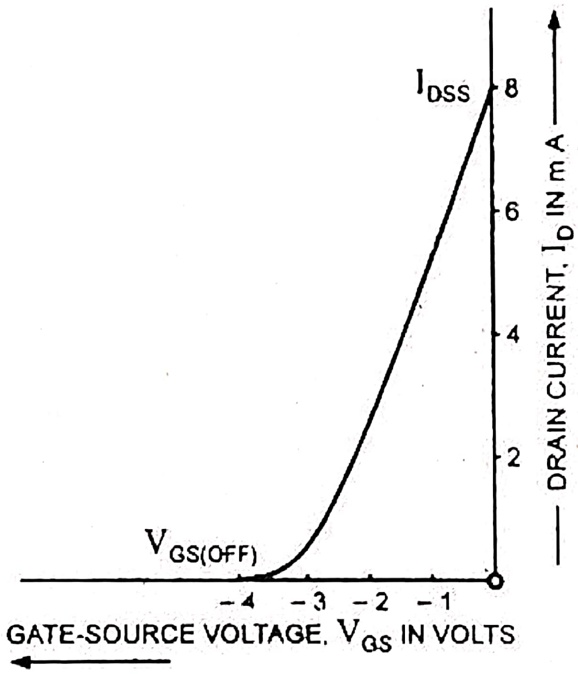


Figure3- Transfer Characteristics of a typical N- Channel JFET

In order to draw the above characteristics perform following steps:

1. The circuit will be same for obtain the transfer characteristics.
2. Set the V_{DS} = 3V. by varying the 0 -12Volt variable power supply.
3. Now increases the V_{GS} in step say -0.5Volt starting from zero and observe the corresponding drain current I_D until I_D become zero.
4. Repeat step 2 for different value of V_{DS}.
5. Plot the graph between V_{GS} vs I_D.

OBSERVATION:

FOR DRAIN CHARACTERISTICS

V_{GS} = 0Volt		V_{GS} = 0.5Volt		V_{GS} =-1Volt		V_{GS} = -2Volt	
V_{DS}(Volt)	I_D (mA)	V_{DS}(Volt	I_D (mA)	V_{DS}(Volt	I_D (mA)	V_{DS}(Volt	I_D (mA)
0		0		0		0	
0.5		0.5		0.5		0.5	
1		1		1		1	
1.5		1.5		1.5		1.5	
2		2		2		2	
2.5		2.5		2.5		2.5	
3		3		3		3	
3.5		3.5		3.5		3.5	
4		4		4		4	
4.5		4.5		4.5		4.5	
5		5		5		5	
6		6		6		6	
7		7		7		7	
8		8		8		8	

FOR TRANSFER CHARACTERISTICS

V_{DS} = 3Volt		V_{DS} = 5Volt	
V_{GS} (Volt)	I_D (mA)	V_{GS} (Volt)	I_D (mA
0		0	
-0.5		-0.5	
-1		-1	
-1.5		-1.5	
-2		-2	
-2.5		-2.5	
-3		-3	
-3.5		-3.5	
-4		-4	
-5		-5	

CALCULATION:

The various parameters of a JFET are:

1. **AC DRAIN RESISTANCE, $r_{d:}$** It is the resistance between drain_and source terminals when JFET is in the Pinch-off region.

   r_d = change in V_{DS} / change in I_D.

2. **TRANSCONDUCTANCE (g_m):** Slope of transfer characteristic.

   g_m = change in I_D/ change in V_{GS}

3. **AMPLIFICATION FACTOR**: It is given by

   A.F. = Change in V_{DS} / Change in V_{GS}.

4. **DC DRAIN RESISTANCE, Rds**: It is given by –

   $R_{DS} = V_{DS}/I_{DS}$

RESULT:

1. AC DRAIN RESISTANCE =--------------------
2. TRANSCONDUCTANCE (g_m) =--------------------
3. AMPLIFICATION FACTOR =-----------------------
4. DC DRAIN RESISTANCE, R =-----------------------

PRECAUTIONS:

- Do not exceed the I_D drain current 10mA.
- Take proper care of terminates of JFET while fixing in the board.

EXPERIMENT NO - 12

OBJECTIVE: To draw the Drain characteristics and Transfer characteristics Of N-channel Metal oxide field effect transistor (MOSFET)

APPARATUS REQUIRED:

1.	Bread Board	01 No.
2.	Transistor (MOSFET)	01 No.
3.	Resistance- 1KΩ	02 No.
4.	Multi-Meter	03 Nos.
5.	Dual Power Supply	01 No.
6.	Connecting Wires	

CIRCUIT DIAGRAM:

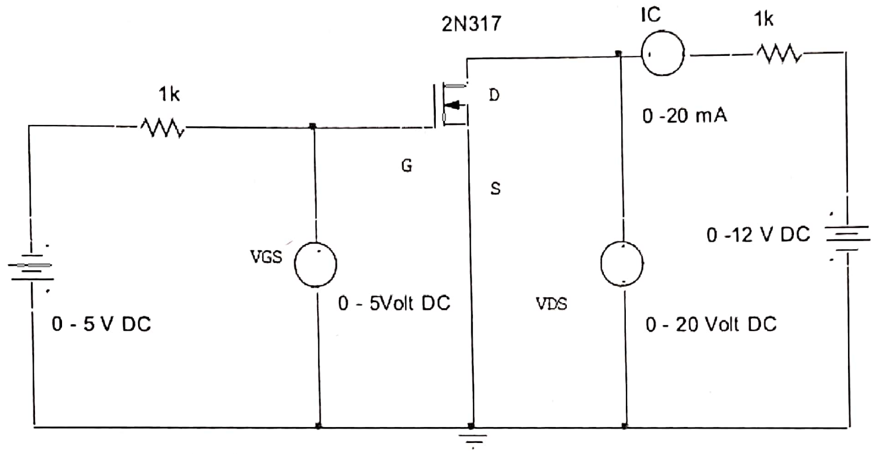


Figure1- Circuit Diagram of N Channel MOSFET (Depletion mode)

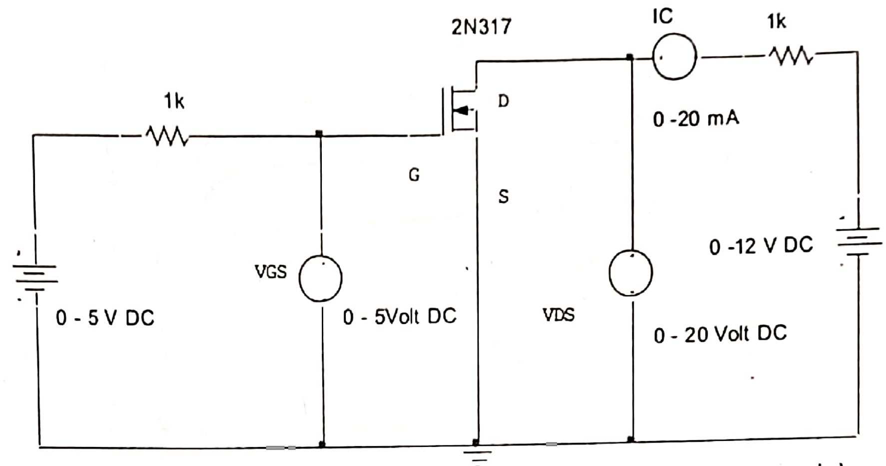


Figure2- Circuit Diagram of N Channel MOSFET (Enhancement mode)

THEORY:

MOSFET is an abbreviation for metal oxide semiconductor filed transistor. Like JFET, it has a source (S), drain (D) and gate (G). However unlike JFET, the gate of MOSFET is insulated from channel. Because of this, MOSFET is sometimes known as IGFET (insulated gate FET).

Basically MOSFET are of two types

1) Depletion type MOSFET and

2) Enhancement type MOSFET.

Enhancement MOSFET has no depletion mode and only operates in enhancement mode. It differs in construction from depletion type MOSFET in the sense that it has no physical channel. The min gate-source voltage (VGS), which produces inversion layer, called as threshold voltage.

Drain characteristics for enhancement MOSFET: -

When VGS< (VGS) the no drain current flows. However in actual practice and extremely small value of drain current does flow through MOSFET. This current flow is generally due to presence of thermally generated electron in P type substrate when value of VGS is kept above (VGS) significant drain current flow. Transfer characteristics of MOSFET: - When VGS=0 there is no drain current, however if VGS is increased rapidly as shown in fig. The relation gives the drain current at any instant along the curve.

ID=k [(VGS-VGS)]

CHARACTERISTICS:

- **Drain Characteristics**

  The typical Drain characteristics are shown in figure- 3.

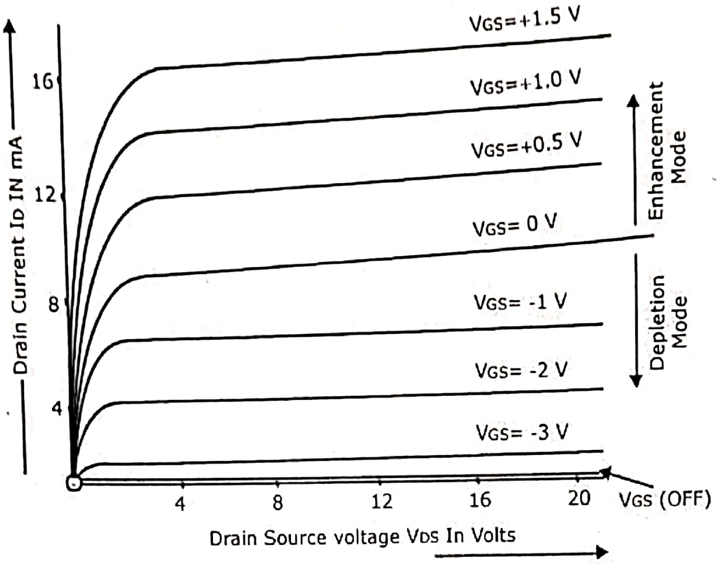


Figure3- Drain Characteristics

- **Transfer Characteristics**

  The typical Transfer characteristics are shown in figure- 4.

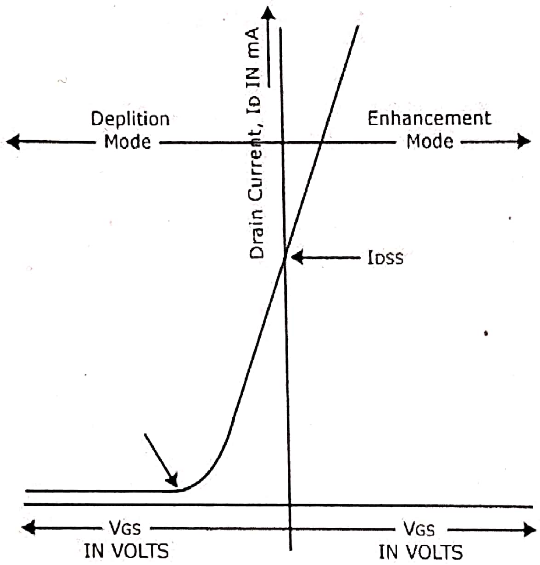


Figure4- Transfer Characteristics

PROCEDURE:

In order to draw the Drain Characteristics perform following steps:

1. Connect the circuit as shown in figure.
2. Set V_{GS} = 0Volt. Keep 0-5Volt variable power supply at anti-clock wise direction for making V_{GS} = 0Volt.
3. Now increase the V_{DS} in step say 1volt starting from zero and observe the corresponding Drain Current (I_D) in milli ammeter.

4. Repeat step 2 for different V_{GS} value say -0.5V,-1V, -1.5, -2V
5. Plot the graph between V_{DS} vs I_D

In order to draw the above characteristics perform following steps:

1. The circuit will be same for obtain the transfer characteristics.
2. Set the V_{DS} = 3V by varying the 0 -12Volt variable power supply.
3. Now increases the V_{GS} in step say -0.5Volt starting from zero and observe the corresponding drain current I_D until I_D become zero.
4. Repeat step 2 for different value of V_{DS}.
5. Plot the graph between V_{GS} vs I_D.

OBSERVATION:

FOR DRAIN CHARACTERISTICS

V_{GS} = 0Volt		V_{GS} = 0.5Volt		V_{GS} =-1Volt		V_{GS} = -2Volt	
V_{DS}(Volt)	I_D (mA)	V_{DS}(Volt	I_D (mA)	V_{DS}(Volt	I_D (mA)	V_{DS}(Volt	I_D (mA)
0		0		0		0	
0.5		0.5		0.5		0.5	
1		1		1		1	
1.5		1.5		1.5		1.5	
2		2		2		2	
2.5		2.5		2.5		2.5	
3		3		3		3	
3.5		3.5		3.5		3.5	
4		4		4		4	
4.5		4.5		4.5		4.5	
5		5		5		5	
6		6		6		6	
7		7		7		7	
8		8		8		8	

FOR TRANSFER CHARACTERISTICS

V_{DS} = 3Volt	V_{DS} = 5Volt

V_{GS} (Volt)	I_D (mA)	V_{GS} (Volt)	I_D (mA
0		0	
-0.5		-0.5	
-1		-1	
-1.5		-1.5	
-2		-2	
-2.5		-2.5	
-3		-3	
-3.5		-3.5	
-4		-4	
-5		-5	

CALCULATION:

The various parameters of a MOSFET are:

1. **AC DRAIN RESISTANCE, r_d**: It is the resistance between drain and source terminals when MOSFET is in the Pinch-off region.

   r_d = change in V_{DS} / change in I_D.

2. **TRANSCONDUCTANCE (g_m):** Slope of transfer characteristic.

   g_m = change in I_D/ change in V_{GS}

3. **AMPLIFICATION FACTOR**: It is given by

   A.F. = Change in V_{DS} / Change in V_{GS}.

4. **DC DRAIN RESISTANCE, Rds**: It is given by

   $R_{DS} = V_{DS}/I_{DS}$

RESULT:

1. AC DRAIN RESISTANCE =--------------------
2. TRANSCONDUCTANCE (g_m) =--------------------
3. AMPLIFICATION FACTOR =-----------------------
4. DC DRAIN RESISTANCE, R =-----------------------

PRECAUTION:

1. Do not exceed the I_D drain current 10mA.
2. Take proper care of terminates of MOSFET while fixing in the board.