GOVT CO-ED POLYTECHNIC

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LAB MANUAL

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2025364(025) – Basic Electronics (Lab)

CONTENTS

Experiment No: 1

Study of CRO & Measurement of Voltage Amplitude & Frequency

Aim:

1. Study of CRO and to find the Amplitude and Frequency using CRO.
2. To measure the Unknown Frequency & Phase difference using CRO.

Components and Equipments Required: Cathode-ray oscilloscope, Function Generator (2), Decade Resistance Box (DRB), Capacitor, CRO Probes and Bread Board.

Theory:

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

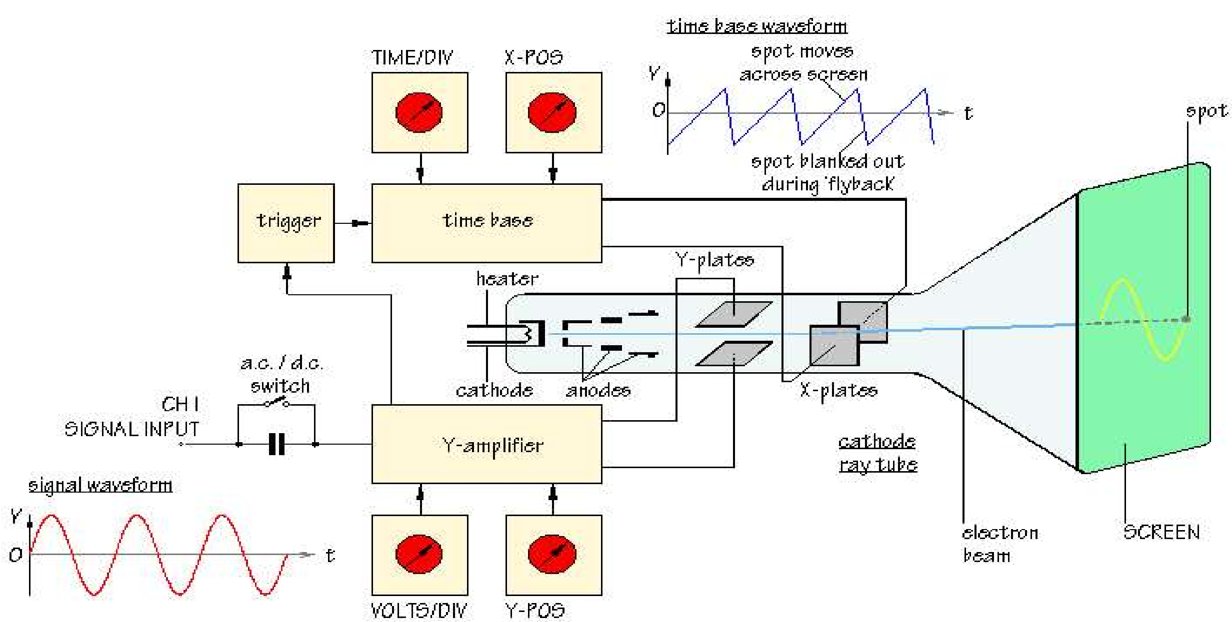


Fig. 1: Cathode Ray Oscilloscope

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.

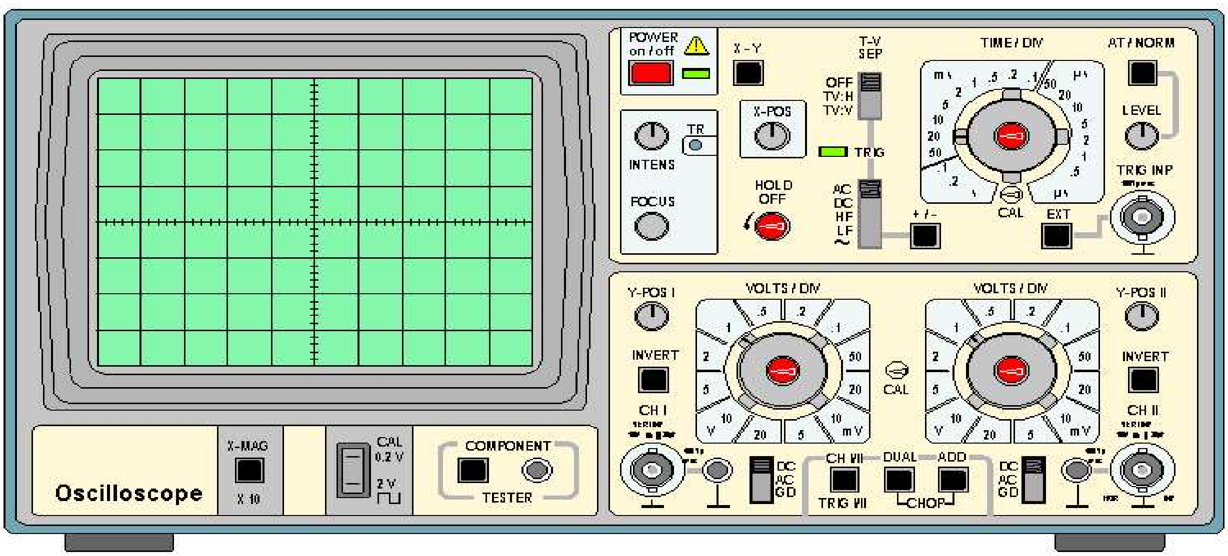


Fig. 2: Front View of Oscilloscope

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.

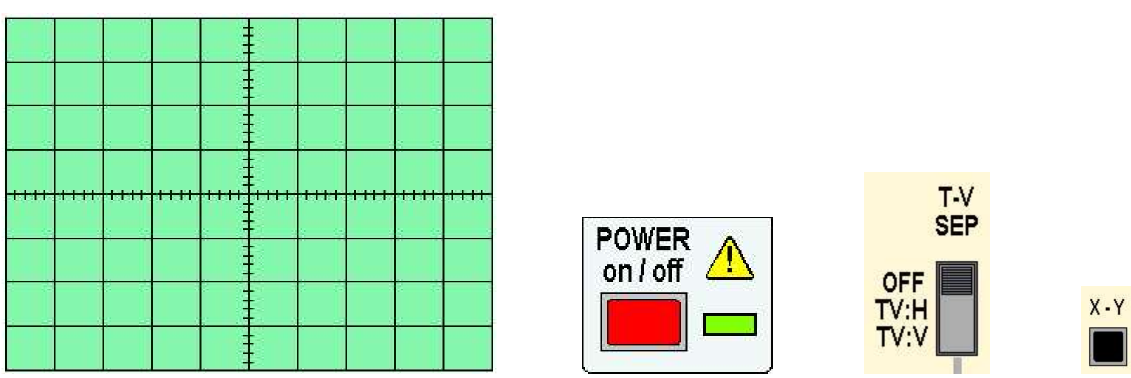


Fig. 3: Screen display of Oscilloscope

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.

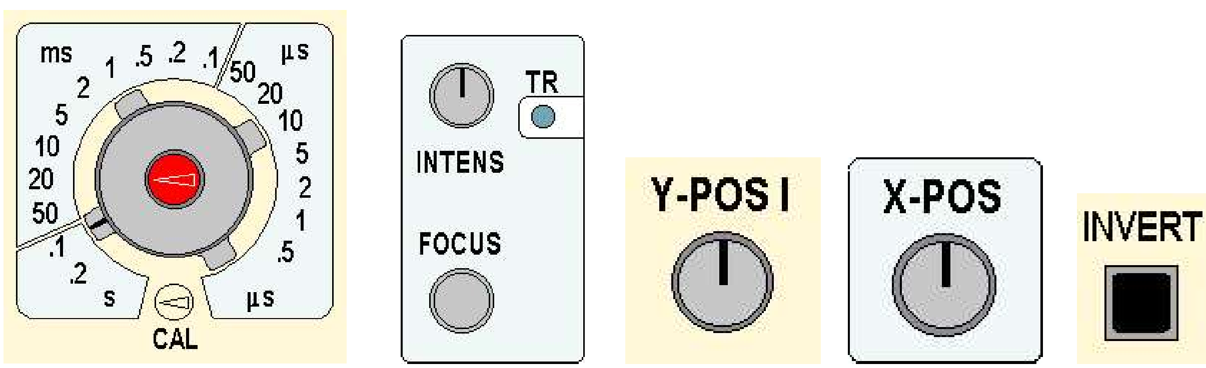


Fig. 4: Time division, Intensity, focus, X-Y mode knobs

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.

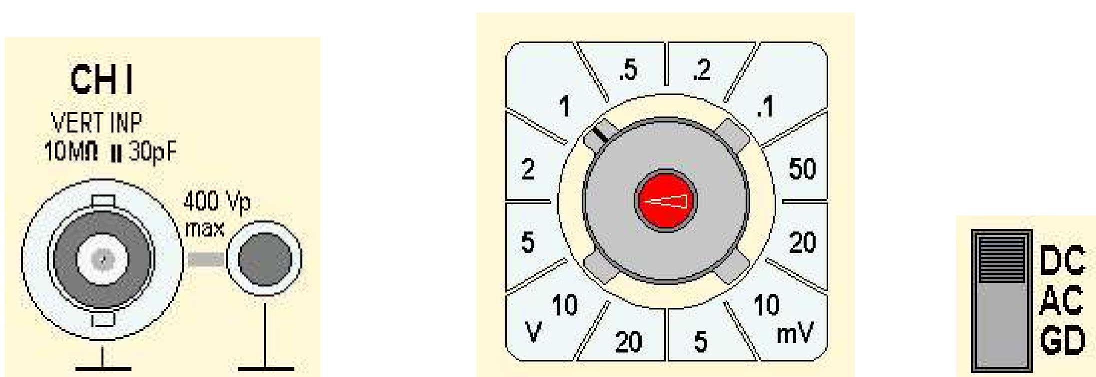


Fig. 5: Voltage division, Channels, AC, DC and GND knobs

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:

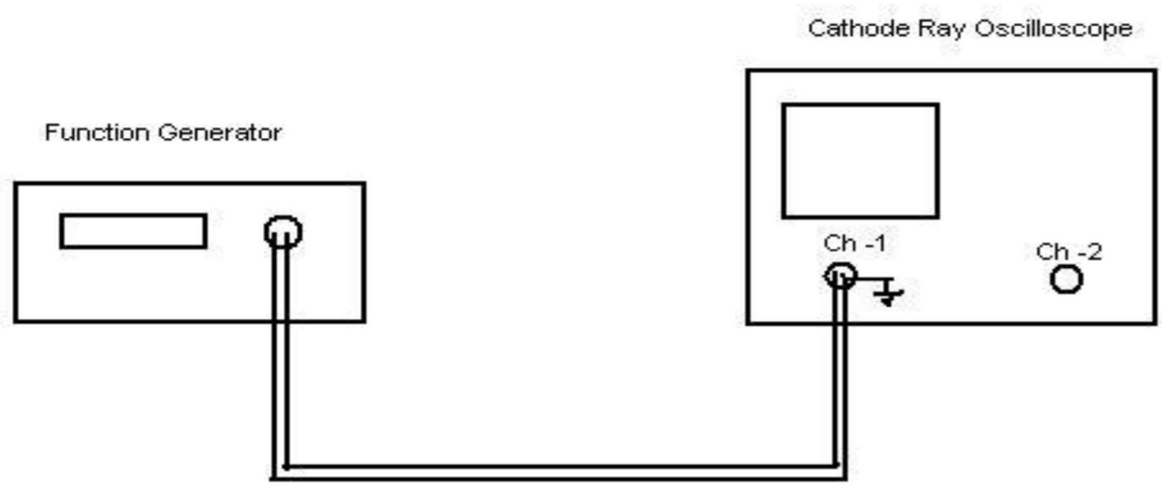


Fig. 6: Measurement of Amplitude & Frequency

Model waveforms:

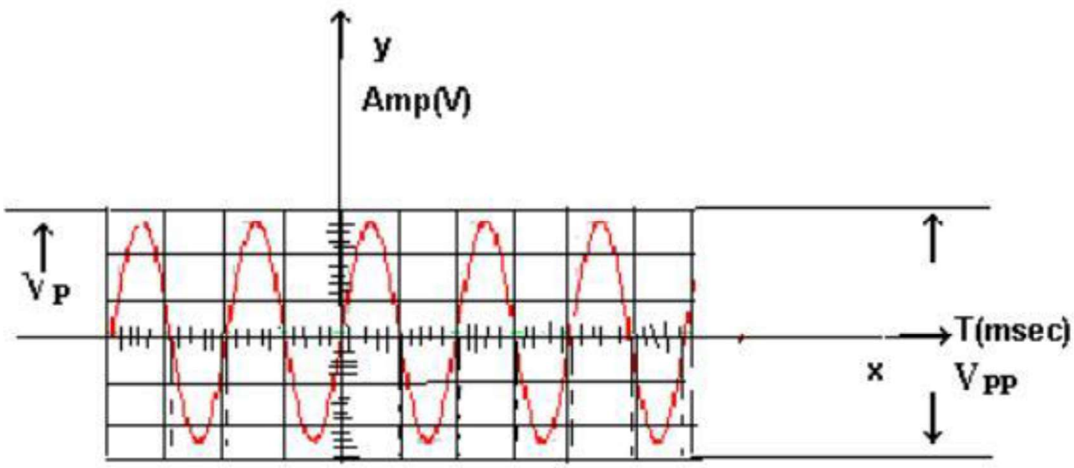


Fig. 7: Sinusoidal waveform

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

C) Measurement of Unknown Frequency:

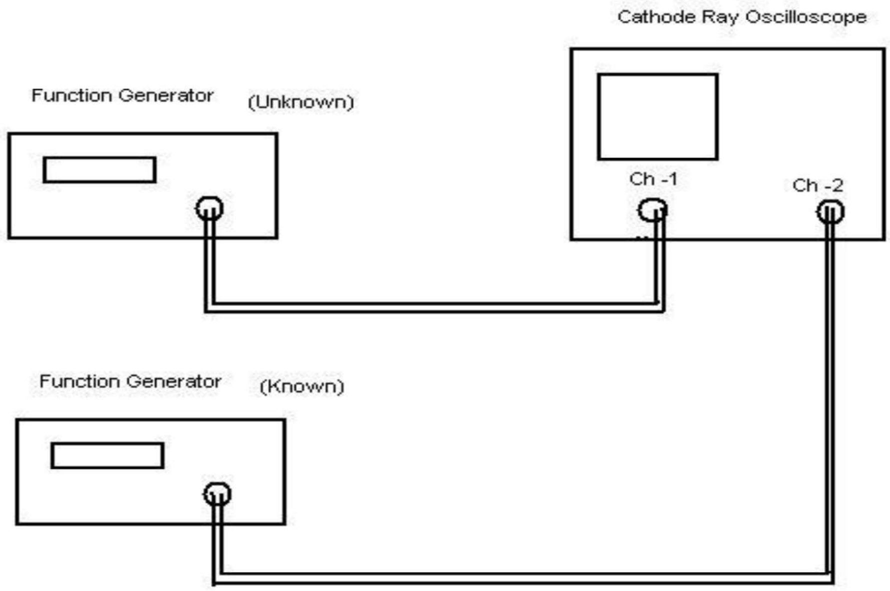


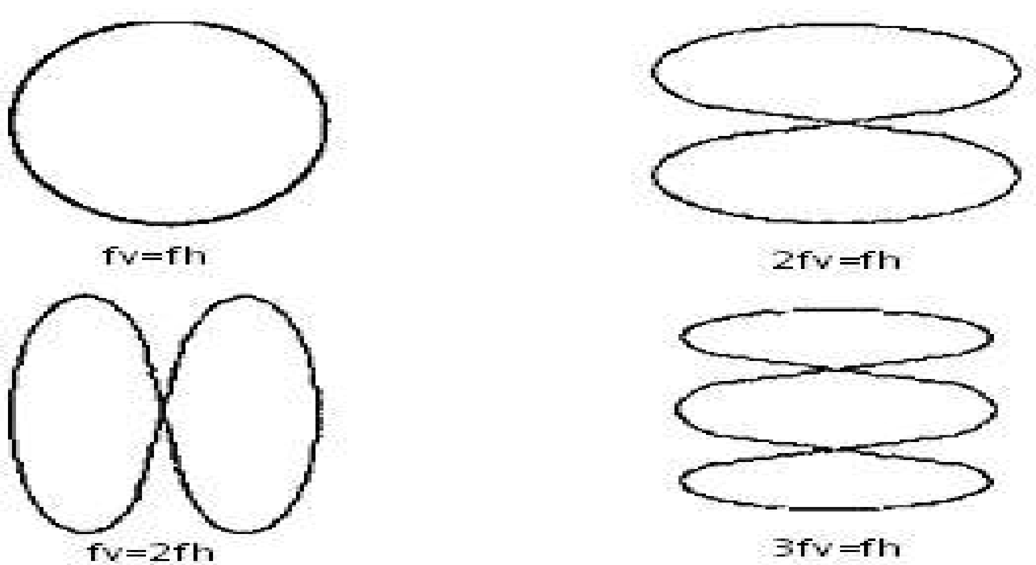
Fig. 8: Measurement of Unknown Frequency

Procedure:

1. Connect the unknown frequency to the vertical (Y) deflection plates (CH -1) and the known frequency to the horizontal (X) deflection plates (Ch-2) from two function generators as shown in the figure.
2. Press X- Y mode button on the CRO and obtain the LISSAJOUS PATTERN. The lissajous pattern is obtained when two sinusoidal signals of different frequencies are applied to the X and Y deflection plates of the CRO. If the two frequencies are equal, we get a circle or ellipse.
3. Note down Nx (Number of touching points on X- axis), Ny (Number of touching points on Y – axis), Fx (Frequency of known signal).
4. If the LISSAJOUS pattern obtained is not clear to note the readings, Vary the known frequency such that a clear lissajous pattern is obtained.
5. The unknown frequency Fy is given by Fy = (Nx * Fx) / (Ny)

Observations:

S. No.	Known frequency (f_x)	N_x	N_y	Unknown frequency $f_y = (N_x \cdot f_x)/N_y$



$$\frac{fv}{fh} = \frac{\text{No.of loops cut by horizontal line}}{\text{No.of loops cut by vertical line}}$$

D) Measurement of Phase Difference:

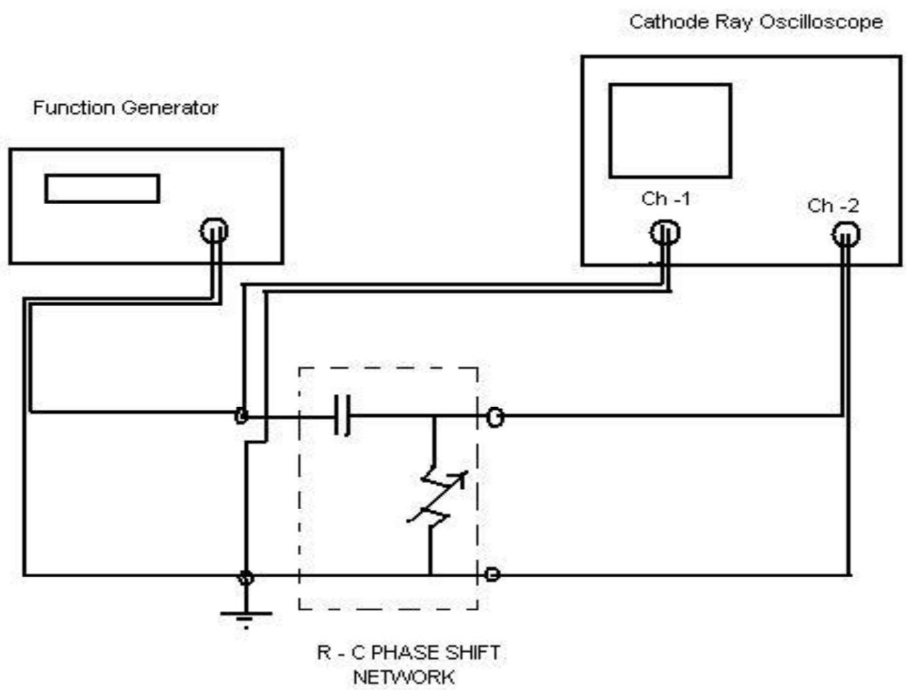


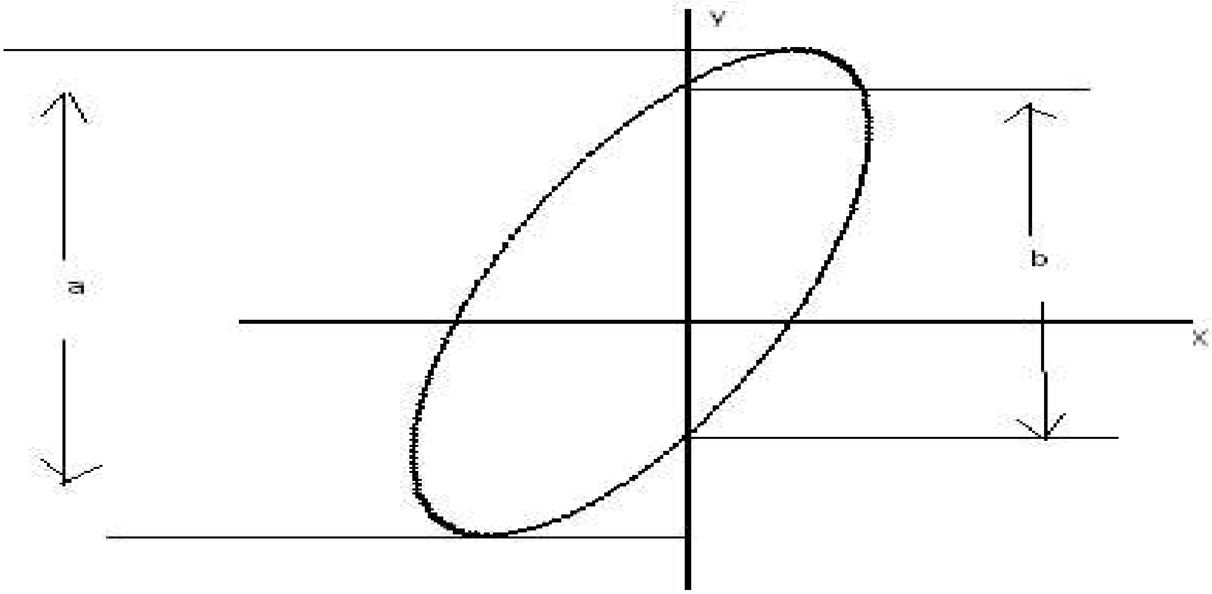
Fig. 9: Measurement of Phase Difference

Procedure:

1. Connect the RC phase shift network as shown above in the circuit diagram.
2. Obtain a sinusoidal signal of 5V (Pk- Pk) at 1 KHz from the function generator.
3. Connect the signal from the function generator to the input of the RC phase shift network and the same signal to the CH-1 of the CRO.
4. Connect the output of the Phase shift network to the CH-2 of the CRO.
5. Press X- Y mode button.
6. The pattern obtained on the screen will be an ellipse.
7. The phase difference between the two signals (θ) is given by $\theta = \sin^{-1}(B/A)$.
8. By varying the different values of the resistances from DRB, frequencies, note the values of B and A and hence find θ.

Observations:

S. No.	f	R	C	θ = $\tan^{-1}(1/wRC)$	B	A	θ = $\sin^{-1}(B/A)$



$\theta=\sin^{-1}(b/a)$

Where "θ" is the phase difference between the two signals

Results:

1. Working of CRO is studied. Amplitude and Frequency a signal is found using CRO.
2. Unknown Frequency & Phase difference are measured using CRO.

Experiment No: 2

V - I Characteristics of Si & Ge Diodes

Aim:

1. To plot V-I Characteristics of Silicon and Germanium P-N Junction Diodes.
2. To find cut-in voltage for Silicon and Germanium P-N Junction diodes.
3. To find static and dynamic resistances in both forward and reverse biased conditions.

Components:

Name	Quantity
Diodes 1N4007(Si)	1
Diodes DR-25(Ge)	1
Resistor 1KΩ	1

Equipment:

Name	Range	Quantity
Bread board		1
Regulated power supply	0-30V	1
Digital Ammeter	0-200µA/200mA	1
Digital Voltmeter	0-20V	1
Connecting Wires		

Specifications:

Silicon Diode 1N 4007:	**Germanium Diode DR 25:**
Max Forward Current = 1A	Max Forward Current = 250mA
Max Reverse Current = 5.0µA	Max Reverse Current = 200µA
Max Forward Voltage = 0.8V	Max Forward Voltage = 1V
Max Reverse Voltage = 1000V	Max Reverse Voltage = 25V
Max Power Dissipation = 30mW	Max Power Dissipation = 250mW
Temperature = -65 to 200° C	Temperature = -55 to 75° C

Theory:

Donor impurities (pentavalent) are introduced into one-side and acceptor impurities into the other side of a single crystal of an intrinsic semiconductor to form a p-n diode with a junction called depletion region (this region is depleted off the charge carriers). This region gives rise to a potential barrier called Cut-in Voltage. This is the voltage across the diode at which it starts conducting. The P-N junction can conduct beyond this potential.

The P-N junction supports uni-directional current flow. If +ve terminal of the input supply is connected to anode (P-side) and –ve terminal of the input supply is connected the cathode. Then diode is said to be **forward biased**. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage. Both the holes from p-side and electrons from n-side cross the junction simultaneously and constitute a forward current from n-side (injected minority current – due to holes crossing the junction and entering P- side of the diode). Assuming current flowing through the diode to be very large, the diode can be approximated as short- circuited switch.

If –ve terminal of the input supply is connected to anode (p-side) and +ve terminal of the input supply is connected to cathode (n-side) then the diode is said to be **reverse biased**. In this condition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction. Both the holes on P-side and electrons on N-side tend to move away from the junction there by increasing the depleted region. However the process cannot continue indefinitely, thus a small current called reverse saturation current continues to flow in the diode. This current is negligible hence the diode can be approximated as an open circuited switch.

The volt-ampere characteristics of a diode explained by the following equations

$$I = I_0 \left(e^{\frac{V_D}{\eta V_T}} - 1 \right)$$

Where I = current flowing in the diode, I_0 = reverse saturation current V_D = Voltage applied to the diode

V_T = volt- equivalent of temperature = k T/q = T/ 11,600 = 26mV (@ room temp)

η = 1(for Ge) and 2 (for Si)

It is observed that **Ge** diodes has smaller cut-in-voltage when compared to **Si** diode. The reverse saturation current in **Ge** diode is larger in magnitude when compared to silicon diode.

Theoretically the dynamic resistance of a diode is determined using the following equation:

Dynamic Resistance:

$$R_D = \frac{\eta\ V_T}{\mathrm{I}}$$

Circuit Diagrams:

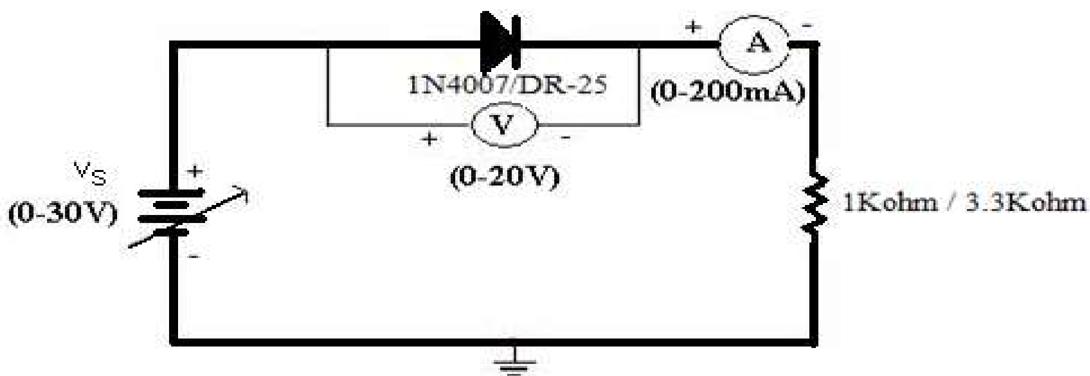


Fig. 1: Forward Bias Condition

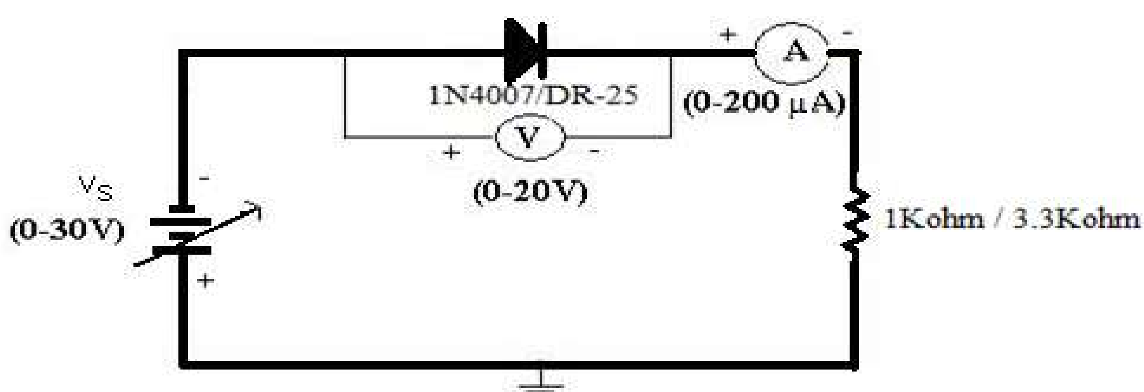


Fig. 2: Reverse Bias Condition

Procedure:

Forward Bias Condition:

1. Connect the components as shown in the Fig.1.
2. Vary the supply voltage such that the voltage across the Silicon diode varies from 0 to 0.6 V in steps of 0.1 V and in steps of 0.02 V from 0.6 to 0.76 V. In each step record the current flowing through the diode as I.
3. Repeat the above steps for Germanium diode too but with the exception that the voltage across the diode should be varied in steps of 0.01 V from 0.1 to 0.3 V in step-2.

Reverse Bias Condition:

1. Connect the diode in the reverse bias as shown in the Fig.2.
2. Vary the supply voltage such that the voltage across the diode varies from 0 to 10V in steps of 1 V. Record the current flowing through the diode in each step.
3. Repeat the above steps for Germanium diode too and record the current in each step.
4. Now plot a graph between the voltage across the diode and the current flowing through the diode in forward and reverse bias, for Silicon and Germanium diodes on separate graph sheets. This graph is called the V-I characteristics of the diodes.
5. Calculate the static and dynamic resistance of each diode in forward and reverse bias using the following formulae.

Static resistance, $R = V/I$

Dynamic resistance, $r = \Delta V/\Delta I$

Observations:

(a) Forward & Reverse bias characteristics of Silicon diode

Forward Bias Condition:

S. No.	Forward Voltage across the diode V_d (Volt)	Forward Current through the diode I_d (mA)

Reverse Bias Condition:

S. No.	Reverse Voltage across the diode V_R (Volt)	Reverse Current through the diode I_R (µA)

(b) Forward & Reverse bias characteristics of Germanium diode

Forward Bias Condition:

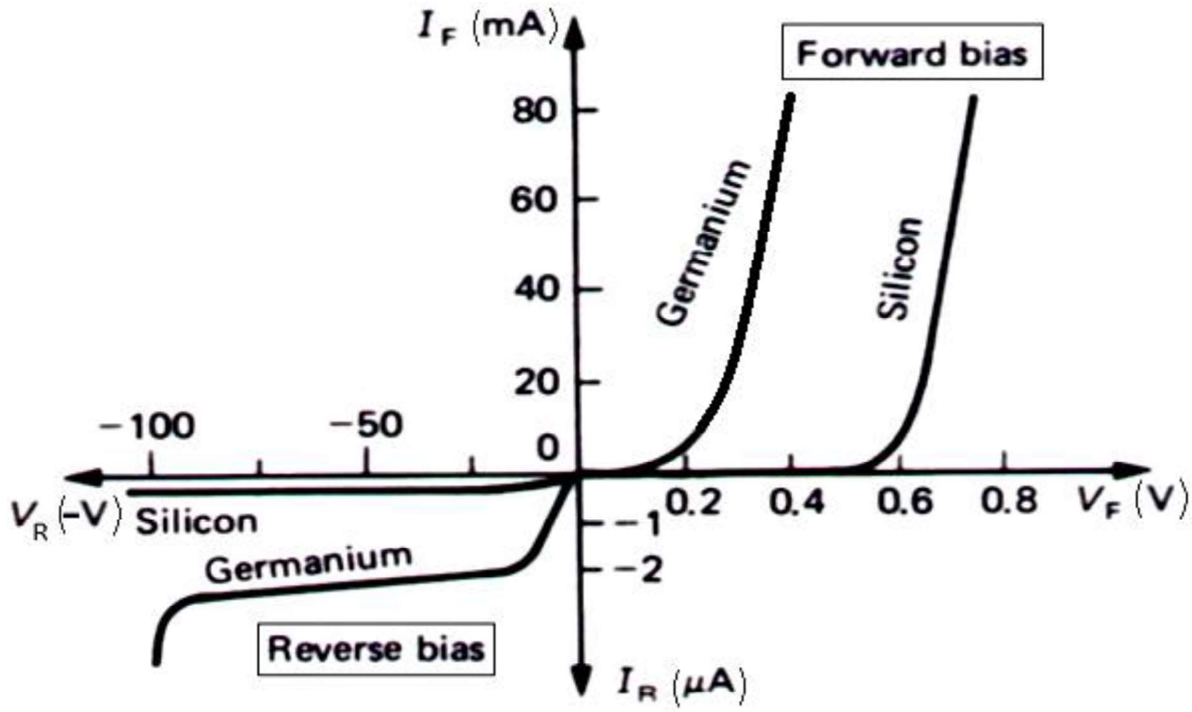
S. No.	Forward Voltage across the diode V_d (Volt)	Forward Current through the diode I_d (mA)

Reverse Bias Condition:

S. No.	Reverse Voltage across the diode V_r (Volt)	Reverse Current through the diode I_R (µA)

Graphs:

1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.
2. Now mark +ve X-axis as V_f, -ve X-axis as V_R, +ve Y-axis as I_f and –ve Y-axis as I_R.
3. Mark the readings tabulated for Si forward biased condition in first Quadrant and Si reverse biased condition in third Quadrant.
4. Repeat the same procedure for plotting the Germanium characteristics.



Calculations from Graph:

Static forward Resistance

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

Dynamic Forward Resistance

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

Static Reverse Resistance

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

Dynamic Reverse Resistance

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

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

V-I Characteristics of Silicon & Germanium P-N Junction Diodes are studied.

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 No.:3

Zener Diode Characteristics

Aim: To plot V-I Characteristics of Zener Diode.

Components:

Name	Quantity
Zener Diodes 1N4735A/ FZ 5.1	1
Resistor 1KΩ	1

Equipments:

Name	Range	Quantity
Bread board		1
Regulated power supply	0-30V	1
Digital Ammeter	200mA	1
Digital Voltmeter	0-20V	1
Connecting Wires		

Specifications:

Breakdown Voltage = 5.1V

Power dissipation = 0.75W

Max Forward Current = 1A

Theory: Zener diode is a heavily doped Silicon diode. An ideal P-N junction diode does not conduct in reverse biased condition. A Zener diode conducts excellently even in reverse biased condition. These diodes operate at a precise value of voltage called break down voltage. A Zener diode when forward biased behaves like an ordinary P-N junction diode. A Zener diode when reverse biased can undergo avalanche break down or zener break down.

Avalanche Break down:

If both p-side and n-side of the diode are lightly doped, depletion region at the junction widens. Application of a very large electric field at the junction increases the kinetic energy of the charge carriers which collides with the adjacent atoms and generates charge carriers by breaking the bond, they in-turn collides with other atoms by creating new charge carriers, this process is cumulative which results in the generation of large current resulting in **Avalanche** Breakdown.

Zener Break down:

If both p-side and n-side of the diode are heavily doped, depletion region at the junction reduces, it leads to the development of strong electric field and application of even a small voltage at the junction may rupture covalent bond and generate large number of charge carriers. Such sudden increase in the number of charge carriers results in **Zener** break down.

Circuit Diagram:

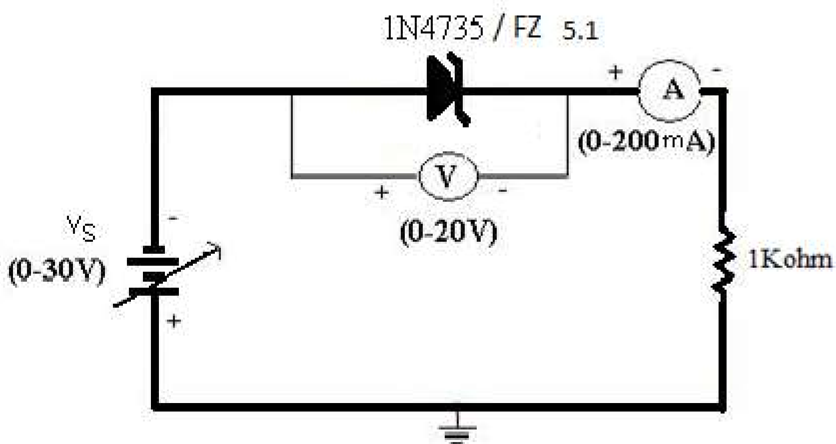


Fig. 1: Forward Bias Condition

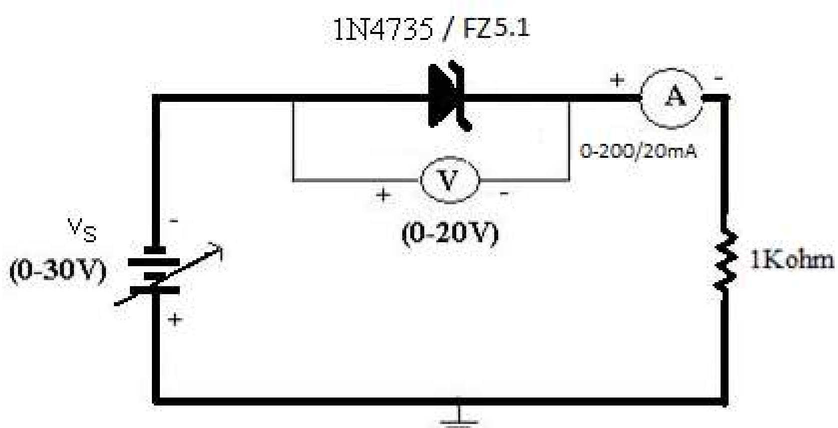


Fig. 2: Reverse Bias Condition

Procedure:

Forward Bias Condition:

1. Connect the circuit as shown in fig.1.
2. Vary V_F gradually from 0 to 0.6 V in steps of 0.1 V and in steps of 0.02 V from 0.6 to 0.76 V. In each step record the current flowing through the diode as I_F.
3. Tabulate different forward currents obtained for different forward voltages.

Reverse Bias Condition:

1. Connect the Zener diode in reverse bias as shown in the fig.2. Vary the voltage across the diode in steps of 1V from 0 V to 6 V and in steps 0.1 V till its breakdown voltage is reached. In each step note the current flowing through the diode
2. Plot a graph between V and I. This graph will be called the V-I characteristics of Zener diode. From the graph find out the breakdown voltage for the diode.

Observations:

Forward Bias Condition:

S. No.	Forward Voltage across the diode V_F (volts)	Forward Current through the diode I_F (mA)

Reverse Bias Condition:

S. No.	Reverse Voltage across the diode V_R (volts)	Reverse Current through the diode I_R (mA)

Graph:

1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.
2. Now mark +ve X-axis as V_F, -ve X-axis as V_R, +ve Y-axis as I_F and –ve Y-axis as I_R.
3. Mark the readings tabulated for forward biased condition in first Quadrant and reverse biased condition in third Quadrant.

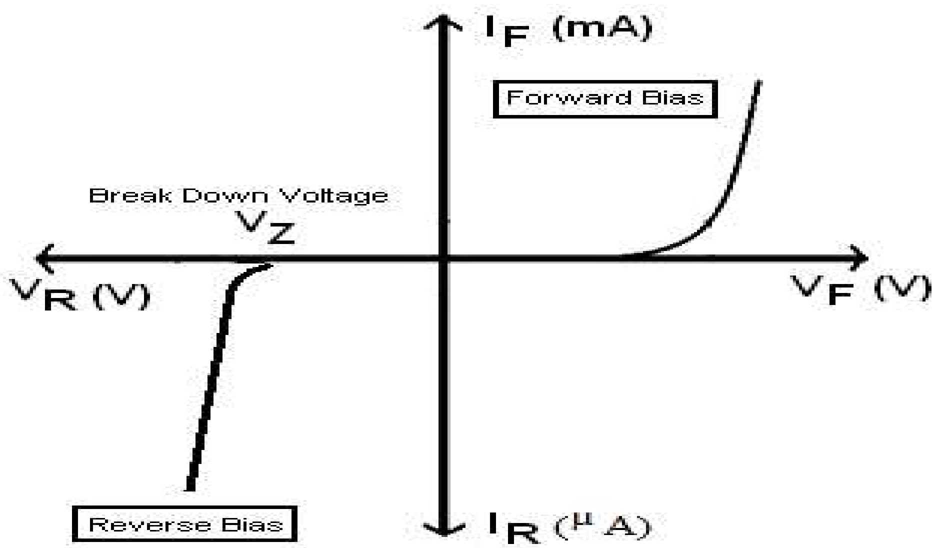


Fig. 3: V-I Characteristics of Zener Diode

Calculations from Graph:

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 No: 4

Characteristics of BJT in Common Emitter Configuration

Aim: To plot the Characteristics of a BJT in Common Emitter Configuration.

Components:

Name	Quantity
Transistor BC 107	1
Resistor 1KΩ	1

Equipment:

Name	Range	Quantity
Bread Board		1
Regulated power supply	0-30V	2
Digital Ammeter	0-200mA/0-200µA	1
Digital Voltmeter	0-20V	2
Connecting Wires		

Specifications:

For Transistor BC 107:

- Max Collector Current= 0.1A
- V_{ceo} max= 50V
- V_{EB0} = 6V
- V_{CB0} = 50V
- Collector power dissipation = 500mW
- Temperature Range = -65 to +150 ^{0}C
- h_{fe} = 110 - 220

Theory:

A BJT is called as Bipolar Junction Transistor and it is a three terminal active device which has emitter, base and collector as its terminals. It is called as a bipolar device because the flow of current through it is due to two types of carriers i.e., majority and minority carriers.

A transistor can be in any of the three configurations viz, Common base, Common emitter and Common Collector.

The relation between **α , β , γ of CB, CE, CC are**

$$\boldsymbol{\alpha = \frac{\beta}{1+\beta} \qquad \beta = \frac{\alpha}{1-\alpha} \qquad \gamma = 1 + \beta = \frac{1}{1-\alpha}}$$

In CE configuration base will be input node and collector will be the output node .Here emitter of the transistor is common to both input and output and hence the name common emitter configuration.

The collector current is given as

$$I_C = \beta\, I_B \;+\; (1+\beta) I_{CO}$$

Where I_{CO} is called as reverse saturation current

A transistor in CE configuration is used widely as an amplifier. While plotting the characteristics of a transistor the input voltage and output current are expressed as a function of input current and output voltage.

i.e, $V_{BE} = f(I_B, V_{CE})$ and

$I_C = f(I_B, V_{CE})$

Transistor characteristics are of two types.

Input characteristics:- Input characteristics are obtained between the input current and input voltage at constant output voltage. It is plotted between V_{BE} and I_B at constant V_{CE} in CE configuration

Output characteristics:- Output characteristics are obtained between the output voltage and output current at constant input current. It is plotted between V_{CE} and I_C at constant I_B in CE configuration

The different regions of operation of the BJT are

Emitter Junction	Collector Junction	Region	Application
RB	RB	CUTT OFF	OFF SWITCH
FB	FB	SATURATION	ON SWITCH
FB	RB	ACTIVE	AMPLIFIER
RB	FB	REVERSE ACTIVE	ATTENUATOR

Circuit Diagram:

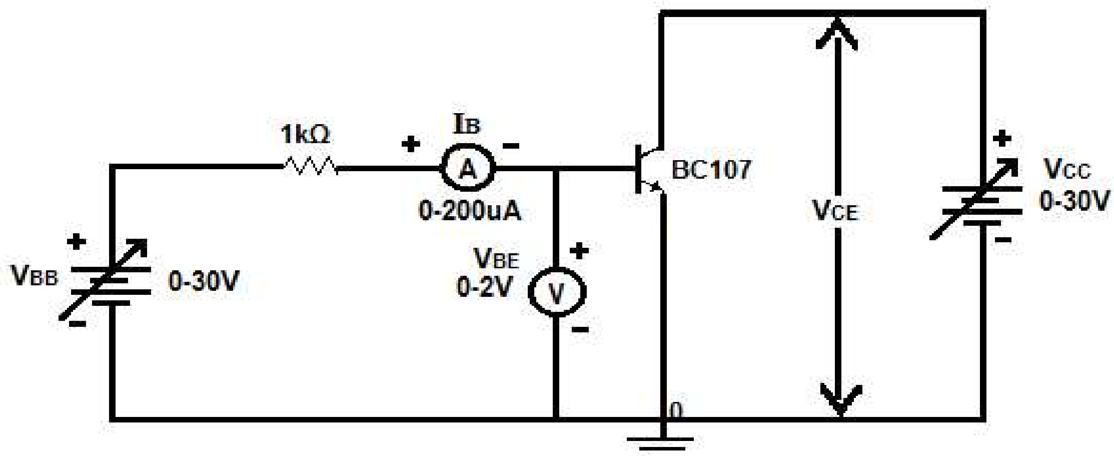


Fig. 1: Input Characteristics

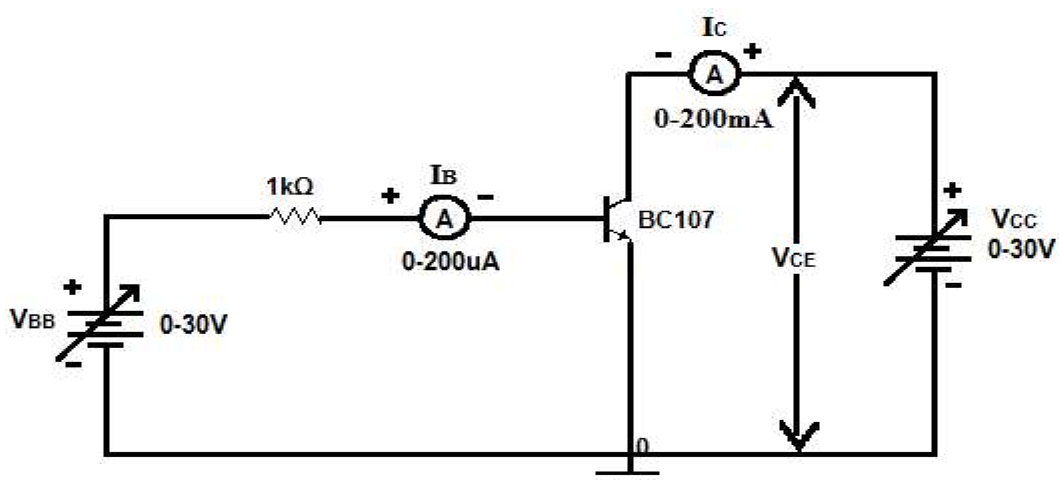
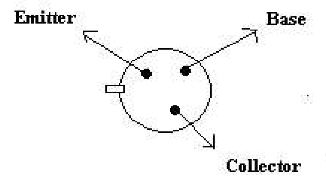


Fig. 2: Output Characteristics

Pin assignment of Transistor:



Procedure:

Input Characteristics:

1) Connect the circuit as shown in fig.(1). Adjust all the knobs of the power supply to their minimum positions before switching the supply on.
2) Adjust the V_{CE} to 0 V by adjusting the supply $V_{CC.}$
3) Vary the supply voltage V_{BB} so that V_{BE} varies in steps of 0.1 V from 0 to 0.5 V and then in steps of 0.02 V from 0.5 to 0.7 V. In each step note the value of base current I_B.
4) Adjust V_{CE} to 1, 2V and repeat step-3 for each value of $V_{CE.}$
5) Plot a graph between V_{BE} and I_B for different values of V_{CE}. These curves are called input characteristic

Output Characteristics:

1) Connect the circuit as shown in fig. (2). All the knobs of the power supply must be at the minimum position before the supply is switched on.
2) Adjust the base current I_B to 20 μA by adjusting the supply V_{BB}.
3) Vary the supply voltage V_{CC} so that the voltage V_{CE} varies in steps of 0.2 V from 0 to 2 V and then in steps of 1 V from 2 to 10 V. In each step the base current should be adjusted to the present value and the collector current I_C should be recorded.
4) Adjust the base current at 40, 60 μA and repeat step-3 for each value of I_B.
5) Plot a graph between the output voltage V_{CE} and output current I_C for different values of the input current I_B. These curves are called the output characteristics.

Observations:

Input Characteristics

V_{CE} = 0V		V_{CE} = 2V	
V_{BE}(V)	I_B(µA)	V_{BE}(V)	I_B(µA)

Output Characteristics

I_B = 20µA		I_B = 40µA		I_B = 60µA	
V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)

Graph:

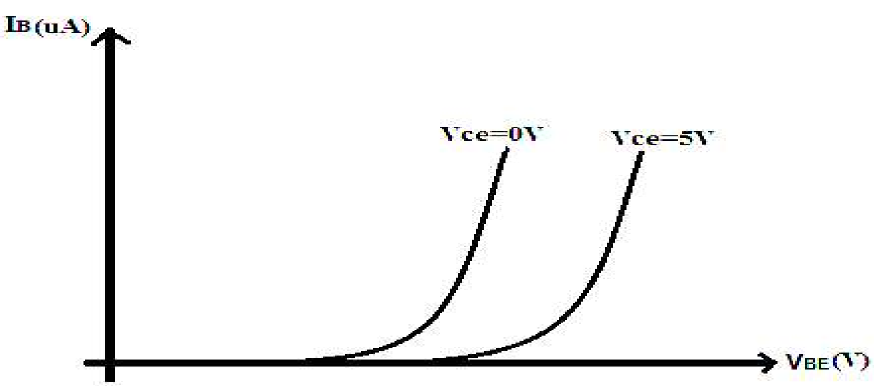


Fig. 3: Input Characteristics

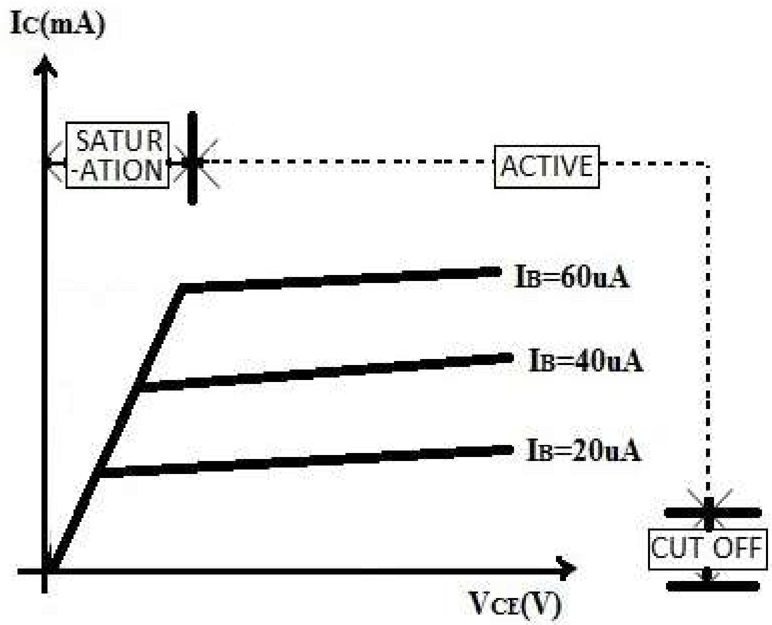


Fig. 4: Output Characteristics

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.

Results:

Input and output Characteristics of a BJT in Common Emitter Configuration are studied.

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 No: 5

Characteristics of JFET in Common source Configuration

Aim:

1. To study Drain Characteristics and Transfer Characteristics of a Junction Field Effect Transistor (JFET).
2. To measure drain resistance, trans-conductance and amplification factor.

Components:

Name	Quantity
JFET BFW 11	1
Resistor 1MΩ	1

Equipment:

Name	Range	Quantity
Bread Board		1
Regulated power supply	0-30V	1
Digital Ammeter	0-200mA	1
Digital Voltmeter	0-20V	2
Connecting Wires		

Specifications:

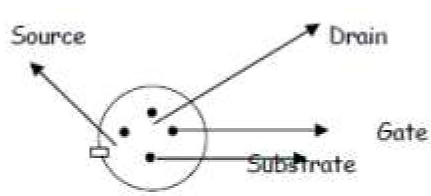
For FET BFW11:

Gate Source Voltage V_{GS} = -30V

Forward Gain Current I_{GF} = 10mA

Maximum Power Dissipation P_D = 300mW

Pin assignment of FET:



Circuit Diagram:

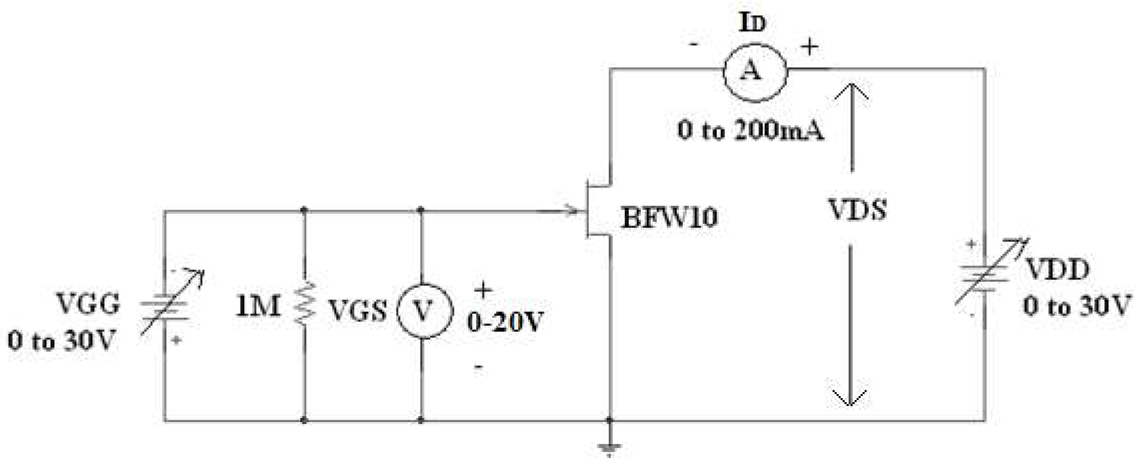


Fig. 1: Characteristics of FET

Theory:

A JFET is called as Junction Field effect transistor. It is a unipolar device because the flow of current through it is due to one type of carriers i.e., majority carriers where as a BJT is a Bi - Polar device, It has 3 terminals Gate, Source and Drain. A JFET can be used in any of the three configurations viz, Common Source, Common Gate and Common Drain. The input gate to source junction should always be operated in reverse bias, hence input resistance $R_i = \infty$, $I_G \approx 0$.

Pinch off voltage V_P is defined as the gate to source reverse bias voltage at which the output drain current becomes zero.

In CS configuration Gate is used as input node and Drain as the output node. A JFET in CS configuration is used widely as an amplifier. A JFET amplifier is preferred over a BJT amplifier when the demand is for smaller gain, high input resistance and low output resistance. Any FET operation is governed by the following equation.

The drain current equation and trans-conductance is given as

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2 , \qquad g_m = \frac{\partial I_D}{\partial V_{GS}} = \frac{2}{|v_p|}\sqrt{I_D\, I_{DSS}}$$

Where I_{DSS} is called as Drain to Source Saturation current & V_p is called as the Pinch off voltage

Procedure:

Transfer Characteristics:

1) Connect the circuit as shown. All the knobs of the power supply must be at the minimum position before the supply is switched on.
2) Adjust the output voltage V_{DS} to 4V by adjusting the supply V_{DD}.
3) Vary the supply voltage V_{GG} so that the voltage V_{GS} varies in steps of -0.25 V from 0 V onwards. In each step note the drain current I_D. This should be continued till I_D becomes zero.
4) Repeat above step for V_{DS} = 8 V.
5) Plot a graph between the input voltage V_{GS} and output current I_D for output voltage V_{DS} in the second quadrant. This curve is called the transfer characteristics.

Drain Characteristics:

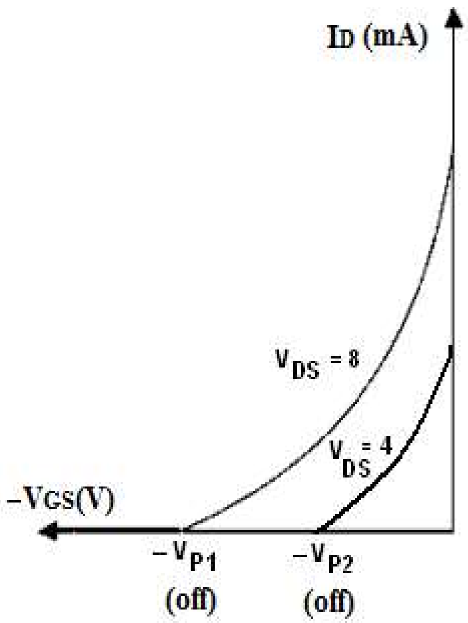
1) Connect the circuit as shown in figure. Adjust all the knobs of the power supply to their minimum positions before switching the supply on.
2) Adjust the input voltage V_{GS} to 0 V by adjusting the supply $V_{GG.}$
3) Vary the supply voltage V_{DD} so that V_{DS} varies in steps of 0.5 V from 0 to 4 V and then in steps of 1 V from 4 to 10 V. In each step note the value of drain current I_D.
4) Adjust V_{GS} to -1 and -2 V and repeat step-3 for each value of $V_{GS.}$
5) Plot a graph between V_{DS} and I_D for different values of V_{GS}. These curves are called drain characteristics.
6) Mark the various regions in the drain characteristics graph and calculate the drain resistance.

Observations:

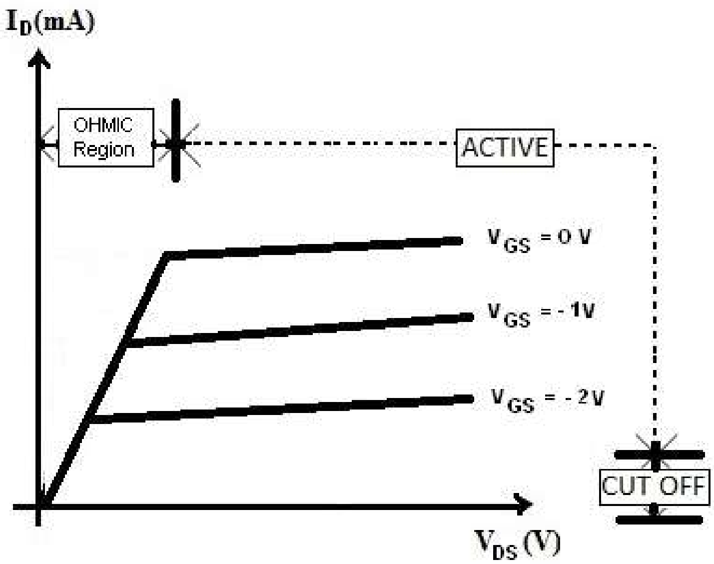
Transfer Characteristics			
V_{DS} = 4V		V_{DS} = 6V	
V_{GS}(V)	I_D(mA)	V_{GS}(V)	I_D(mA)

Drain Characteristics					
V_{GS} = 0V		V_{GS} = -1V		V_{GS} = -2V	
V_{DS}(V)	I_D(mA)	V_{DS}(V)	I_D(mA)	V_{DS}(V)	I_D(mA)

Graph:



Transfer Characteristics



Drain Characteristics

1. Plot the drain characteristics by taking V_{DS} on X-axis and I_D on Y-axis at a constant V_{GS}.
2. Plot the transfer characteristics by taking V_{GS} on X-axis and taking I_D on Y-axis at constant V_{DS}.

Calculations from Graph:

1. **Drain Resistance (r_d):** It is given by the relation of small change in drain to source voltage (ΔV_{DS}) to the corresponding change in Drain Current (ΔI_D) for a constant gate to source voltage (ΔV_{GS}), when the JFET is operating in pinch-off region.
2. **Trans Conductance (gm):** Ratio of small change in drain current (ΔI_D) to the corresponding change in gate to source voltage (ΔV_{GS}) for a constant V_{DS}.

gm $= \dfrac{\Delta I_D}{\Delta V_{GS}}$ at constant V_{DS} (from transfer characteristics).

The value of **gm** is expressed in mho's ($\mho$) or Siemens (**s**).

3. **Amplification factor (μ):** It is given by the ratio of small change in drain to source voltage (ΔV_{DS}) to the corresponding change in gate to source voltage (ΔV_{GS}) for a constant drain current (I_D).

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.

Results:

1. Drain Characteristics and Transfer Characteristics of a Field Effect (FET) Transistor are studied.
2. Drain resistance, trans-conductance and amplification factor are measured.

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 direct-current (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: $\mu = g_m * r_d$