Experiment No: 1

AIM:

Study of Electronics Components (Resistor, Capacitors, Inductor)

APPRATUS:

Resistor, Capacitors, Inductor, wires

THEORY:

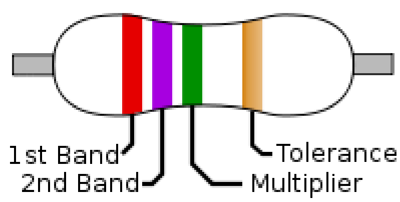
Resistors

A resistor is a component of an electrical circuit that resists the flow of electrical current. A resistor has two terminals across which electricity must pass, and is designed to drop the voltage of the current as it flows from one terminal to the next. A resistor is primarily used to create and maintain a known safe current within an electrical component.

Band Color Options	Band 1 position No	Band 2 position No	Band 3 Multiplier Value	Band 4 Value Tolerance
Black	0	0	$\times 10^0$	---
Brown	1	1	$\times 10^1$	± 1%
Red	2	2	$\times 10^2$	± 2%
Orange	3	3	$\times 10^3$	---
Yellow	4	4	×10	----
Green	5	5	×10	± 0.5%
Blue	6	6	×10	± 0.25%
Violet	7	7	--	± 0.1%
Gray	8	8	--	± 0.05%
White	9	9	--	----
None	--	--	--	± 20%
Silver	--	--	× 0.1	± 10%
Gold	--	--	× 0.01	± 5%

Example:- (Measurement process) -Most resistors have 4 bands:

- The **first band** gives the **first digit**.
- The **second band** gives the **second digit**.
- The **third band** indicates the **number of zeros**.
- The **fourth band** is used to show the tolerance (precision) of the resistor

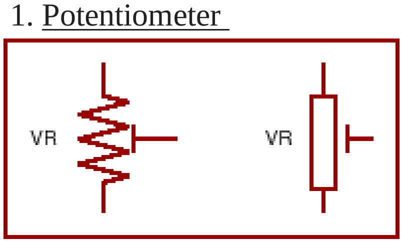


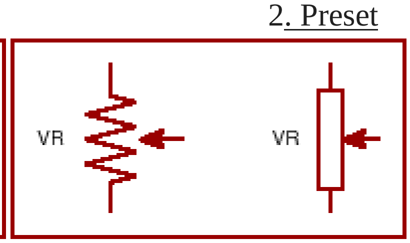
Calculation	**First Band**	**Second Band**	**Third Band**	**Fourth Band**	**Calculated Value**
Color Name Position Value	Red 2	Violet 7	Green 10^5	Silver ±10%	2700000W ±10% 2.7MW ±10%

VARIABLE RESISTOR

There are two types of variable resistors

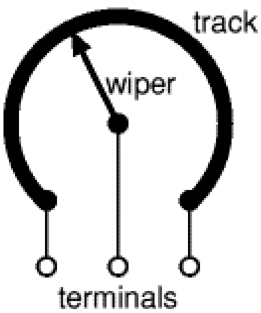
1. Potentiometer 2. Preset





Variable resistors consist of a resistance **track** with connections at both ends and a **wiper** which moves along the track as you turn the spindle. The track may be made from carbon, cermet (ceramic and metal mixture) or a coil of wire (for low resistances). The track is usually rotary but straight track versions, usually called sliders, are also available.

Variable resistors may be used as a potentiometer with all **three** connections in use. Miniature versions called presets are made for setting up circuits which will not require further adjustment. Variable resistors are often called **potentiometers** in books and catalogues. They are specified by their maximum resistance, **linear or logarithmic track**, their physical size. The standard spindle diameter is 6mm.



Potentiometer Preset

Linear (LIN) track means that the resistance changes at a constant rate as you move the wiper.

Logarithmic (LOG) track means that the resistance changes slowly at one end of the track and rapidly at the other end, so halfway along the track is **not** half the total resistance! This arrangement is used for volume (loudness) controls because the human ear has a logarithmic response to loudness so fine control (slow change) is required at low volumes and coarser control (rapid change) at high volumes

Function :-Resistor has a lot of functions. The resistor has function of current limiting and voltage drop. when used with other devices like capacitors and inductors it can have a vast variety of functions depending upon in which configuration it is used.

Potentiometer are used for voltage dividing purpose.

Specification :- 1. Power Rating (W) 2. Resistive Value (Ω Value)

The **Resistor Power Rating** is sometimes called the Resistors Wattage Rating and is defined as the amount of heat that a resistive element can dissipate for an indefinite period of time without degrading its performance. Every resistor has a maximum power rating which is determined by its physical size as generally, the greater its surface area the more power it can dissipate safely into the ambient air or into a heat sink

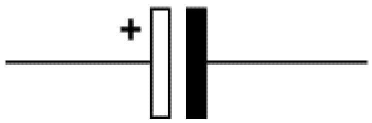
CAPACITORS

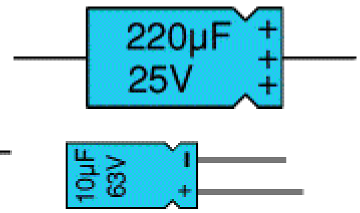
A capacitor is a passive electronic component that stores energy in the form of an electrostatic field. In its simplest form, a capacitor consists of two conducting plates separated by an insulating material called the dielectric. Capacitance is directly proportional to the surface areas of the plates, and is inversely proportional to the plates' separation.

Capacitance also depends on the dielectric constant of the dielectric material separating the plates.

There are two types of capacitor

Polarised (Electrolytic Capacitors , Value Above 1uF)



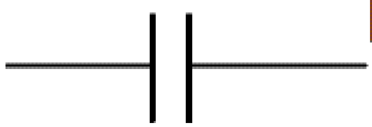


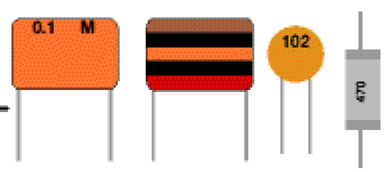
Circuit Symbol **Physical Structure**

A type of capacitor in which one plate is coated through electrolysis with an oxide to serve as the dielectric, while the other plate is replaced by an electrolyte. Electrolytic capacitors can achieve very high capacitance (>1uF) with very small sizes, but only act as capacitors as long as the current flows in one direction.

Measurement Value:-- Its capacitance value(uF) and voltage level is given on the surface

Unpolarised (Non- Electrolytic) Small Value below 1uF)

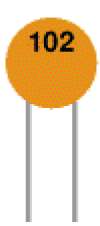




Circuit Symbol **Physical structure**

It has no electrical polarization. So in any direction you can use or measure.

Capacitor Number Code(for non electrolytic)



A number code is often used on small capacitors where printing is difficult:

· the 1st number is the 1st digit,

· the 2nd number is the 2nd digit,

· the 3rd number is the number of zeros to give the capacitance in pF.

· Ignore any letters - they just indicate tolerance and voltage rating.

For example: **102** means 1000pF = 1nF *(not 102pF!)*

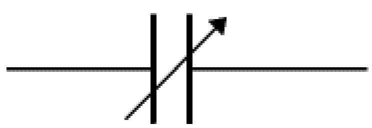
If there is no third digit(only two digit),then specified number is the capacitive value in pF. Three prefixes (multipliers) are used, µ (micro), n (nano) and p (pico):

- µ means 10^{-6} (millionth), so 1000000µF = 1F
- n means 10^{-9} (thousand-millionth), so 1000nF = 1µF
- p means 10^{-12} (million-millionth), so 1000pF = 1nF

Variable capacitors **1. Gang Capacitor 2.Trimmer Capacitor**

Its maximum Value is given on the surface

Gang Capacitor:A combination of two or more variable capacitors mounted on a common shaft to permit adjustment by a single control



1. Trimmer Capacitors:Trimmer capacitors (trimmers) are miniature variable capacitors. They are designed to be mounted directly onto the circuit board and adjusted only when the circuit is built. Trimmer capacitors are only available with very small capacitances, normally less than 100pF

1. Voltage Rating: All capacitors have a voltage rating. This tells you how much voltage the dielectric (insulator) can withstand before allowing DC to pass between its plates
2. Capacitor's Rating:- The capacitance rating is there because the energy stored in a capacitor is $W = 1/2CV^2$, where W is the stored energy in joules, C is the capacitance rating in farads, and V is the voltage on the cap. The cap's capacitance is a necessary specification because circuit design and performance hinge on having caps the correct value for the configuration of the circuit.

Function :- A capacitor stores electric charge. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals

INDUCTORS:

An inductor is an electrical component with specific inductance. These are used in tuning & filter circuits. Also used in radio receivers as a built in antenna coil to peak up radio signals, in transformer & coupled circuits to transfer energy from one circuit to another. It is also used to minimize the alternating current, while permitting flow of direct current. It is used for audio & radio frequency range. They are specified with inductance value & current capacity.
Types of Inductors
They are mainly of two types -1) Fixed Inductors
They are of three types -i) Air –core ii) Iron – core iii) Ferrite –core

Air core inductor uses any non-magnetic material as core to reduce the core losses i.e. eddy current & stray losses, especially when the operating frequency is very high. But the use of non-magnetic core also decreases its inductance.

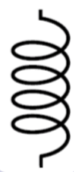
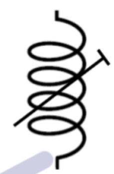
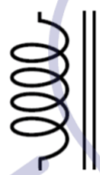
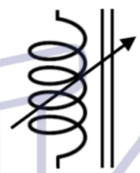
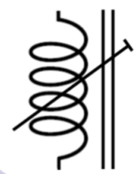
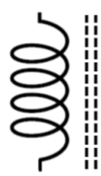
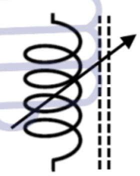
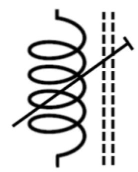
They are widely used in RF applications because of their low losses at high operating frequencies.

Ferromagnetic materials are magnetic in nature & their magnetic core is used to increase the inductance of the coil significantly. It is because of the fact that the ferromagnetic materials have high magnetic permeability & they increase the magnetic field of the coil.

However, there are some drawbacks of using ferromagnetic core in the form of losses called core losses. The core losses comprise of the eddy current loss & hysteresis loss.

Ferrite is a material with **high magnetic permeability** made from the mixture of iron oxide (ferric oxide, Fe_2O_3) & a small percentage of other metals such as nickel, zinc, barium, etc.
There are two types of ferrites i.e. **Hard Ferrites** & **Soft Ferrites.**

- The **Hard ferrites** are used in permanent magnets as they do not demagnetize very well. They are not used in inductor because of their high hysteresis loss.
- While **Soft ferrites** magnetization changes easily & are a good conductor of the magnetic field. Thus they are used in transformer & inductors.

Inductor	Fixed	Variable	Pre-set	Shape
Air Core				
Iron Core				
Ferrite Core				

EXPERIMENT NO.2

AIM:

Study Operation of Function Generator and Cathode Ray Oscilloscopes; and measurement of Amplitude and Frequency of signal.

APPRATUS:

Cathode-ray oscilloscope, Function Generator

THEORY:

An outline explanation of how an oscilloscope works can be given using the block diagram shown below.

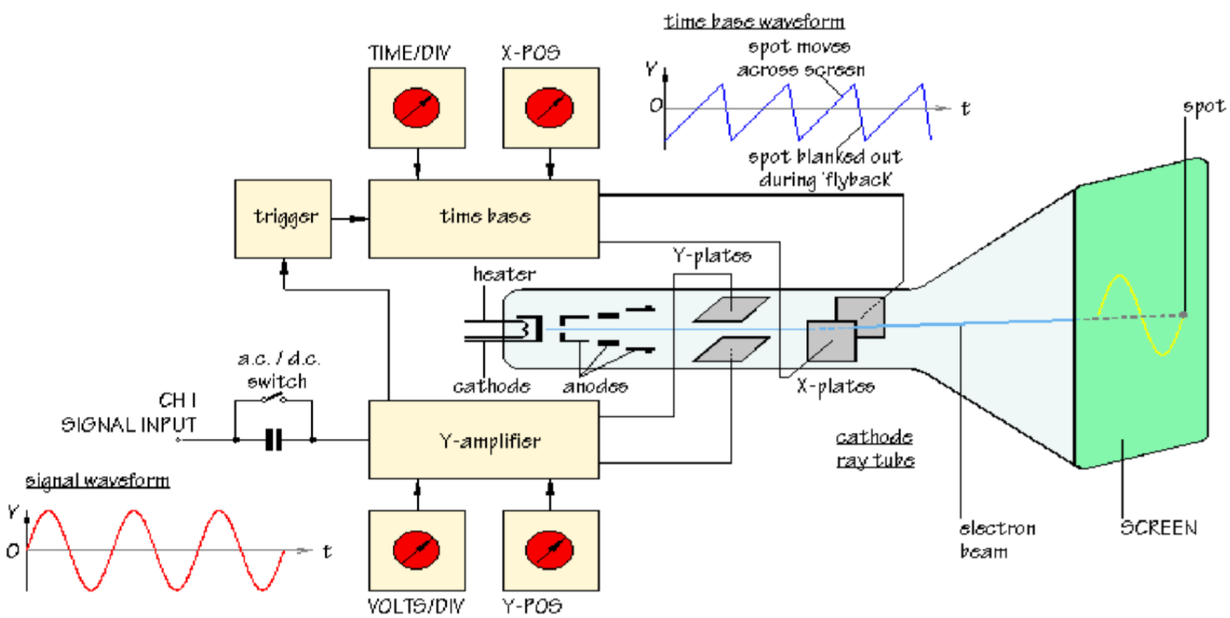


Fig. 1: Cathode Ray Oscilloscope

Like a television screen, the screen of an oscilloscope consists of a **Cathode Ray Tube**. Although the size and shape are different, the operating principle is the same. Inside the tube is a vacuum. The electron beam emitted by the heated cathode at the rear end of the tube is accelerated and focused by one or more anodes, and strikes the front of the tube, producing a bright spot on the phosphorescent screen.

The electron beam is bent, or deflected, by voltages applied to two sets of plates fixed in the tube. The horizontal deflection plates or **X-plates** produce side to side movement. As you can see, they are linked to a system block called the **time base**. This produces a saw tooth waveform. During the rising phase of the saw tooth, the spot is driven at a uniform rate from left to right across the front of the screen. During the falling phase, the electron beam returns rapidly from right ot left, but the spot is 'blanked out' so that nothing appears on the screen. In this way, the time base generates the X-axis of the *V*/*t* graph.

The slope of the rising phase varies with the frequency of the saw tooth and can be adjusted, using the TIME/DIV control, to change the scale of the X-axis. Dividing the oscilloscope screen into squares allows the horizontal scale to be expressed in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV). Alternatively, if the squares are 1 cm apart, the scale may be given as s/cm, ms/cm or µs/cm.

The signal to be displayed is connected to the **input**. The AC/DC switch is usually kept in the DC position (switch closed) so that there is a direct connection to the **Y-amplifier**. In the AC position (switch open) a capacitor is placed in the signal path. The capacitor blocks DC signals but allows AC signals to pass.

The Y-amplifier is linked in turn to a pair of **Y-plates** so that it provides the Y-axis of the the *V*/*t* graph. The overall gain of the Y-amplifier can be adjusted, using the VOLTS/DIV control, so that the resulting display is neither too small nor too large, but fits the screen and can be seen clearly. The vertical scale is usually given in V/DIV or mV/DIV.

The **trigger** circuit is used to delay the time base waveform so that the same section of the input signal is displayed on the screen each time the spot moves across. The effect of this is to give a stable picture on the oscilloscope screen, making it easier to measure and interpret the signal.

Changing the scales of the X-axis and Y-axis allows many different signals to be displayed. Sometimes, it is also useful to be able to change the *positions* of the axes. This is possible using the **X-POS** and **Y-POS** controls. For example, with no signal applied, the normal trace is a straight line across the centre of the screen. Adjusting Y-POS allows the zero level on the Y-axis to be changed, moving the whole trace up or down on the screen to give an effective display of signals like pulse waveforms which do not alternate between positive and negative values.

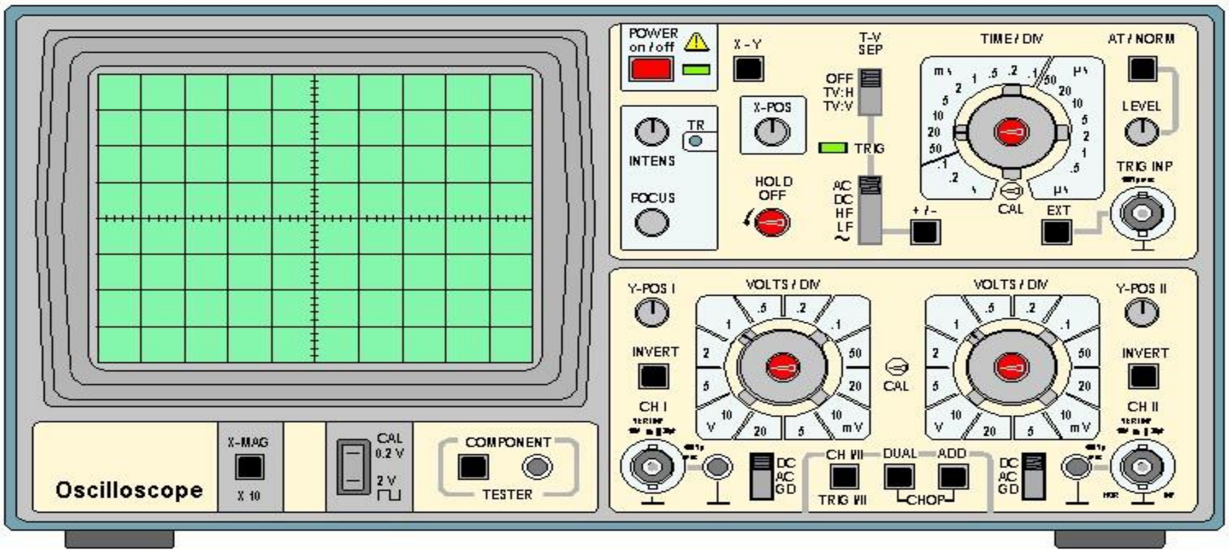


Fig. 2: Front View of Oscilloscope

Screen: Usually displays a *V/t* graph, with voltage *V* on the vertical axis and time *t* on the horizontal axis. The scales of both axes can be changed to display a huge variety of signals.

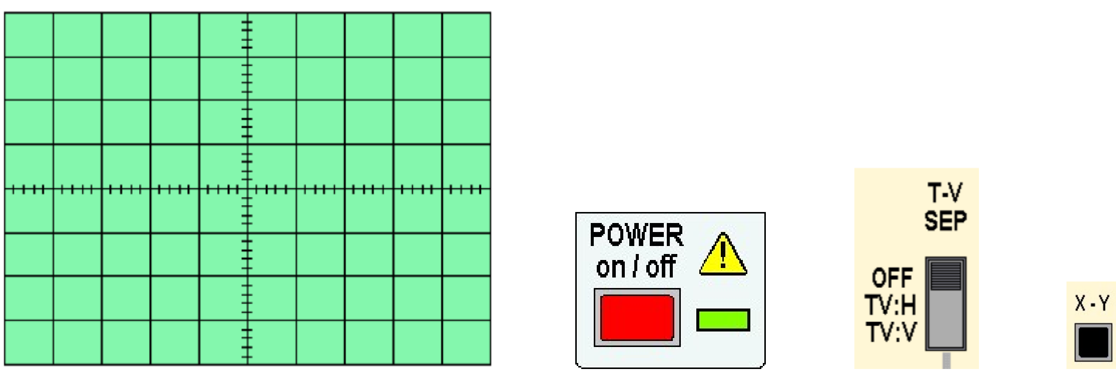


Fig. 3: Screen display of Oscilloscope

On/Off Switch: Pushed in to switch the oscilloscope on. The green LED illuminates.

X-Y Control: Normally in the OUT position.

When the X-Y button is pressed IN, the oscilloscope does not display a *V/t* graph. Instead, the vertical axis is controlled by the input signal to CH II. This allows the oscilloscope to be used to display a *V/V* voltage/voltage graph.

The X-Y control is used when you want to display component characteristic curves, or Lissajous figures. (Links to these topics will be added later.)

TV-Separation: Oscilloscopes are often used to investigate waveforms inside television systems. This control allows the display to be synchronized with the television system so that the signals from different points can be compared.

Time / Div: Allows the horizontal scale of the *V/t* graph to be changed.

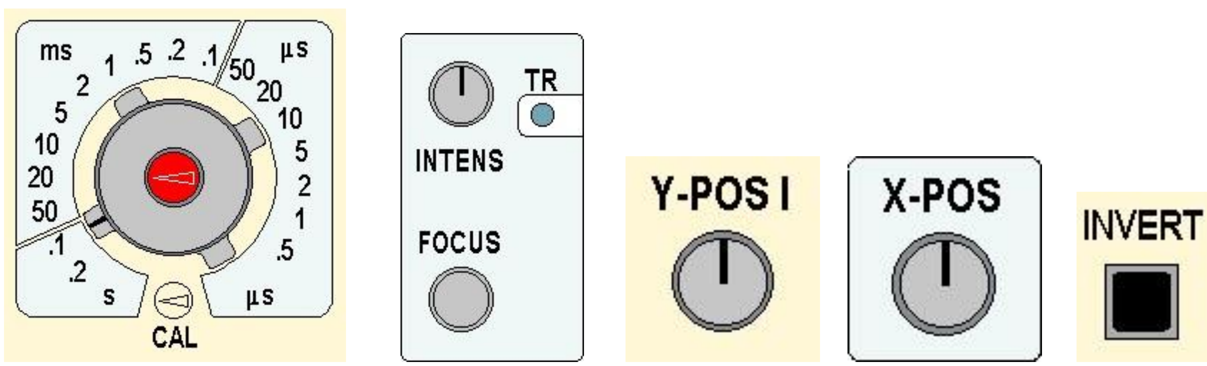


Fig. 4: Time division, Intensity, focus, X-Y mode knobs

With more experience of using the oscilloscope, you will develop a clear understanding of the functions of the important trigger controls and be able to use them effectively.

Intensity and Focus: Adjusting the INTENSITY control changes the brightness of the oscilloscope display. The FOCUS should be set to produce a bright clear trace.

If required, TR can be adjusted using a small screwdriver so that the oscilloscope trace is exactly horizontal when no signal is connected.

X-POS: Allows the whole *V/t* graph to be moved from side to side on the oscilloscope screen.

This is useful when you want to use the grid in front of the screen to make measurements, for example, to measure the period of a waveform.

Y-POS I and Y-POS II: These controls allow the corresponding trace to be moved up or down, changing the position representing 0 V on the oscilloscope screen.

To investigate an alternating signal, you adjust Y-POS so that the 0 V level is close to the centre of the screen. For a pulse waveform, it is more useful to have 0 V close to the bottom of the screen. Y-POS I and Y-POS II allow the 0 V levels of the two traces to be adjusted independently.

Invert: When the INVERT button is pressed IN, the corresponding signal is turned upside down, or inverted, on the oscilloscope screen. This feature is sometimes useful when comparing signals.

CH I And CH II Inputs: Signals are connected to the BNC input sockets using BNC plugs.

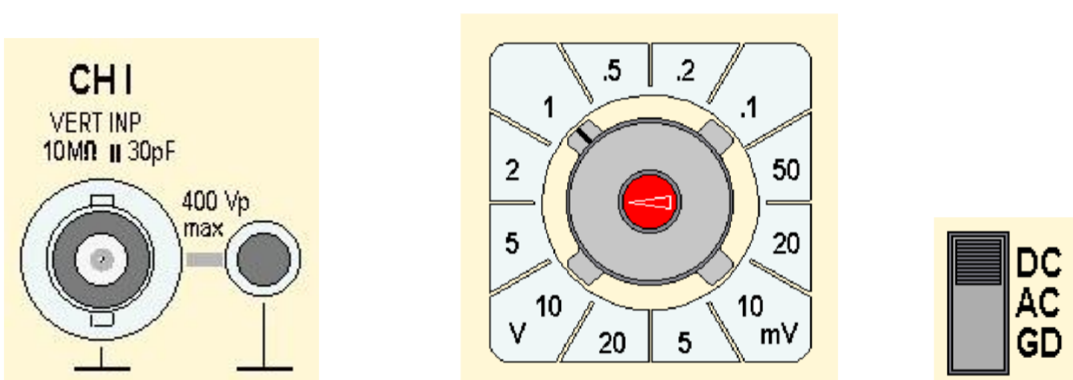


Fig. 5: Voltage division, Channels, AC, DC and GND knobs

The smaller socket next to the BNC input socket provides an additional 0 V, GROUND or EARTH connection.

Volts / Div: Adjust the vertical scale of the *V*/*t* graph. The vertical scales for CH I and CH II can be adjusted independently.

DC/AC/GND Slide Switches: In the DC position, the signal input is connected directly to the Y-amplifier of the corresponding channel, CH I or CH II. In the AC position, a capacitor is connected into the signal pathway so that DC voltages are blocked and only changing AC signals are displayed.

In the GND position, the input of the Y-amplifier is connected to 0 V. This allows you to check the position of 0 V on the oscilloscope screen. The DC position of these switches is correct for most signals.

Trace Selection Switches: The settings of these switches control which traces appear on the oscilloscope screen.

Measurement of Amplitude & Frequency:

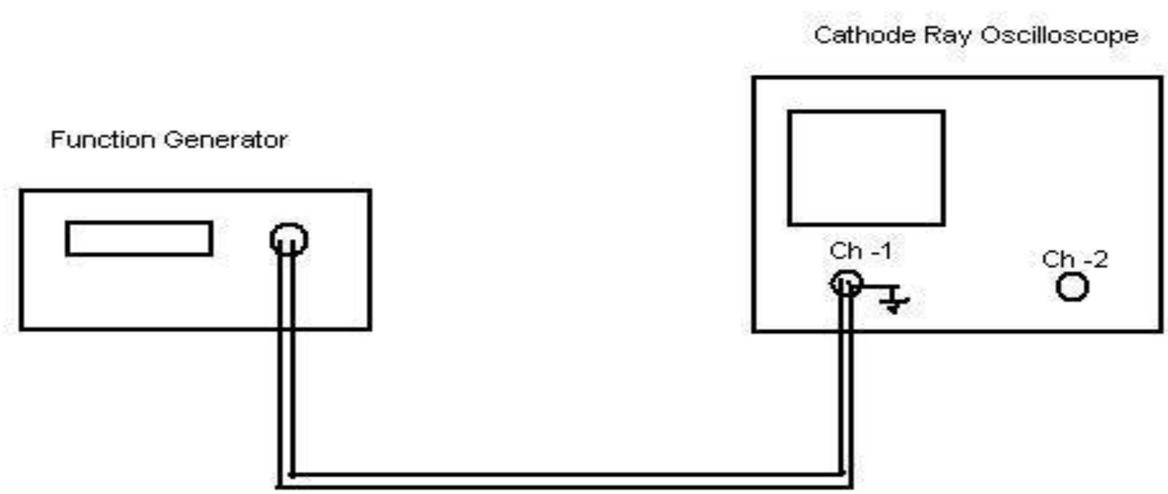


Fig. 6: Measurement of Amplitude & Frequency

Model waveforms:

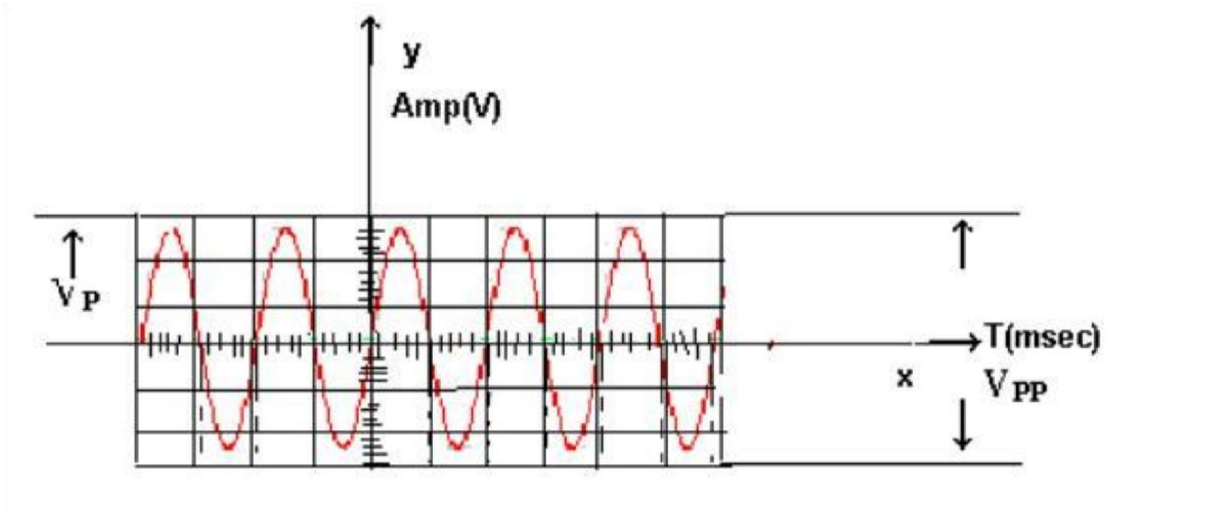


Fig. 7: Sinusoidal waveform

(A) Measurement of Amplitude:

Procedure:

1. Make the connections as per the diagram shown above.
2. Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.
3. Now apply the sinusoidal wave of different amplitudes by using the LEVEL and COARSE buttons of the function generator.
4. Note on the vertical scale the peak to peak amplitude (Vpp).

Observations:

S. No.	No. of Vertical Divisions(X)	Voltage/ Division (Y)	Vp-p=X*Y	Vm=Vp-p/2

B) Measurement of Frequency:

Procedure:

1. Make the connections as per the diagram shown above.
2. Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.
3. Now apply the sinusoidal wave of different frequencies by using the LEVEL and COARSE buttons of the function generator.
4. Note down the horizontal scale period (T) in second by observing difference between the two successive peaks of the waveform.

Observations:

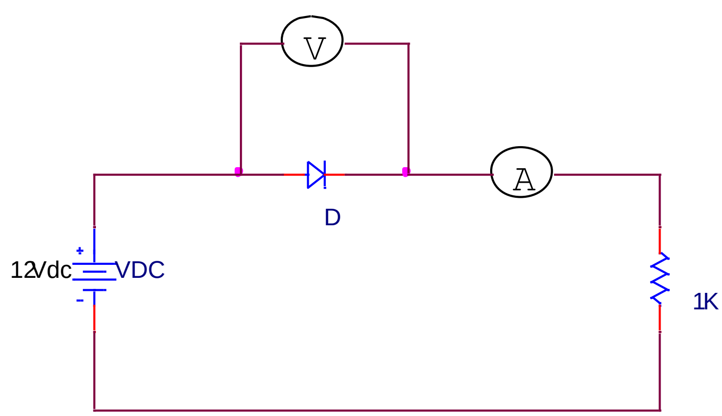
S. No.	No. of Horizontal Divisions(X)	Time/Division (Y)	T=X*Y	f=1/T

EXPERIMENT: 3

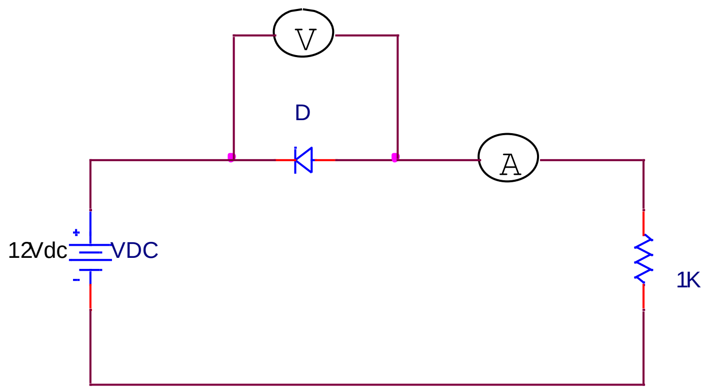
Aim : **Obtain the V-I characteristics of p-n junction diode. (Silicon & Germanium Diode)**

Apparatus: p-n junction diode, Digital Multi-meter, variable resistance, power supply, bread board, connecting wires, etc.

Figure:



(a) P-N junction diode in F.B



(b) P-N junction diode in R.B

Theory:

- The contact surface between the layers of p-type and n-type semiconductor pieces placed together so as to from a p-n junction is called the P-N Junction.
- When an external field with p-region connected to the +ve terminal & n-region connected to the -ve terminal of the battery is applied across the junction , the junction is said to be forward biased. The voltage at which current flows is called knee voltages.
- When an external bias voltage is applied with positive terminal to n-side and the negative terminal to the p-side of a p-n-junction , the junction is said to be reverse biased. It has one limitation of breakdown voltage, at which diode has very high current.

V-I Characteristics of p-n junction diode:-

- The nature of the p-n junction diode is that it conducts current in the forward direction but not in reverse direction. It is therefore a basic tool for rectification in the building of D.C. Power supply.
- The forward current turns on at about 0.5 V for a Si diode and can reach very high currents by 0.7 V for Ge diode, the turn on voltage is about 0.2V.
- The reverse current is in the order of 10^8 A and is almost independent of voltage until the breakdown point is reduced.
- P-n junction is represented by schematic symbol. The p-region of diode is anode. And n-region is cathode.
- The D.C. battery is connected to the diode through potentiometer P. The D.C battery is pushing conventional current in same direction.
- If excessive current is permitted to flow through the diode, it may get permanently damaged.
- Fact value of diode voltage produce particular current being the dependent variable is plotted along the vertical axis.

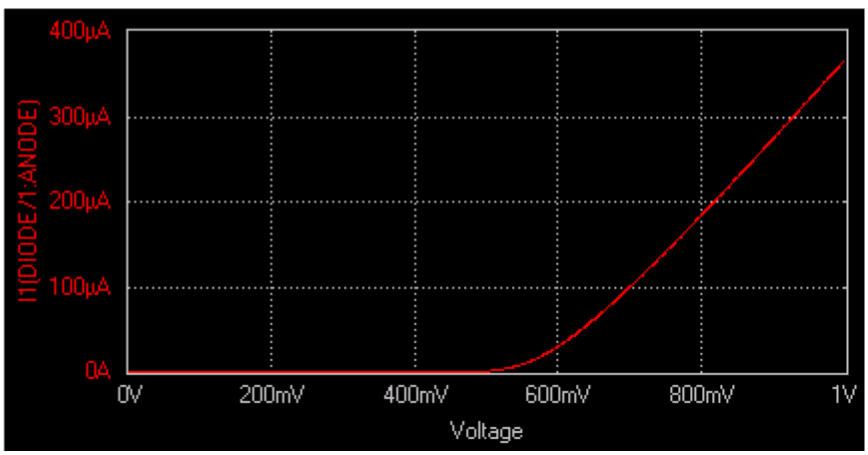
- The diode does not conduct well until the external voltage overcomes the barrier potential.

Procedure:-

P-N junction diode (Forward bias):

- Take a p-n junction diode and connect the positive terminal of p-n junction diode with the positive terminal of the battery (12V) vice versa.
- Connect a voltmeter in parallel with the p-n junction diode and an ammeter in series with the same, also resistance in series.
- Increase slowly and steadily a voltage of a source and note down the voltmeter and ammeter readings.

Waveform:



Observation table:

Observation Table for Silicon Diode:

Sr. No	Vin(volt)	Vd (volt)	I (mA)
1			
2			
3			
4			
5			

Observation Table for Germanium Di:

Sr. No	Vin(volt)	Vd (volt)	I (mA)
1			
2			
3			
4			
5			

6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

6			
7			
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9			
10			
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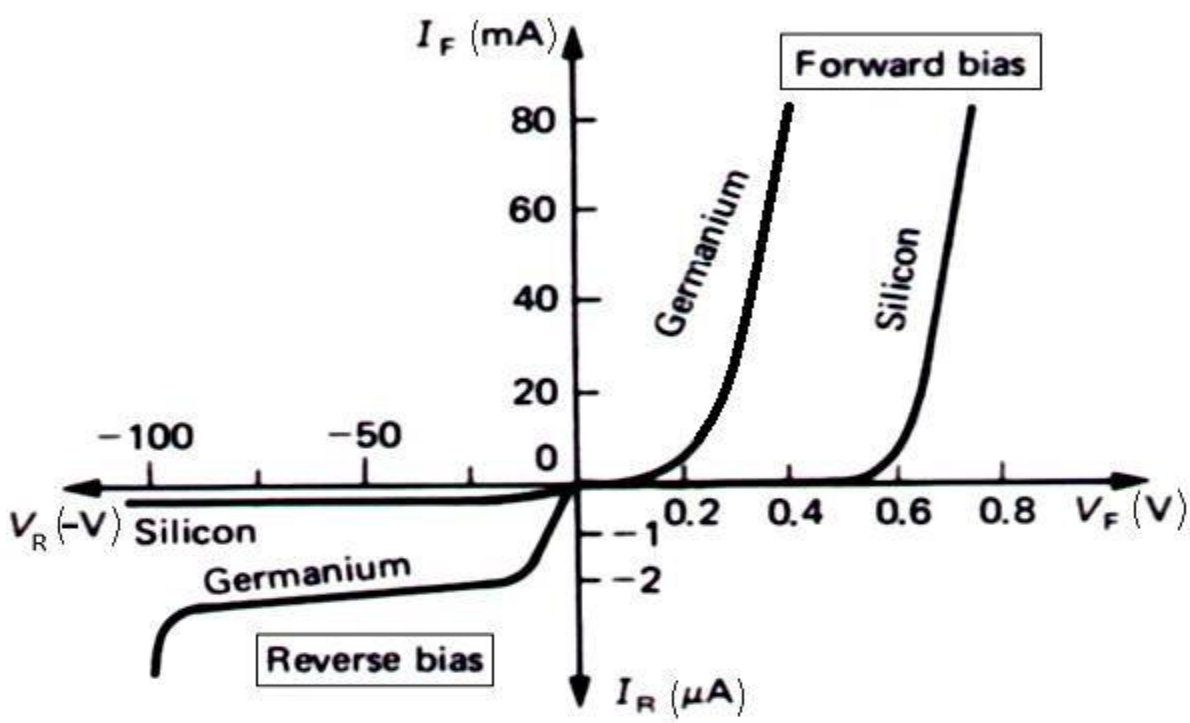
16			

- Plot the graph of Voltage Vs Current for Silicon & Germanium diode with a single graph paper. Mark the cut-in voltage for both.

Conclusion:



Calculations from Graph:

Static forward Resistance

Static Reverse Resistance

$R_{dc} = V_f / I_f \Omega$ $R_{dc} = V_r / I_r \Omega$

Dynamic Forward Resistance

Dynamic Reverse Resistance

$r_{ac} = \Delta V_f / \Delta I_f \Omega$ $r_{ac} = \Delta V_r / \Delta I_r \Omega$

Precautions:

1. While doing the experiment do not exceed the readings of the diode. This may lead to damaging of the diode.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

Results:

Cut in voltage = _______________ V

Static Forward Resistance = ________________ Ω

Dynamic Forward Resistance = ________________ Ω

Static Reverse Resistance = ________________ Ω

Dynamic Reverse Resistance = ________________ Ω

Viva Questions

1. What are trivalent and pentavalent impurities?

Ans: Doping is the process of adding impurity atoms to intrinsic silicon or germanium to improve the conductivity of the semiconductor.

Commonly Used Doping Elements

Trivalent Impurities to make p-Type: Aluminum (Al), Gallium (Ga), Boron(B) and Indium (In). Pentavalent Impurities to make n-type: Phosphorus (P), Arsenic (As), Antimony (Sb) and Bismuth (Bi).

2. How PN junction diode does acts as a switch?

Ans: Apply voltage in one direction; it acts like an open circuit. Reverse the polarity of the voltage and it acts like a short circuit.

3. Diode current equation?

Ans: $I = I_S(e^{V_D/(\eta V_T))} - 1)$

4. What is the value of V_t at room temperature?

Ans: 25mV

5. What is cut-in-voltage?

Ans: The forward voltage at which the current through the junction starts increasing rapidly is called as the cut-in voltage. It is generally 0.7V for a Silicon diode and 0.3V for a germanium diode.

6. Dynamic resistance expression?

Ans:

$$r_d = \Delta V/\Delta I = \frac{\eta\ V_T}{I}$$

EXPERIMENT: 4

Aim : Obtain the V-I characteristics of Zener diode.

Apparatus: p-n junction diode, Digital Multi-meter, Zener diode, variable resistance, power supply, bread board, connecting wires, etc.

Figure:

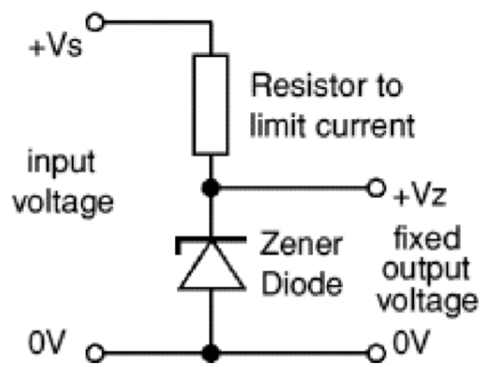


Fig 1. Zener diode in reverse bias

Zener Diode:

Zener doide is a special diode with increased amounts of doping. This is to compensate for the damage that occurs in the case of a *pn* junction diode when the reverse bias exceeds the breakdown voltage and thereby current increases at a rapid rate.

Applying a positive potential to the anode and a negative potential to the cathode of the zener diode establishes a forward bias condition. The forward characteristic of the zener diode is same as that of a *pn* junction diode i.e. as the applied potential increases

the current increases exponentially. Applying a negative potential to the anode and positive potential to the cathode reverse biases the zener diode.

As the reverse bias increases the current increases rapidly in a direction opposite to that of the positive voltage region. Thus under reverse bias condition breakdown occurs. It occurs because there is a strong electric filed in the region of the junction that can disrupt the bonding forces within the atom and generate carriers. The breakdown voltage depends upon the amount of doping. For a heavily doped diode depletion layer will be thin and breakdown occurs at low reverse voltage and the breakdown voltage is sharp. Whereas a lightly doped diode has a higher breakdown voltage. This explains the zener diode characteristics in the reverse bias region.

The maximum reverse bias potential that can be applied before entering the zener region is called the Peak Inverse Voltage referred to as PIV rating or the Peak Reverse Voltage Rating (PRV rating).

Zener diode is same as a simple P-N junction diode in forward bias condition, with adequate power dissipation capabilities in reverse bias condition.

Zener diode will regulate the variation in load current and load voltages in the break down region.

An increase in temperature increases the energies of the valence electrons and hence makes easier for electrons to escape from their positions in covalent bond. So, Zener break down voltages decreases with temperature.

Procedure:

- Note down reading of current for different voltages.
- Note down Zener break down voltage
- Plot the Graph.

Observation table:

Observation Table for Zener diode:

Sr.No	V(volt)	I(mA)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Conclusion:

Precautions:

1. While doing the experiment do not exceed the readings of the diode. This may lead to damaging of the diode.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

Results:

1. The Zener Diode Characteristics have been studied.
2. The breakdown voltage of Zener diode in reverse bias was found to be = _____

Viva Questions

1. What is the difference between p-n Junction diode and zener diode?

Ans: A zener is designed to operate stably in reverse breakdown, which is designed to be at a low voltage, between 3 volts and 200 volts. The breakdown voltage is specified as a voltage with a tolerance, such as 10 volts ±5%, which means the breakdown voltage (or operating voltage) will be between 9.5 volts and 10.5 volts. A signal diode or rectifier will have a high reverse breakdown, from 50 to 2000 volts, and is NOT designed to operate in the breakdown region. So exceeding the reverse voltage may result in the device being damaged. In addition, the breakdown voltage is specified as a minimum only. Forward characteristics are similar to both, although the zener's forward characteristics is usually not specified, as the zener will never be used in that region. A signal diode or rectifier has the forward voltage specified as a max voltage at one or more current levels.

2. What is break down voltage?

Ans: The breakdown voltage of a diode is the minimum reverse voltage to make the diode conduct in reverse.

3. What are the applications of Zener diode?

Ans: Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits.

4. What is cut-in-voltage ?

Ans: The forward voltage at which the current through the junction starts increasing rapidly, is called the knee voltage or cut-in voltage. It is generally 0.6v for a Silicon diode.

5. What is voltage regulator?

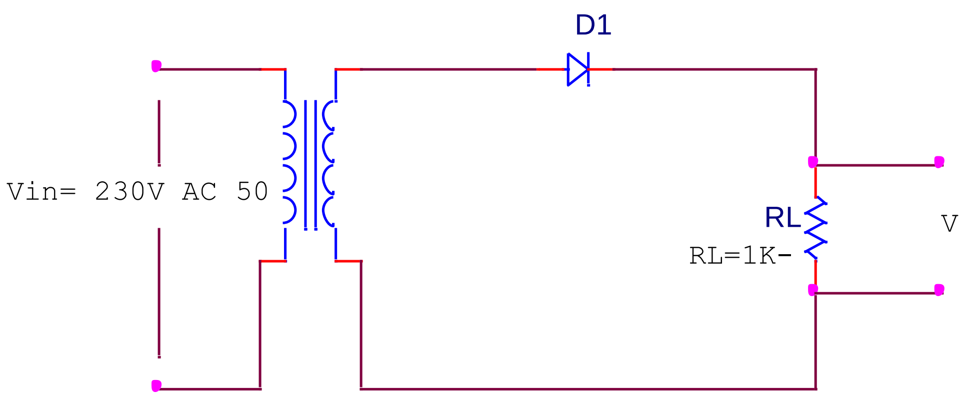
Ans: A voltage regulator is an electronic circuit that provides a stable dc voltage independent of the load current, temperature and ac line voltage variations.

EXPERIMENT: 5

Aim: To study about half-wave rectifier and find ripple factor and percentage of Regulation.

Apparatus: Probes, steps down transformer, DMM, CRO, resister, connecting wires, power supply, p-n junction diode, etc.

Figure:



Theory:

- A device which converts the 'AC' wave form (sinusoidal waveform) into a unidirectional waveform (DC) is called a 'RECTIFIER'.

- In a rectifier circuit, the input $v_i = v_m$+sinѠt has a peck value v_m, which is very large compare to cut-in voltage v_n of the diode.
- With the diode idealized to be a resistance R_f in the ON state and an open circuit in the OFF state. The current in the diode R_l given by i=I_m+sinѠt, o<=α<=π, i=0, if π<=α<=2π (α=ωt).

$$I_m = \frac{Vm}{Rm+Rl}$$

- After rectification, we get the output current in unidirectional.
- A DC ammeter is constructed so that needle deflection indicates the average value of current passing through it.

$$I_{DC} = \frac{1}{2\pi}\int_0^{2\pi} i\,dx$$

- For half wave,

$$I_{DC} = \frac{1}{2\pi}\int_0^{\pi} Im\,sin\alpha\,d\alpha$$

$$= \frac{Im}{\pi}$$

- Here reading of a DC voltmeter reads average voltage, diode has 2 values of resistence, R_f in ON and α in the OFF state.
- Average value of voltage,

$$V_{DC}=\frac{1}{2\pi}\int_0^{\pi} ImRf sin\alpha\, d\alpha+\int_{\pi}^{2\pi} Vmsin\alpha\, d\alpha$$

$$=\frac{1}{\pi}(I_mR_f-V_m)$$

$$V_{DC}=\frac{1}{\pi}\left[ImRf-\frac{Im}{\pi}(Rl+Rf)\right]=\frac{-ImRl}{\pi}$$

Ripple factor:

- The rectifier output consist of AC as well as DC components the ripple factor measures percentage of AC component in rectifier output.
- It indicates how close the rectified output is to the pure ideal DC voltage waveform. Small value of 'ripple factor' indicates how close the rectified output wave form is, and should be small (≈0) as possible.

$$\text{Ripple factor}=\frac{RMS\ value\ of\ AC\ component\ of\ output}{DC\ average\ value\ of\ output}$$

$$r=\frac{\sqrt{(Vrms^2-Vldc^2)}}{Vldc}$$

$$r=\frac{[\left(\frac{Vm}{2}\right)^2-(\frac{Vm}{\pi})^2]^{\frac{1}{2}}}{\frac{Vm}{\pi}}$$

=1.21 %

Voltage regulation:

- Ideally the voltage rectifier output voltage should remain constant.
- But practically,

$$\text{Voltage regulation}=\frac{Vnl-Vfl}{Vfl}\times 100\ \%$$

- Where, V_{NL}= average load voltage at no load

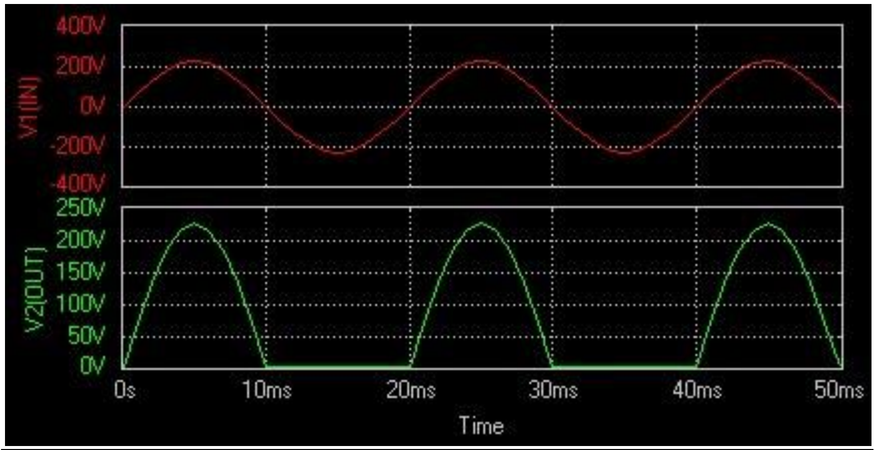
$$=\frac{Vm}{\pi}$$

- V_{FL}=average load at full load

$$=\frac{Vm}{\pi}\frac{Rl}{(Rf+Rs+Rl)}$$

- voltage regulation=$(\frac{Rs+Rf}{Rl})\times100\%$

Waveform :



Observation table:

R_L (k Ω)	V_{AC} (V)	V_{DC} (V)	Ripple factor=V_{AC}/V_{DC}	% of regulation
1				
2				
3				
4				
5				

Procedure:

- Take a step down transformer (230 to 9 volts).
- Connect one end to 230V, 50H_z AC supply and one through p-n junction diode to R_l (load resistance).
- Change the load resistance from 1K to 5K and note the corresponding AC volts and DC volts from CRO.
- Find ripple factor from each reading.
- Find % of voltage variation in the rectifier.
- Draw the graph of $V_{op}\rightarrow V_{ip}$, and test the characteristic of half wave rectifier.

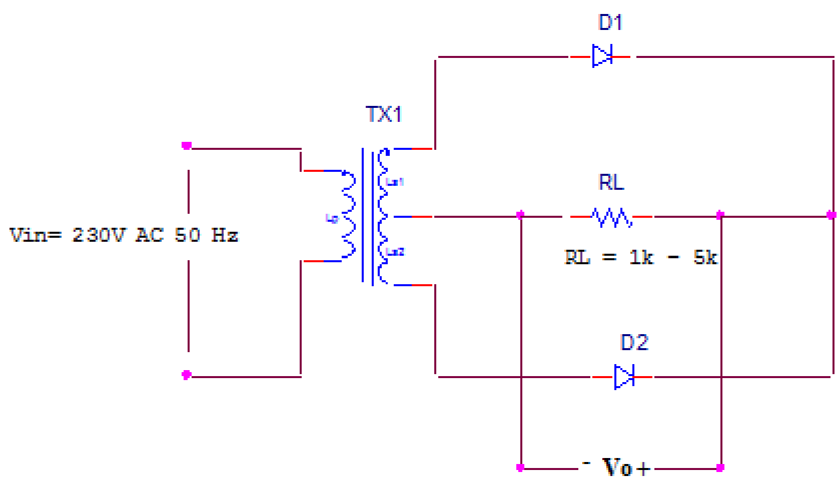
Conclusion:

EXPERIMENT: 6

Aim: To study the full wave rectifier and find the ripple factor and Percentage of Regulation.

Apparatus: center taped transfer, probes, connecting wires, p-n junction diodes, resistance, DMM, CRO, etc.

Figure:



Theory:

- Full wave rectifier consists of a step down center taped transformer T_1 & purely resistive load.
- In half wave rectifier, load current flows in only one half cycles but in the full wave rectifier, it flows in both half cycles of AC supply.

Operation in positive half cycle (0-π):

- In +ve half cycle of AC supply, polarities are V_{A0} (+ve) & V_{B0} (-ve).
- Due to center tapped, secondary V_{A0} & V_{B0} are equal and opposite of each other.
- D_1 in forward bias and D_2in reverse biased the load current starts from a through D_1, load resistance R_L back to the point O.
- The resistance load voltage is positive & equal to V_{A0}.

Operation in –ve half cycle(π-2π):

- In –ve half cycle of the AC supply, polarities of the secondary induced voltages are shown in fig. V_{A0} (-ve) & V_{B0} (+ve).

- Hence, D_2 will be forward biased & D_1 is reverse biased. D_2 carries the entire load current.
- The direction of load current is as same as that in +ve. · The instantaneous voltage ≈ V_{B0}.

Average load current (I_{LDC}):

$$I_{LDC} = \frac{1}{\pi}\int_0^{\pi} I_m \, sin\omega t \, d\omega t$$

$$= \frac{I_m}{\pi}[cos\omega t]_0^{\pi}$$

$$= 2I_m/\pi \quad = 2\, I_{LDC} \quad \text{(HWR)}$$

Average load voltage (V_{LDC}):

$$V_{LDC} = I_{LDC} \times R_L$$

$$= 2I_m/\pi \quad \times R_L$$

RMS load current:

$$I_{LRMS} = \left[\frac{1}{\pi}\int_0^{\pi} {I_m}^2 \, sin^2\omega t \;\; d\omega t\right]^{1/2}$$

$$= I_m/\sqrt{2}$$

RMS voltage:

$$V_{rms} = I_m / \sqrt{2} \times R_L$$

$$= V_m / \sqrt{2}$$

Ripple factor:

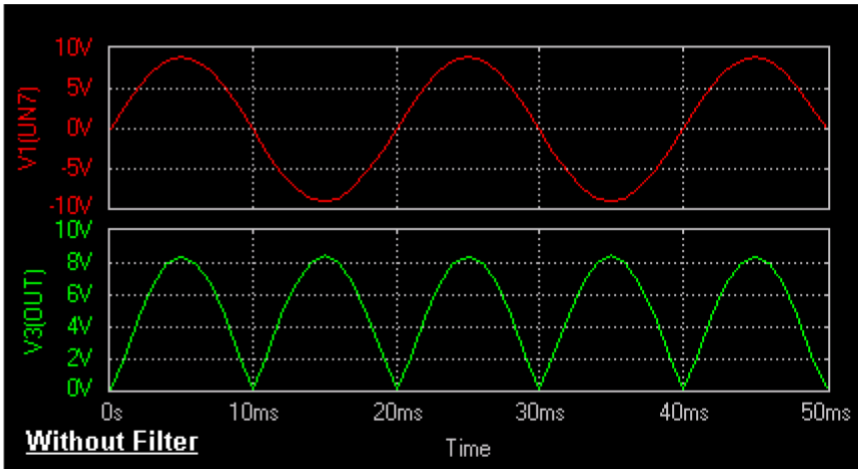
$$R_f = \frac{[v_{L\,rms}^2 - v_{LDC}^2]^{1/2}}{V_{LDC}}$$

$$= \left[\frac{\left(\left({}^{V_m}/_{\sqrt{2}}\right)^2 - \left({}^{2V_m}/_{\pi}\right)^2\right)^{1/2}}{{}^{2V_m}/_{\pi}}\right]$$

= 0.48

- Here, the R_f of FWR is less than HWR, so quality is much better than that of HWR.
- The voltage is regulation is same as the regulation of HWR.

Waveform:



Observation table:

R(in kΩ)	V_{AC} (V)	V_{DC} (V)	Ripple factor=V_{AC}/V_{DC}	% of regulation
1				
2				
3				
4				
5				

Procedure:

- Take the center tapped transformer; connect the primary coil of the transformer to the battery.
- Connect the secondary coil with 2 diodes, D_1 & D_2 & load resistance R_L.
- Change the value of R_L (load resistance) and measure the output DC voltage for the given AC voltage trough DMM.
- Find and examine the characteristic of wave form in full wave rectifier.
- Draw the graph of V_{ip} -->V_{DP} for full wave rectifier.

Conclusion:

Viva Questions

1. What is a rectifier?

Ans: A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification.

2. What is a ripple factor?

Ans: Ripple factor can be defined as the variation of the amplitude of DC (Direct current) due to improper filtering of AC power supply. it can be measured by RF = v_{rms} / v_{dc}

3. What is efficiency?

Ans: Rectifier efficiency is the ratio of the DC output power to the AC input power.

4. What is PIV?

Ans: The peak inverse voltage is either the specified maximum voltage that a diode rectifier can block, or, alternatively, the maximum that a rectifier needs to block in a given application.

5. What are the applications of rectifier?

Ans: The primary application of rectifiers is to derive DC power from an AC supply. Virtually all electronic devices require DC, so rectifiers are used inside the power supplies of virtually all electronic equipment. Rectifiers are also used for detection of amplitude modulated radio signals. rectifiers are used to supply polarized voltage for welding.

6. Give some rectifications technologies?

Ans: Synchronous rectifier, Vibrator, Motor-generator set, Electrolytic ,Mercury arc, and Argon gas electron tube.

7. What is the efficiency of bridge rectifier?

Ans: 81 %

EXPERIMENT: 7

Aim: To study about diode clipping circuit

Apparatus: p-n junction diode (silicon), resistor, CRO, function generator, power supply, probes, DMM, connecting wires, etc.

Circuit:

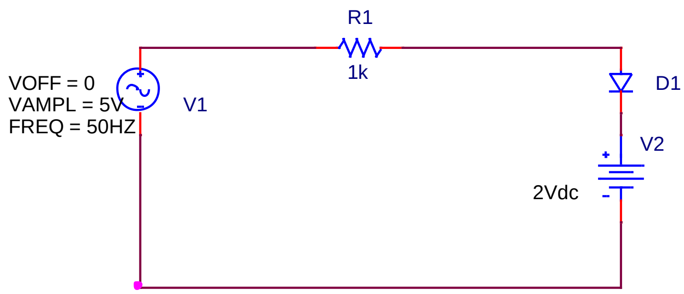


Fig.1

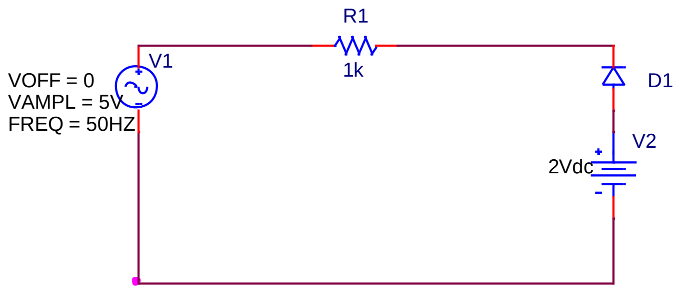


Fig.2

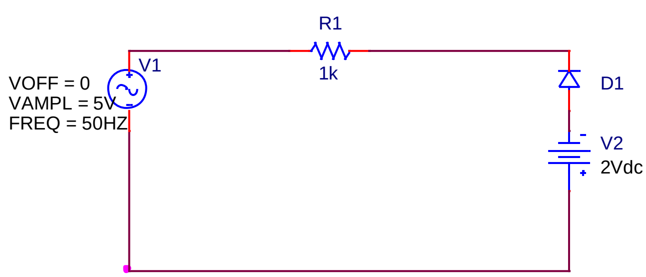


Fig.3

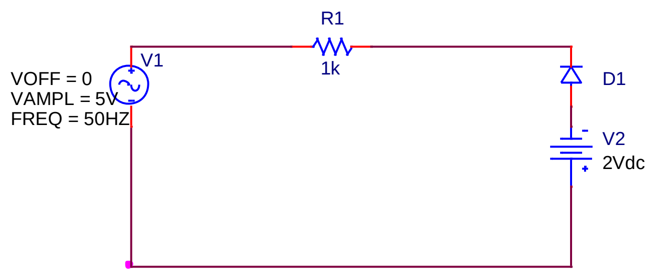


Fig.4

<u>Theory:</u> The basic components required for a clipping circuit are – an ideal diode and a resistor. In order to fix the clipping level to the desired amount, a dc battery must also be included. When the diode is forward biased, it acts as a closed switch, and when it is reverse biased, it acts as an open switch. Different levels of clipping can be obtained by varying the amount of voltage of the battery and also interchanging the positions of the diode and resistor.

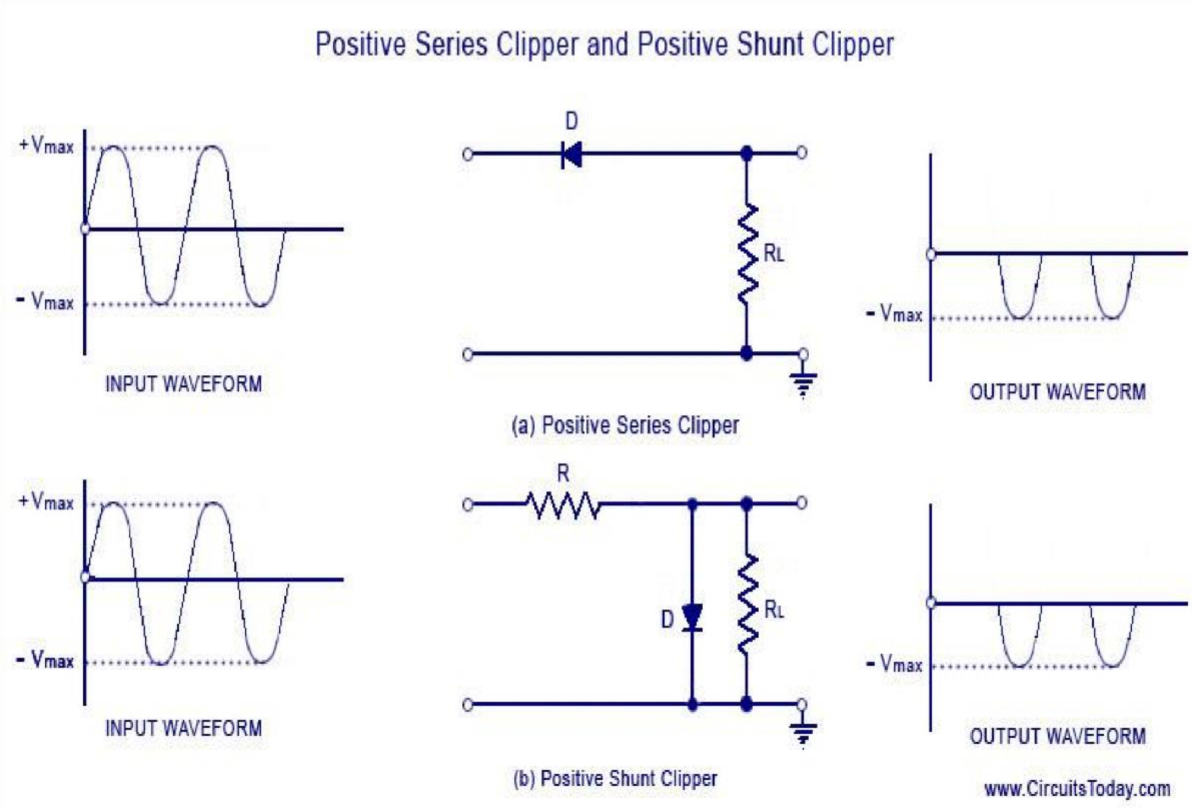
Depending on the features of the diode, the positive or negative region of the input signal is "clipped" off and accordingly the diode clippers may be positive or negative clippers.

There are two general categories of clippers: series and parallel (or shunt). The series configuration is defined as one where diode is in series with the load, while the shunt clipper has the diode in a branch parallel to the load.

1. Positive Clipper and Negative Clipper

Positive Diode Clipper

In a positive clipper, the positive half cycles of the input voltage will be removed. The circuit arrangements for a positive clipper are illustrated in the figure given below.



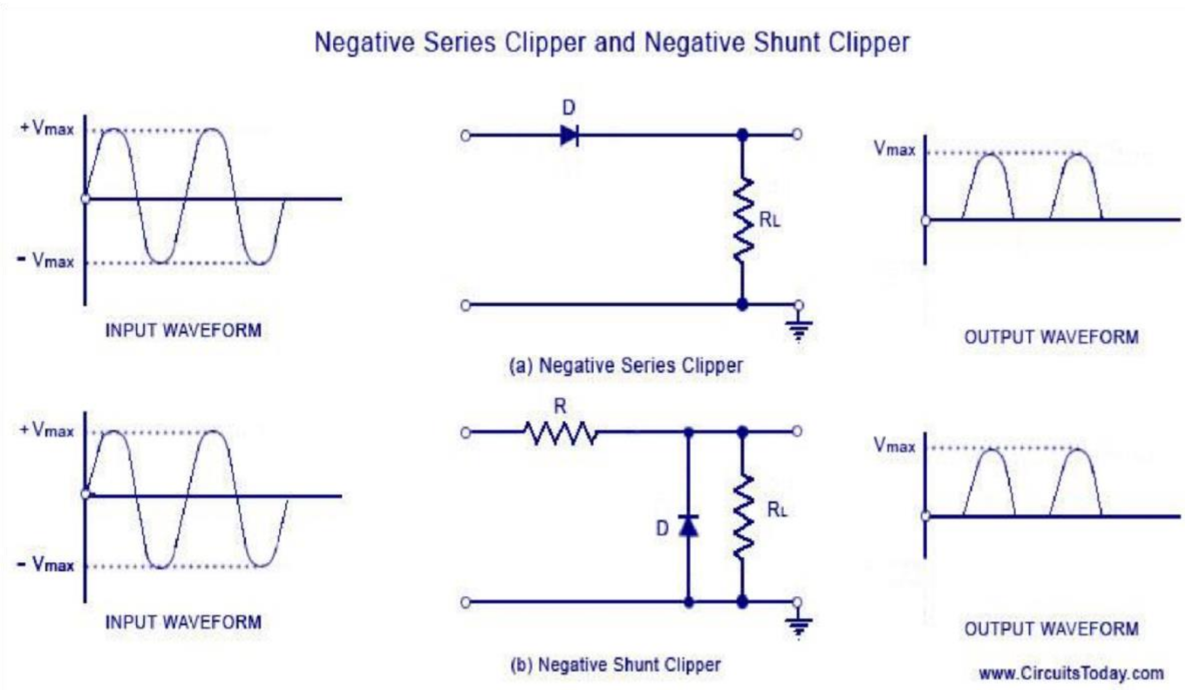
As shown in the figure, the diode is kept in series with the load. During the positive half cycle of the input waveform, the diode 'D' is reverse biased, which maintains the output voltage at 0 Volts. Thus causes the positive half cycle to be clipped off. During the negative half cycle of the input, the diode is forward biased and so the negative half cycle appears across the output.

In Figure (b), the diode is kept in parallel with the load. This is the diagram of a positive shunt clipper circuit. During the positive half cycle, the diode 'D' is forward biased and the diode acts as a closed switch. This causes the diode to conduct heavily. This causes the voltage drop across the diode or across the load resistance R_L to be zero. Thus output voltage during the positive half cycles is zero, as shown in the output waveform. During the negative half cycles of the input signal voltage, the diode D is reverse biased and behaves as an open switch. Consequently the entire input voltage appears across the diode or across the load resistance R_L if R is much smaller than R_L

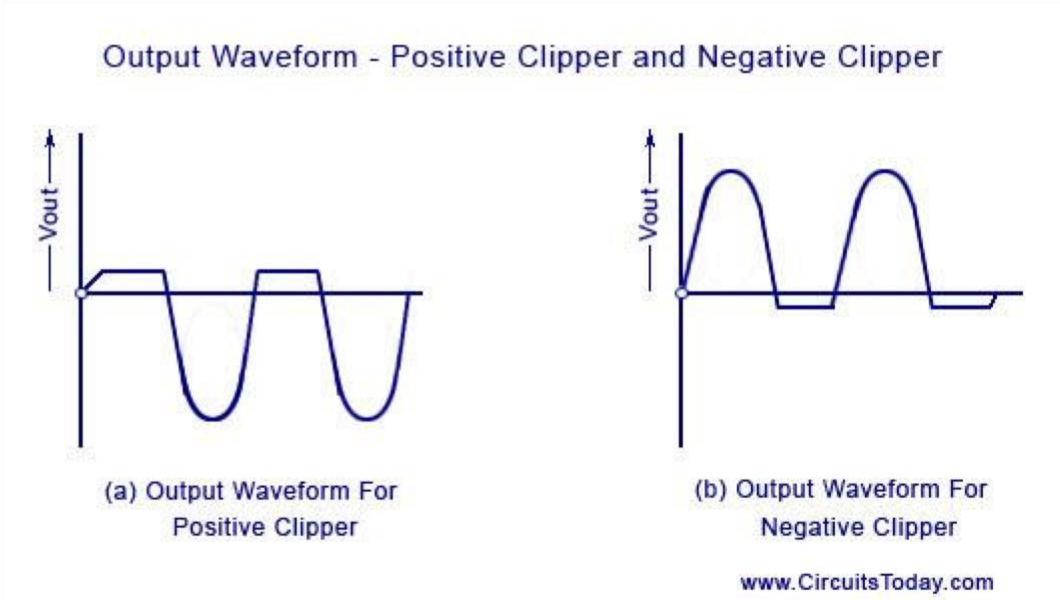
Actually the circuit behaves as a voltage divider with an output voltage of $[R_L / R+ R_L]\ V_{max} = -V_{max}$ when $R_L >> R$

Negative Diode Clipper

The negative clipping circuit is almost same as the positive clipping circuit, with only one difference. If the diode in figures (a) and (b) is reconnected with reversed polarity, the circuits will become for a negative series clipper and negative shunt clipper respectively. The negative series and negative shunt clippers are shown in figures (a) and (b) as given below.



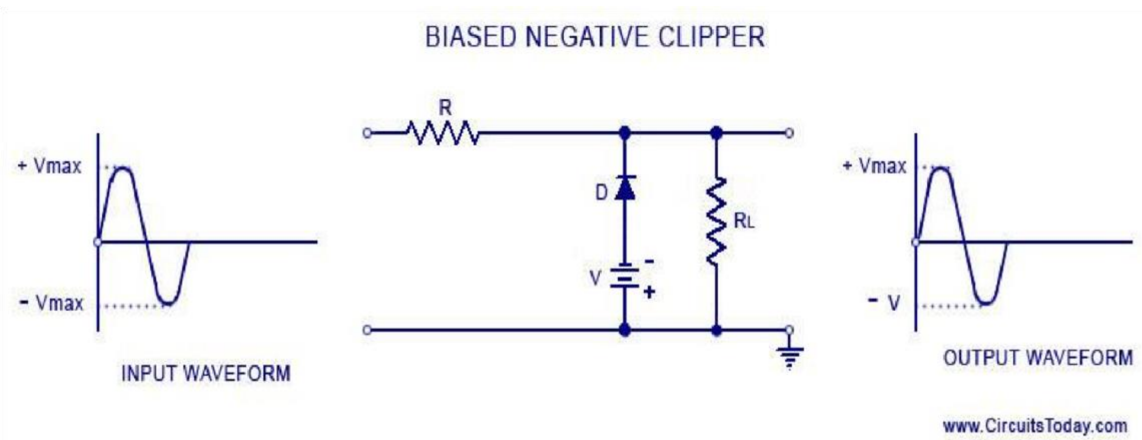
In all the above discussions, the diode is considered to be ideal one. In a practical diode, the breakdown voltage will exist (0.7 V for silicon and 0.3 V for Germanium). When this is taken into account, the output waveforms for positive and negative clippers will be of the shape shown in the figure below.



Negative and Positive Clipping Waveforms

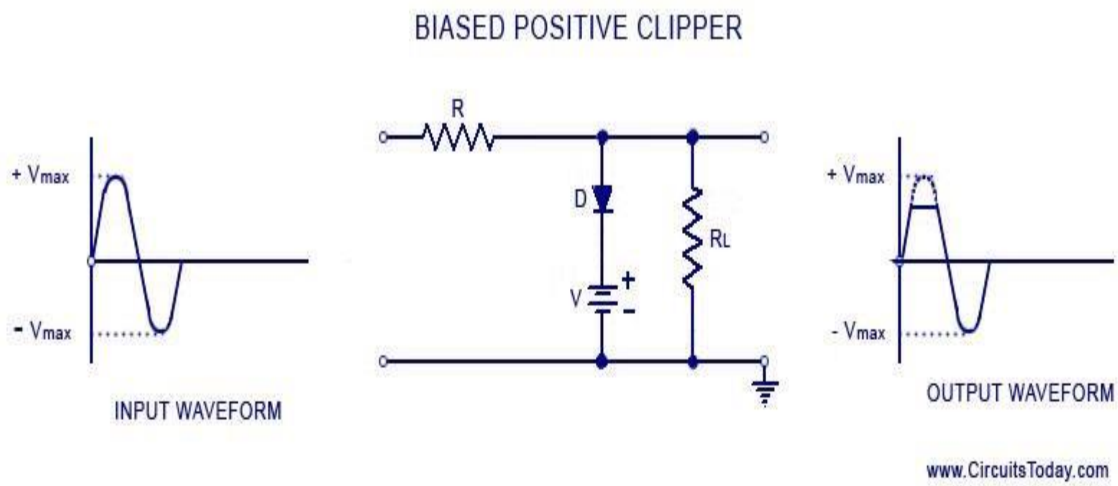
2. Biased Positive Clipper and Biased Negative Clipper

A biased clipper comes in handy when a small portion of positive or negative half cycles of the signal voltage is to be removed. When a small portion of the negative half cycle is to be removed, it is called a biased negative clipper. The circuit diagram and waveform is shown in the figure below.

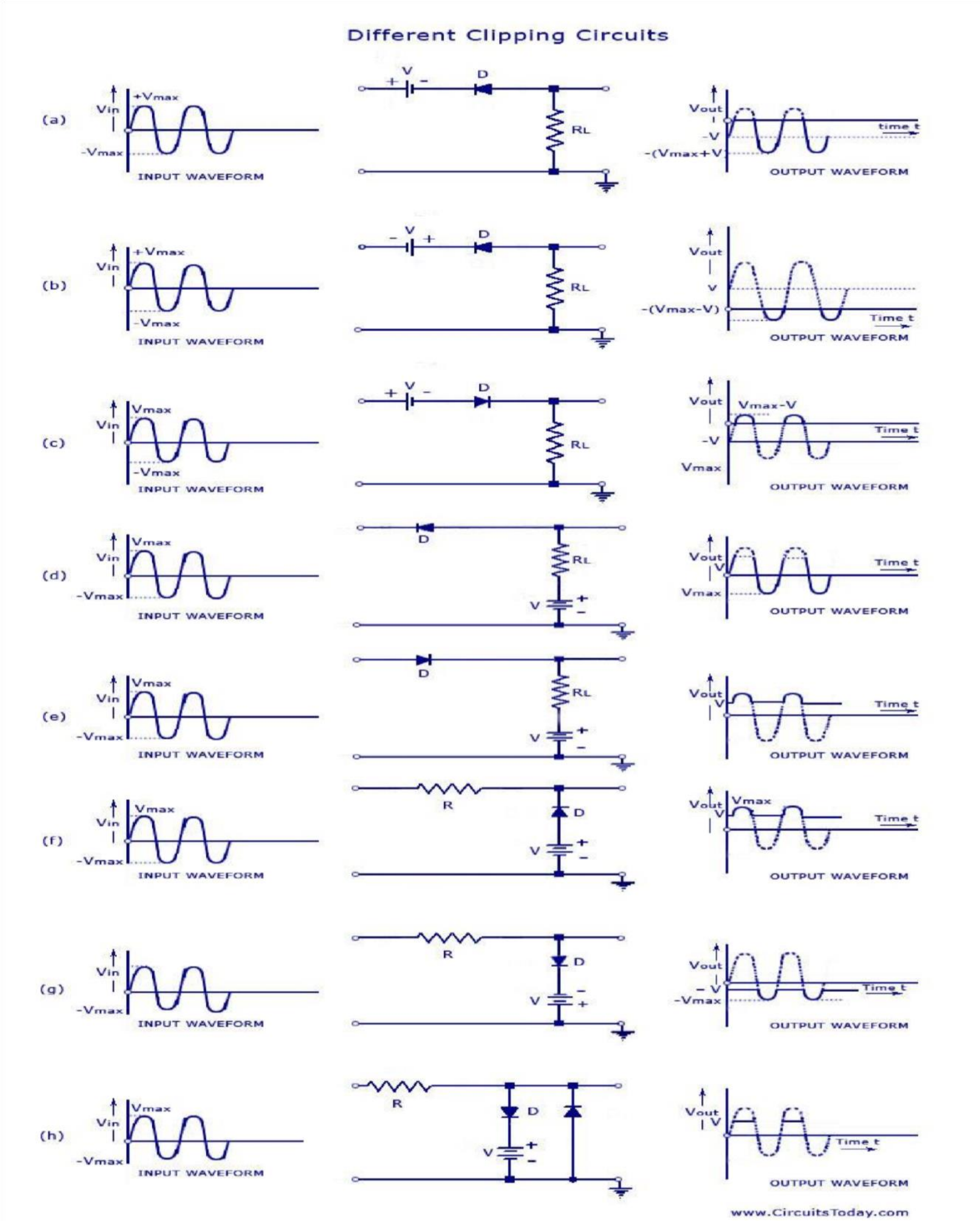


In a biased clipper, when the input signal voltage is positive, the diode 'D' is reversebiased. This causes it to act as an open-switch. Thus the entire positive half cycle appears across the load, as illustrated by output waveform [figure (a)]. When the input signal voltage is negative but does not exceed battery the voltage 'V', the diode 'D' remains reverse-biased and most of the input voltage appears across the output. When during the negative half cycle of input signal, the signal voltage becomes more than the battery voltage V, the diode D is forward biased and so conducts heavily.

The output voltage is equal to '- V' and stays at '- V' as long as the magnitude of the input signal voltage is greater than the magnitude of the battery voltage, 'V'. Thus a biased negative clipper removes input voltage when the input signal voltage becomes greater than the battery voltage. Clipping can be changed by reversing the battery and diode connections, as illustrated in figure (b).

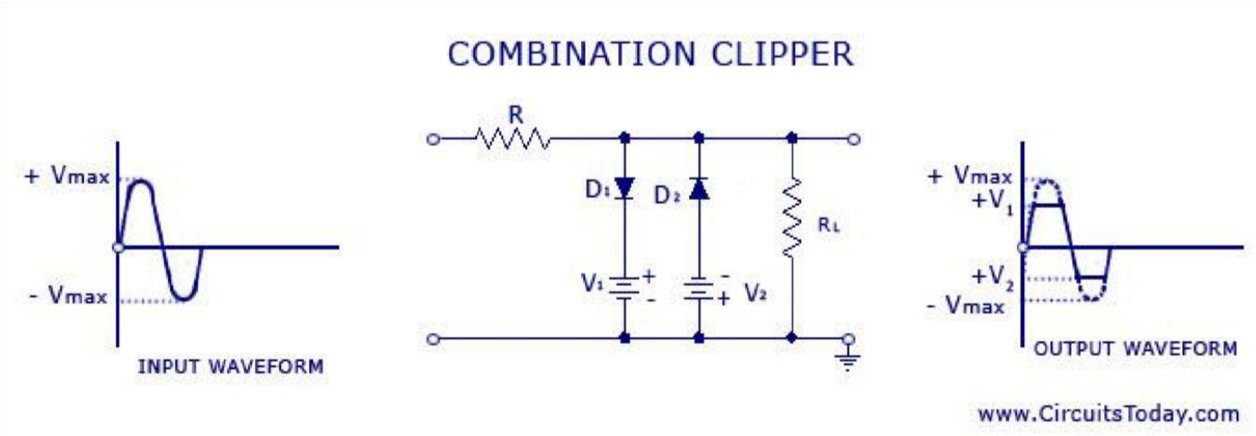


Some of other biased clipper circuits are given below in the figure. While drawing the wave-shape of the output basic principle discussed above are followed. The diode has been considered as an ideal one.



3. Combination Clipper

When a portion of both positive and negative of each half cycle of the input voltage is to be clipped (or removed), combination clipper is employed. The circuit for such a clipper is given in the figure below.



The action of the circuit is summarized below. For positive input voltage signal when input voltage exceeds battery voltage '+ V_1' diode D_1 conducts heavily while diode 'D_2' is reversed biased and so voltage '+ V_1' appears across the output. This output voltage '+ V_1' stays as long as. the input signal voltage exceeds '+ V_1'. On the other hand for the negative input voltage signal, the diode 'D_1' remains reverse biased and diode 'D_2' conducts heavily only when input voltage exceeds battery voltage 'V_2' in magnitude. Thus during the negative half cycle the output stays at '- V_2' so long as the input signal voltage is greater than '-V_2'.

Drawbacks of Series and Shunt Diode Clippers

- In series clippers, when the diode is in 'OFF' position, there will be no transmission of input signal to output. But in case of high frequency signals transmission occurs through diode capacitance which is undesirable. This is the drawback of using diode as a series element in such clippers.

- In shunt clippers, when diode is in the 'off condition, transmission of input signal should take place to output. But in case of high frequency input signals, diode capacitance affects the circuit operation adversely and the signal gets attenuated (that is, it passes through diode capacitance to ground).

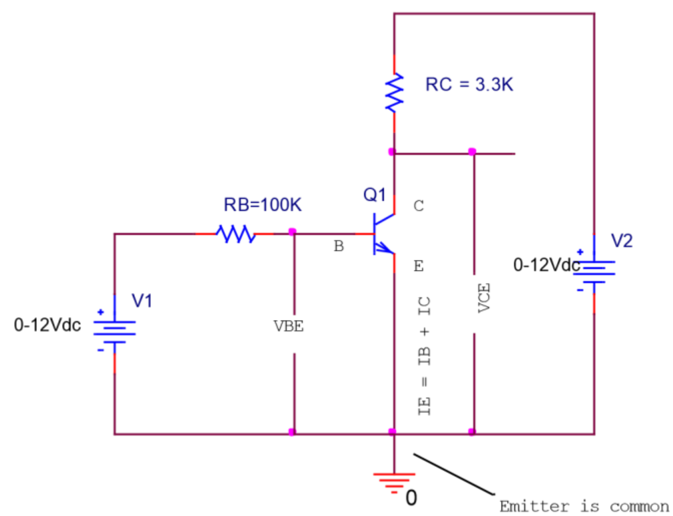
Conclusion:

EXPERIMENT: 8

Aim: To study about input & output characteristic of N-P-N transistor for Common Emitter (CE) configuration.

Apparatus: N-P-N transistor kit with C-E configuration, wires 2 batteries etc.

Figure:



Theory:

- Transistor is a three terminal device: collector, emitter & base
- Its characteristics are as follow:-

Input characteristics: (N-P-N CE transistor)

- It is a graph of input current I_{BE} versus input voltage V_{BE} at a constant output voltage.
- For C-E configuration, I_B is the input current and V_{BE} is the input voltage.
- At constant output voltage, V_{CE} the input characteristics of a N-P-N transistor is shown in fig-a. The input characteristic also shows the effect of V_{CE}.
- The input characteristic resembles the forward characteristics of p-n junction diode. The reason that BE junction is forward biased p-n junction that BE junction is forward biased p-n junction.

- The base current increases rapidly as the emitter voltage crosses the cut in voltage of the B-E p-n junction. The dynamic input resistance is defined as

$$R_I=\Delta V_{BE}/\Delta I_B/V_{CE} \text{ constant}$$

- Its value can be obtained from the input characteristic because 'R_I' is equal to the reciprocal of slope of the input characteristic.

R_I is low for C-E configuration.

Effect of change in V_{CE} on the input characteristic:

- Fig. a shows that at a constant $V_{BE,}$ if we increase V_{CE} from 5v to 15v then the base current decreases from 60µA to 20A

- Thus I_B decreases with increases V_{CE} we can explain this as follows: · As V_{CE} increases CB junction is more reverse biased
- The depletion region at CB junction penetrates more into base
- This reduces the electrical width of bias
- The chances of recombination in the base region reduce
- Hence the base current will reduce

Output characteristics (n-p-n CE transistor):

- This is a graph of output current (I_C) versus output voltage (V_{CE}) for various fixed values of the input current (I_B). The typical output characteristics of a n-p-n transistor operating in the CE configuration are as shown in fig. b.
- As shown in fig. b. there are three regions of operations namely the cut off region, active region & saturation region.
- Cut off region:
- Both the BE & CB junction are reverse biased to operate the transistor in cut off region, the base current I_B=0 and the collector current is equal to the reverse leakage current I_{CE} the region below the characteristic for I_B=0 is cut-off region · Active region:
- The B-E junction is forward biased and C-B junction is reverse biased to operate the transistor in the active region
- The collector current I_C increases slightly with increase in the voltage $V_{CE.}$ However the collector current is largely dependent on the base current I_B
- The collector current I_C increases slightly with increase in the voltage V_{CE}. However the collector current is dependent on I_B
- At a fixed value of V_{CE}, if I_B is increased, then it will cause I_C to increase substantially.
- Saturation region:

- The B-E junction as well as the collector junction must be forward biased to operate the transistor in its saturation region.
- The collector base junction can be forward biased if and only if V_{CE} drops down to about 0-2 volts because V_{BE}=0.1 v will forward bias the CB junction.
- The collector current increases rapidly with increase in $V_{CE.}$
- The collector current increases rapidly with increase in $V_{CE.}$ · The transistor is operated as a switch in this region.

Dynamic output resistance(R):-

- The dynamic output resistance of a transistor in CE configuration is defined as

$$R=\Delta V_{CE}/\Delta I_C/\text{constant } I_B$$

- The dynamic output resistance can be obtained as reciprocal of slope of output characteristic.
- Its value is large in the active region because ΔI_C is very small .However value of R will be very small in saturation region .This is because ΔI_C in that region is large for a small value of $\Delta V_{CE.}$

Observation Table:

1) Input Characteristics:

V_{cc} = 10 V $\qquad\qquad$ R_B = ______________

V_{BB}(V)	V_{BE} (V)	$I_B = V_{RB} / R_B$	I_C
0.2			
0.4			
0.7			
1			
2.5			
5			
7.5			
10			

2) Output Characteristics:

IB = 0				IB = 40μA			
V_{CE}	V_{RC}	$I_C = V_{RC}/R_C$	V_{BE}	V_{CE}	V_{RC}	$I_C = V_{RC}/R_C$	V_{BE}
0.1							
0.2							
0.3							
0.4							
0.5							
0.6							
0.7							
0.8							
1							
1.5							

Procedure:

- Connect the circuit as shown in fig. on n-p-n transistor kit.
- To study input characteristic, we have to keep V_{CE} constant & equal to 10v. Then, for different values of V_{BE}, we have to measure I_B.
- Then plot the graph of input current I_B versus input voltage V_{BE} at constant output voltage V_{CE}=10v.
- Then to study about output characteristics .We have to keep I_B constant .first, we keep I_B=10μA and then I_B=30μA and for different values of V_{CE}, we measure I_C , then plot the graph of I_C versus V_{CE} that gives us output characteristic. · Then we measure output characteristic in both the cases.

Conclusion:

Precautions:

1. While performing the experiment do not exceed the ratings of the transistor. This may lead to damage the transistor.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
4. Make sure while selecting the emitter, base and collector terminals of the transistor.

Viva Questions

1. What is transistor?

Ans: A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. The term transistor was coined by John R. Pierce as a portmanteau of the term "transfer resistor".

2. Write the relation between α, β and γ?

Ans: $\alpha = \frac{\beta}{1+\beta}$ $\beta = \frac{\alpha}{1-\alpha}$ $\gamma = 1 + \beta = \frac{1}{1-\alpha}$

3. What is the range of α ?

Ans: The important parameter is the common-base current gain, α. The common-base current gain is approximately the gain of current from emitter to collector in the forward-active region.

This ratio usually has a value close to unity; between 0.98 and 0.998.

4. Why is α is less than unity?

Ans: It is less than unity due to recombination of charge carriers as they cross the base region.

5. Input and output impedance equations for CB configuration?

Ans: $h_{ib}=V_{EB}/I_E, 1/h_{ob}=V_{CB}/I_C$

6. Can we replace transistor by two back to back connected diodes?

Ans: No, because the doping levels of emitter (heavily doped), base(lightly doped) and collector(doping level greater than base and less than emitter) terminals are different from p and n terminals in diode.

7. For amplification CE is preferred, why?

Ans: Because amplification factor beta is usually ranges from 20-500 hence this configuration gives appreciable current gain as well as voltage gain at its output on the other hand in the Common Collector configuration has very high input resistance(~750KΩ) & very low output resistance(~25Ω) so the voltage gain is always less than one & its most important application is for impedance matching for driving from low impedance load to high impedance source

8. To operate a transistor as amplifier, emitter junction is forward biased and collector junction is reverse biased, why?

Ans: Voltage is directly proportional to Resistance. Forward bias resistance is very less compared to reverse bias. In amplifier input forward biased and output reverse biased so voltage at output increases with reverse bias resistance.

9. Which transistor configuration provides a phase reversal between the input and output signals?

Ans: Common emitter configuration (180 DEG)

10. What is the range if β?

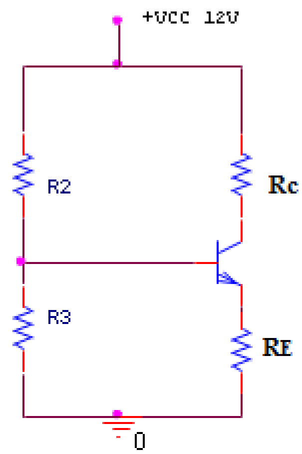
Ans: β usually ranges from 20-500.

EXPERIMENT: 9

Aim: Analyze Voltage Divider Biasing Circuit

Apparatus: NPN junction transistor, 3resisters, connecting wires, DMM etc.

Figure:



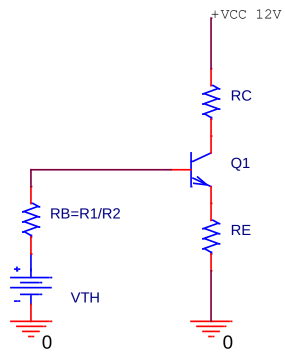
Theory:

- The circuit used to establish a stable operating point is the self biasing (voltage divider) ckt.
- As shown in fig. R1 &R2 are potential divider to apply a fixed voltage Vg to base.
- The current in Rc in the emitter lead causes a voltage drop which is in the direction to reverse bias the emitter junction.
- The junction must be forward biased .The biased voltage is obtained from the supply voltage.

- Here Ic tends to increase because IC0 has risen in Rc increases, so voltage drop across Rc increase , which increases voltage drop across Rc the base current decreases .Thus tends to decrease in Ic & compensation For in Ic achieved.

Analysis using Thevenin's equivalent Circuit:

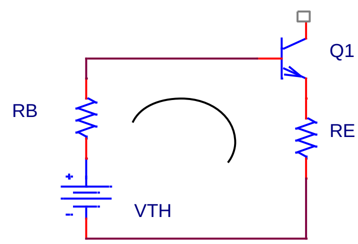
Thevenin's Equivalent Circuit:



R_B=(R1*R2) / (R1+R2)

V_{th}=(R2*V_{cc}) / (R1+R2)

Obtain Expression for I_b:



Applying KVL to base loop

$Vth-I_B.R_B-V_{BE}-I_E.R_E=0$

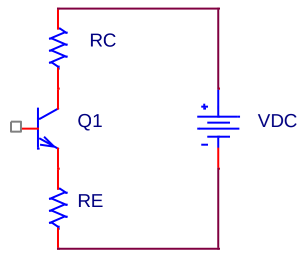
$Vth-I_B.R_B-V_{BE}-(H\beta_{dc}).I_BR_E=0.$

$I_B=(Vth-V_{BE})/R_B+(H\beta_{dc})R_E$

Obttain expression for I_C& V_{CE}:

$I_C=\beta_{dc}*I_B$

$=\beta_{dc}(V_{th}-V_{BE})/R_B+(1+\beta_{dc}).R_E$



Applying KVL to loop:

$$V_{CC}=I_CR_C+V_{CE}+I_ER_E$$

$$V_{CE}= V_{CC} - I_CR_C-I_ER_E$$

Procedure:

- As shown in fig take n-p-n junction diode and connect 2 diodes (R1=variables and R2=1kΩ) in base emitter circuit junction.
- Connect Rc=3.3kΩ collector emitter junction. · Apply biasing voltage Vcc=12v.
- Here, output voltage V_{CE} is measured.
- For setting quiescent point in the middle we assume that VCE=V_{CC}/2, so very R1 and find V_{CE}.
- Continue above procedure until output is V_{CE}=Vcc/2.

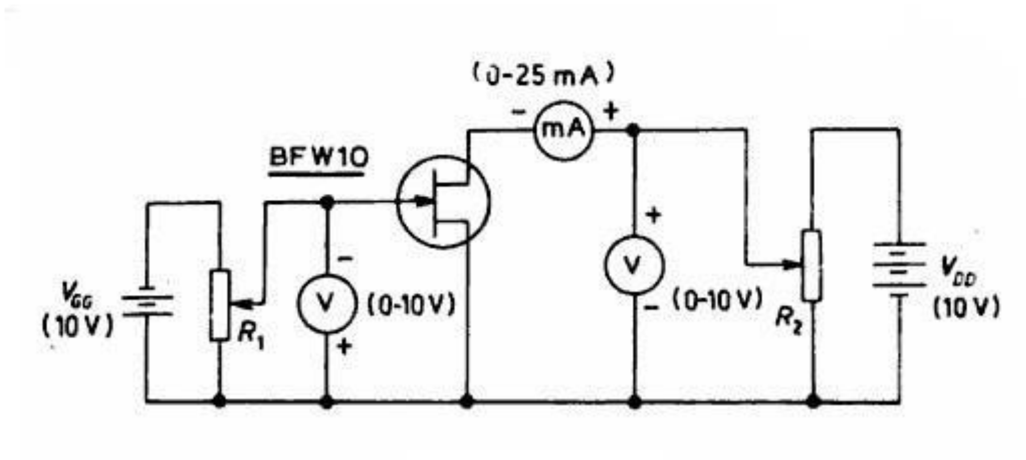
Conclusion:

EXPERIMENT: 10

Aim: To study V-I characteristic of JFET.

Apparatus : Experimental board, power supply, millimeter (0 to 25 mA), two electronics millimeters, connecting wires.

Figure:



Theory:

Like an ordinary junction transistor, a field effect transistor is also a three terminal device, because its function depends only upon one type of carrier. (The ordinary transistor is bipolar; hence it is called bipolar-junction transistors). Unlike a BJT, an FET has high input impendence. This is a great advantage.

A field-effect transistor can be either a JFET or MOSFET. Again, a JFET can either have N-channel or P-channel. An N-channel JFET, has a N-type semiconductor bar; the two ends of which make the drain and source terminals. On the two sides of this bar , PN-junctions are made. These P regions make gates. Usually, the gate is given a negative bias with respect to the source. The gate is given a negative bias with respect to the source. The drain is given positive potential with respect to the source. In case of a Pchannel JFET, the terminals of all the batteries are reversed. The important parameters of JFET are defined as bellow:

1. Drain dynamic resistance, $r_d = \frac{\Delta vDS}{\Delta Id}\Big|_{V_{gs}}$=constant..

2. Mutual Conductance, $g_m = \frac{\Delta id}{\Delta vgs}\Big|_{V_{Ds}}$ = constanst.

3. Amplification Factor, $\mu = \frac{\Delta vDs}{\Delta vGs}\Big|_{I_d}$= constant.

These parameters are related by the equation

$$\mu = r_d g_m$$

Procedure:

1. Note the type of FET connected in the experimental board. See its specifications from data book. Identify its terminals. Trace the circuit.

2. Make the circuit connections as shown in figure. Use millimeter and electronic voltmeter in suitable range.
3. First, fix V_{GS} at some value; say 0 V. increase the drain voltage v_{DS} slowly in steps. Note drain current i_d for each step. Now change V_{GS} to another value and repeat the the above. This way, take readings for 3 to 4 gate-voltage values.
4. Plot the drain characteristics (graph between iD and vDS for fixed values of V_{GS}).
5. Use the definitions given in brief theory to calculate the FET parameters, from the characteristics.

Observations:

1. Type Number of the FET =_____________________________________ 2. Drain Characteristics:

Drain Current id(mA)						
S. No	v_{DS} (V)	Vgs=0V	Vgs= -1V	Vgs= -2 V	Vgs = -3 V	Vgs = -4 V
1						
2						
3						

Calculations:

A suitable operating point is selected, say at VDS = 8 mA, VGS = -3 V. At this operating point, the parameters are calculated as follows:

1. $r_d = \frac{\Delta v_{DS}}{\Delta I_d} \Big|_{V_{gs} = -3\ V}$ = ______________kΩ
2. $g_m = \frac{\Delta i_d}{\Delta v_{gs}} \Big|_{V_{DS} = 8\ V}$ = ______________mS
3. $\mu = \frac{\Delta v_{DS}}{\Delta v_{GS}} \Big|_{I_d = \_\_\_\_\_\_ mA}$ =_________________

Results:

1. The drain characteristics of FET are plotted on the graph.
2. The parameters of FET determined from drain characteristics.

Conclusion:

Precautions:

1. While performing the experiment do not exceed the ratings of the FET. This may lead to damage the FET.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
4. Make sure while selecting the Source, Drain and Gate terminals of the transistor.

Viva Questions

1. Why FET is called a Unipolar device?

Ans: FETs are unipolar transistors as they involve single-carrier-type operation.

2. What are the advantages of FET?

Ans: The main advantage of the FET is its high input resistance, on the order of 100 MΩ or more. Thus, it is a voltage-controlled device, and shows a high degree of isolation between input and output. It is a unipolar device, depending only upon majority current flow. It is less noisy. and is thus found in FM tuners and in low-noise amplifiers for VHF and satellite receivers. It is relatively immune to radiation. It exhibits no offset voltage at zero drain current and hence makes an excellent signal chopper. It typically has better thermal stability than a bipolar junction transistor (BJT)

3. What is trans-conductance?

Ans: Trans-conductance is an expression of the performance of a bipolar transistor or field-effect transistor (FET). In general, the larger the trans-conductance figure for a device, the greater the gain (amplification) it is capable of delivering, when all other factors are held constant. The symbol for trans-conductance is gm. The unit is Siemens, the same unit that is used for directcurrent (DC) conductance.

4. What are the disadvantages of FET?

Ans: It has a relatively low gain-bandwidth product compared to a BJT. The MOSFET has a drawback of being very susceptible to overload voltages, thus requiring special handling during installation.The fragile insulating layer of the MOSFET between the gate and channel makes it vulnerable to electrostatic damage during handling. This is not usually a problem after the device has been installed in a properly designed circuit.

5. Relation between μ, g_m and r_d? Ans: $\mu = g_m * r_d$

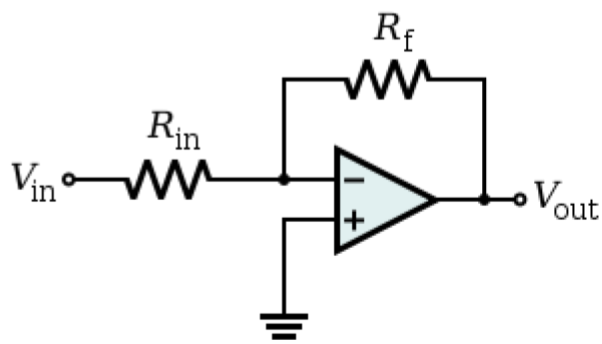
EXPERIMENT:11

AIM: To configure op-amp in inverting amplifier mode and measure their gain and bandwidth

APPARATUS :741 Op Amp, Assorted Resistors, signal generator, CRO,DMM, power supply, connecting wires, probes,etc

THEORY:

Inverting amplifier



An inverting amplifier uses negative feedback to invert and amplify a voltage. The R_f resistor allows some of the output signal to be returned to the input. Since the output is 180° out of phase, this amount is effectively subtracted from the input, thereby reducing the input into the operational amplifier. This reduces the overall gain of the amplifier and is dubbed negative feedback.

$$V_{\mathrm{out}} = -\frac{R_{\mathrm{f}}}{R_{\mathrm{in}}} V_{\mathrm{in}}$$

- $Z_{in} = R_{in}$ (because V_- is a virtual ground)
- A third resistor, of value $R_{\mathrm{f}} \| R_{\mathrm{in}} \triangleq R_{\mathrm{f}} R_{\mathrm{in}} / (R_{\mathrm{f}} + R_{\mathrm{in}})$, added between the non-inverting input and ground, while not necessary, minimizes errors due to input bias currents

The gain of the amplifier is determined by the ratio of R_f to R_{in}. That is:

$$A = -\frac{R_f}{R_{in}}$$

Take Rf = 100KΩ and Rin = 10 KΩ, we get Af =10

PROCEDURE:

- As shown in figure connect the circuit on bread board using 741 C op-amps or connect the same circuit by using kit.
- Now for both of the amplifier circuits apply the inputs and check the output wave forms in both circuits.
- Compare the waveforms with the input signals and measure the voltage gain of the circuits.

- Now for both of the amplifier increase the frequency and meanwhile check the output waveform on CRO.
- Plot the Graph on semi log graph paper of Frequency Vs Gain (dB) and determine the value of the bandwidth of the circuit. Compare with the theoretical values.

OBSERVATIONS TABLE AND CALCULATIONS:

Vin =

Frequency	**Output voltage Vo (inv)**	**Output voltage Vo (Non-inv)**	**Voltage Gain Ad(dB)(inv)**

Conclusion:

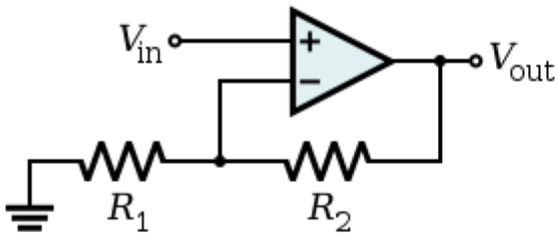
EXPERIMENT:12

AIM: To configure op-amp in non-inverting amplifier mode and measure their gain and bandwidth

APPARATUS :741 Op Amp, Assorted Resistors, signal generator, CRO,DMM, power supply, connecting wires, probes,etc

THEORY:

Non-inverting amplifier



Amplifies a voltage (multiplies by a constant greater than 1)

$$V_{out} = V_{in}\left(1 + \frac{R_2}{R_1}\right)$$

- Input impedance $Z_{in} \approx \infty$
- R2 = 10K
- And R1 = 1K

Gain bandwidth product of the op amp,

$(A)(fo) = (A_f)\ (F_f)$

For 741 fo = 5 Hz and A= 2 X 10^5

If we adjust the gain Af = 10 we can easily calculate the Bandwidth Ff $_{of}$ the op amp

741C

PROCEDURE:

- As shown in figure connect the circuit on bread board using 741 C op-amps or connect the same circuit by using kit.
- Now for both of the amplifier circuits apply the inputs and check the output wave forms in both circuits.

- Compare the waveforms with the input signals and measure the voltage gain of the circuits.

- Now for both of the amplifier increase the frequency and meanwhile check the output waveform on CRO.
- Plot the Graph on semi log graph paper of Frequency Vs Gain (dB) and determine the value of the bandwidth of the circuit. Compare with the theoretical values.

OBSERVATIONS TABLE AND CALCULATIONS:

Vin =

Frequency	**Output voltage Vo(inv)**	**Output voltage Vo(Non-inv)**	**Voltage Gain Ad(dB)(Non-inv)**

Conclusion:

ANNEXURE

i. The number of experiments in each laboratory course shall be as per the curriculum.
ii. The students will maintain a separate note book for observations in each laboratory course.

iii. In each session the students will conduct the allotted experiment and enter the data in the observation table.

iv. The students will then complete the calculations and obtain the results. The course coordinator will certify the result in the same session.

v. The students will submit the record in the next class. The evaluation will be continuous and not cycle-wise or at semester end.

vi. Laboratory Record: Each experimental record is evaluated based on the following **parameters:**
   a. Write up format -
   b. Experimentation Observations & Calculations -
   c. Results and Graphs -
   d. Discussion of results -

vii. The experiment evaluation rubric is therefore as follows:

Parameter	Max Score
Observations & Calculations	2
Write up format	2
Results & graphs	2
Discussion of Results	2
Regularity	2
Total	10

Course Outcomes (COs):

At the end of this course, students will be able to:

1. Recognize the basic concepts of Electronics and Electrical Sources.
2. Comprehend the role of Semiconductor Devices
3. To understand Basics of Electronic Communication and its applications