Laboratory Manual

Electronics Engineering

B.Sc. Mechanical Engineering

Submitted by

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Submitted to

Engr. Huma Iqbal

Department Of Mechanical Engineering

College of Engineering & Technology

University of Sargodha

Lab Contents

Lab Session 01
Introduction to Laboratory Equipments

Objective:

In this lab students will learn the basics of operating a digital multimeter, function generator and an oscilloscope that are used extensively in circuits and electronics.

Equipments required:

- Digital Multimeter
- Function Generator
- Digital Storage Oscilloscope
- Bread Board

Theory:
The Function Generator (SG2120):

Function generators generate various waves, with the most useful of them (for our purposes) being sine waves. Function generators allow you to set the amplitude, frequency and shape (sine, triangular, square) of the wave. Sometimes they allow you to set the dc offset, which is simply a dc voltage added to the oscillating signal. The front panel of the function generator is shown in figure below.
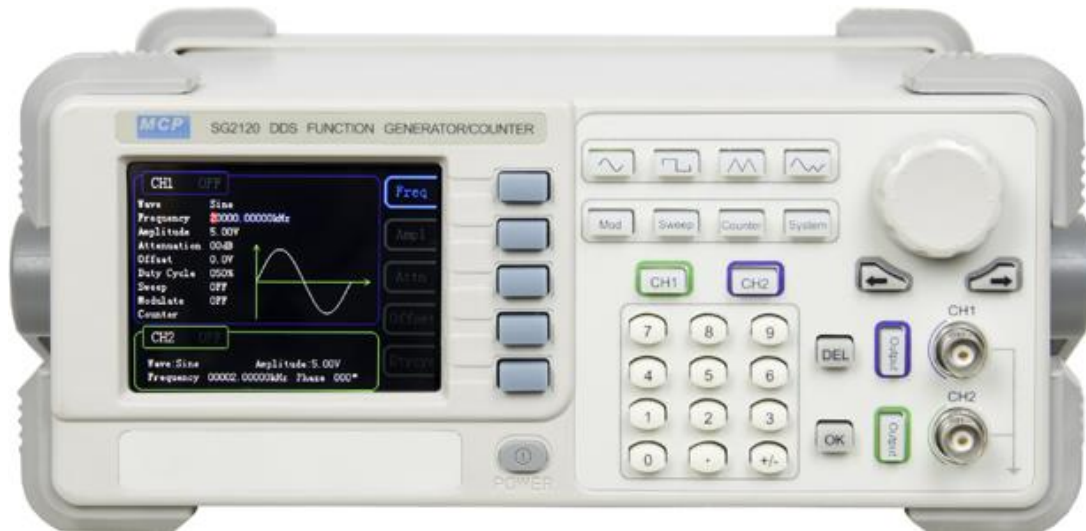

Fig 1.1 Function Generator

The main characteristics of the function generator are:

- Shape: sine, square, or triangle waves.
- Frequency: inverse of the period of the signal; units are cycles per second (Hz)
- V_{pp}: peak to peak Voltage value of the signal
- DC Offset: constant voltage added to the signal to increase or decrease its mean or average level. In a schematic, this would be a DC voltage source in series with the oscillating voltage source.

Specifications:

Output Frequency 10 mHz ~ 20MHz
Output amplitude   10 mV$_{p-p}$ ~ 20 V$_{p-p}$
The Oscilloscope (UTD2052CL)

Oscilloscopes are very useful instruments that are used to measure and display a variety of signals. In this lab students will use the oscilloscope to measure voltage, time and frequency. Oscilloscopes vary widely depending on the manufacturer and the model but the basic operation remains the same. Most oscilloscopes will have 2 or 4 channels normally labeled either 1, 2,… or A,B,. . . . Using these channels you can input more than one signal for comparison and analysis. The front panel of the oscilloscope is shown in figure below.
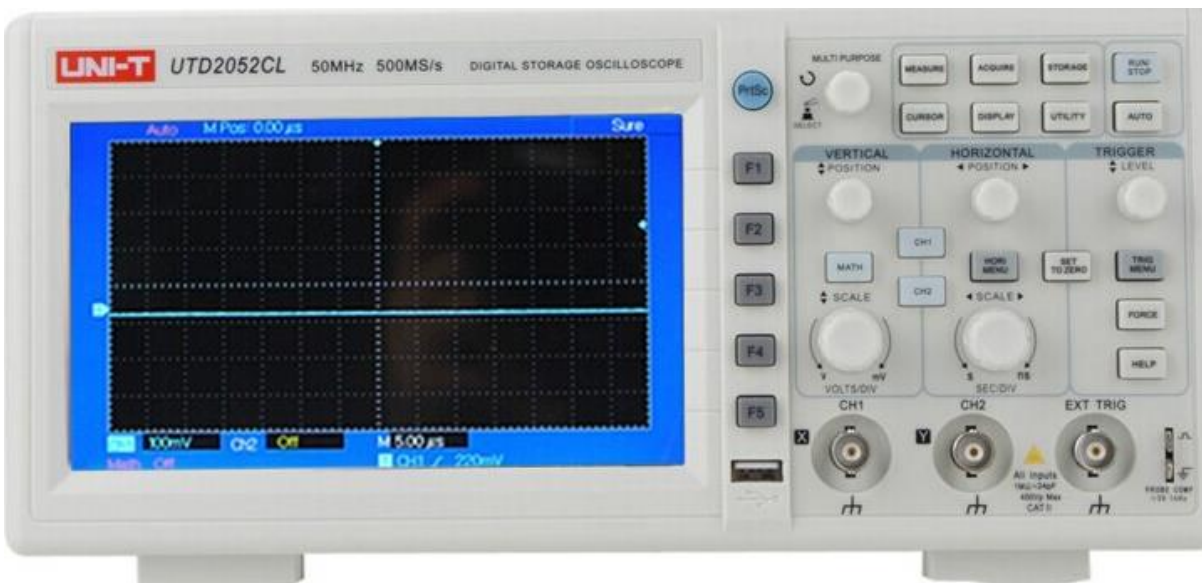

Fig 1.2 Oscilloscope

In general an oscilloscope has the following controls:

- Position: positions knobs (Vertical or Horizontal) shift the trace around the screen.
- Vertical sensitivity or V/div or V/cm: the gain that must be applied to the input to control the amount of signal displayed per division (Figure 2(c)).
- Sweep time or time/div: controls the time it takes to sweep the screen and show the signal. The higher the number is the more compact the signal will look.
- Source or Trigger Source: selects the source to trigger the sweep. Common sources are (a) internal - the input signal controls the triggering and you can choose which channel to use; (b) line - selects the 60Hz line voltage as the trigger signal; (c) Ext - an external signal is used to trigger. At this time you will always be using the internal trigger.

In addition to these controls you will have menus that allow you to measure different values of the signal such as peak or peak-to-peak voltages, phase, frequency, etc. You also have two vertical and two horizontal cursor lines that you can move. If you are using the vertical lines, the oscilloscope will display

the time difference between them. On the other hand, if you are using the horizontal lines, the oscilloscope will display the voltage difference between them.

The Digital Multimeter:

A Multimeter is an electronic device that is used to make various electrical measurements, such as AC and DC voltage, AC and DC current, and resistance. It is called a Multimeter because it combines the functions of a voltmeter, ammeter, and ohmmeter. Multimeter may also have other functions, such as diode test, continuity test, transistor test, TTL logic test and frequency test.

 Parts of Multimeter

- Display: The display usually has four digits and the ability to display a negative sign. A few multimeters have illuminated displays for better viewing in low light situations.
- Selection Knob: The selection knob allows the user to set the multimeter to read different things such as milliamps (mA) of current, voltage (V) and resistance (Ω).
- Ports: Two probes are plugged into two of the ports on the front of the unit. COM stands for common and is almost always connected to Ground or '-' of a circuit. The COM probe is conventionally black but there is no difference between the red probe and black probe other than color. 10A is the special port used when measuring large currents (greater than 200mA). mAVΩ is the port that the red probe is conventionally plugged in to. This port allows the measurement of current (up to 200mA), voltage (V), and resistance (Ω). The probes have a banana type connector on the end that plugs into the multimeter. Any probe with a banana plug will work with this meter.

Fig 1.3 Digital Multimeter

Input Jacks:

The black lead is always plugged into the common terminal. The red lead is plugged into the 10 A jack when measuring currents greater than 300 mA, the 300 mA jack when measuring currents less than 300 mA, and the remaining jack (V-ohms-diode) for all other measurements.

Fig 1.4 Input Jacks

Procedure for Measurement

Voltage Measurement

D.C. / A.C. Voltage Measurement

- Connect the positive (red) test lead to the 'V/mA' jack socket and the negative (black) lead to the 'COM' jack socket.
- Set the selector switch to the desired mV D.C./D.C.V/A.C.V range.
- Connect the test leads to the circuit to be measured.
- Turn on the power to the circuit to be measured; the voltage value should appear on the digital display along with the voltage polarity (if reversed only).

Fig 1.5 Voltage Measurement

Current Measurement

- Connect the positive(red) test lead to the 'V/mA' jack socket and the negative(black) lead to the 'COM' jack socket(for measurements up to 200mA). For measurements between 200mA and 10A connect the red test lead to the '10mA' socket.
- Set the selector switch to the desired uA/mA/A range.
- Open the circuit to be measured and connect the test leads in SERIES with the load in which current is to be measured.

- To avoid blowing an input fuse, use the 10A jack until you are sure that the current is less than 300 mA. Turn off power to the circuit. Break the circuit. (For circuits of more than 10 amps, use a current clamp.) Put the meter in series with the circuit and turn power on.

Resistance Measurement

- Connect the positive(red) test lead to the 'V/mA' jack socket and the negative(black) lead to the 'COM' jack socket.
- Set the selector switch to the desired 'OHM Ω'.
- If the resistance to be measured is part of a circuit, turn off the power and discharge all capacitors before measurement.
- Connect the test leads to the circuit to be measured.
- The resistance value should now appear on the digital display.
- If the resistance to be measured is part of a circuit, turn off the power and discharge all capacitors before measurement.

Continuity Test

This mode is used to check if two points are electrically connected. It is often used to verify connectors. If continuity exists (resistance less than 210 ohms), the beeper sounds continuously.

- Connect the positive (red) test lead to the 'V/mA' jack socket and the negative (black) lead to the 'COM' jack socket.
- Set the selector switch to the position.
- Connect the test leads to two points of the circuit to be tested. If the resistance is in Ohms, the buzzer will sound.
- If the resistance to be measured is part of a circuit, turn off the power and discharge all capacitors before measurement.

Diode Test

- Connect the positive (red) test lead to the 'V/mA' jack socket and the negative(black) lead to the 'COM' jack socket
- Set the selector switch to the position.
- Connect the test leads to be measured.
- Turn on the power to the circuit to be measured and the voltage value should appear on the digital display.

Bread Board:

Bread Board is an array of horizontal and vertical wires inside the body of the bread board, and upper side of it is perforated to insert wires in it. Bread board is used for checking circuit before printing it on PCB. It can also be used for making temporary circuit.
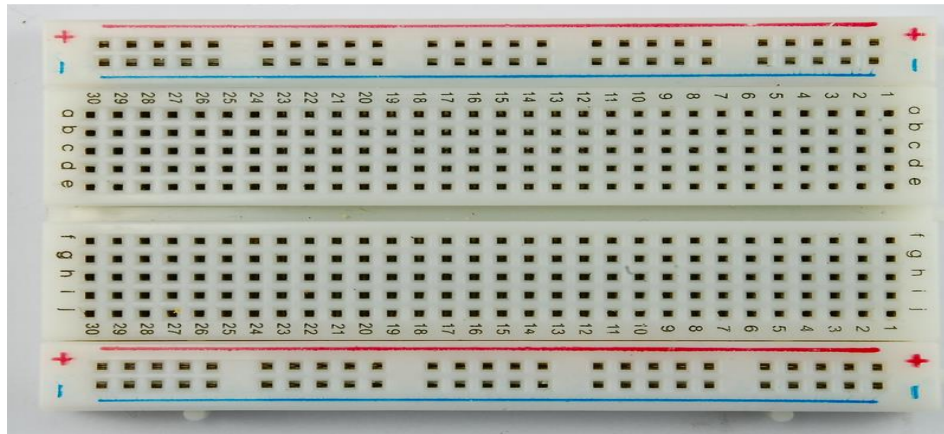
Fig 1.6 Breadboard

Lab work:

Procedure:

1.Connect function generator output at the input of CRO at channel 1 or at channel 2.

2.Select proper channel i.e. if signal is connected to channel 1 select CH1 and if signal is connected to channel 2 select CH2.

3.Adjust Time/Div knob to get sufficient time period displacement of the wave on the CRO screen. With fine tuning of time/div make the waveform steady on screen.

4.Use triggering controls if waveform is not stable.

5.Keep volt/div knob such that waveform is visible on the screen without clipping.

6.Measure P-P reading along y-axis. This reading multiplied with volt/div gives peak to peak amplitude of the AC input wave.

7.Measure horizontal division of one complete cycle. This division multiplied by Time/Div gives time period of the input wave.

8.Calculate frequency using formula f = 1/T.

Note down your readings in the observation table

Observations:

Task 1:

Calculation of frequency on waveform basis:							
Function	Vertical Division	Vertical Sensitivity	Amplitude	Horizontal Division	Horizontal Sensitivity	Time Period	$f = \frac{1}{T}$
	(a)	V/div (b)	V$_{P-P}$ (axb)	(c)	Time/div (d)	sec (cxd)	Hz
Sine							
Square							
Triangular							

Table 1.1

Task-2:

Draw waveforms using Function Generator & Oscilloscope, and plot it on graph paper.

Sine Wave:

$V_{in} = 3\,V\,(p-p), \quad f = 0.5\,kHz$

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Square Wave:

$$V_{in} = 4\,V\,(p-p), \quad f = 2.5\,kHz$$

Triangular Wave:

$$V_{in} = 5\,V\,(p-p), \quad f = 2.75\,kHz$$

Precautions:

For Digital multimeter

- ➢ Voltage should always be measured in *parallel*.
- ➢ Current should always be measured in *series*.
- ➢ Switch off circuit supply before measuring resistance of a resistor connected in circuit, and take out the resistor from circuit.

For Breadboard

- ➢ Before implementing circuit on it determine its continuity.

For Function generator do not exceed the values provided in the specifications.

Remember to calibrate Oscilloscope probe.

Conclusions & Comments:

Lab Session 02

Characteristics of P-N Junction diode

Objectives:

Observe and plot Forward and Reverse V-I Characteristics of a P-N Junction diode.

Equipments and Components Required:

- Digital Multimeter

- DC Power supply

- Resistor (1kΩ)

- Diode

Theory:
Diodes are semiconductor devices which have conductivity between conductors and insulators. By the process of doping, P type and N type semiconductors are formed. By doping with pentavalent and trivalent element, P-N junction diode is form.

Application of voltage across a diode, transistor etc is called Biasing. A diode can be in three states. It can be in an unbiased, forward biased or reverse biased condition. In forward biased condition, positive terminal of diode is connected to positive terminal of battery while in reverse biased condition, they are connected in reverse polarities.

Procedure:
Forward Biased:
1.First of all check diode terminals with Digital Multimeter.
2.Connect power supply with the diode as shown in the Fig 2.1.
3.Increase voltage from the power supply from 0.1V to 1V in given steps as shown in the table 2.1 and measure voltage across diode and current through diode. Note down readings in the table.
4.Plot VI characteristics for forward bias.

Reverse Biased:
1.Reverse diode position for reverse bias as shown in Fig 2.1.
2.Increase voltage from the power supply from 20V to 200V in given steps as shown in the table 2.2 and measure voltage across diode and current through diode. Note down readings in the table.
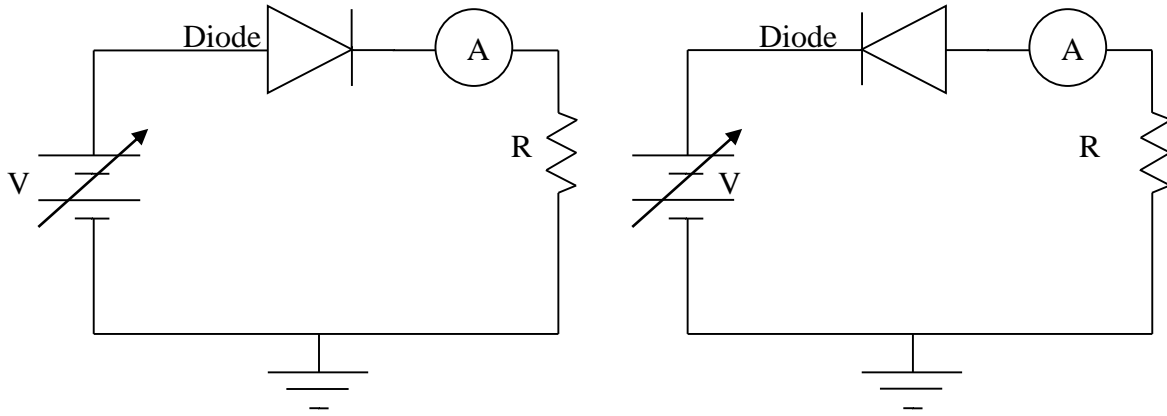3.Plot VI characteristics for reverse bias.
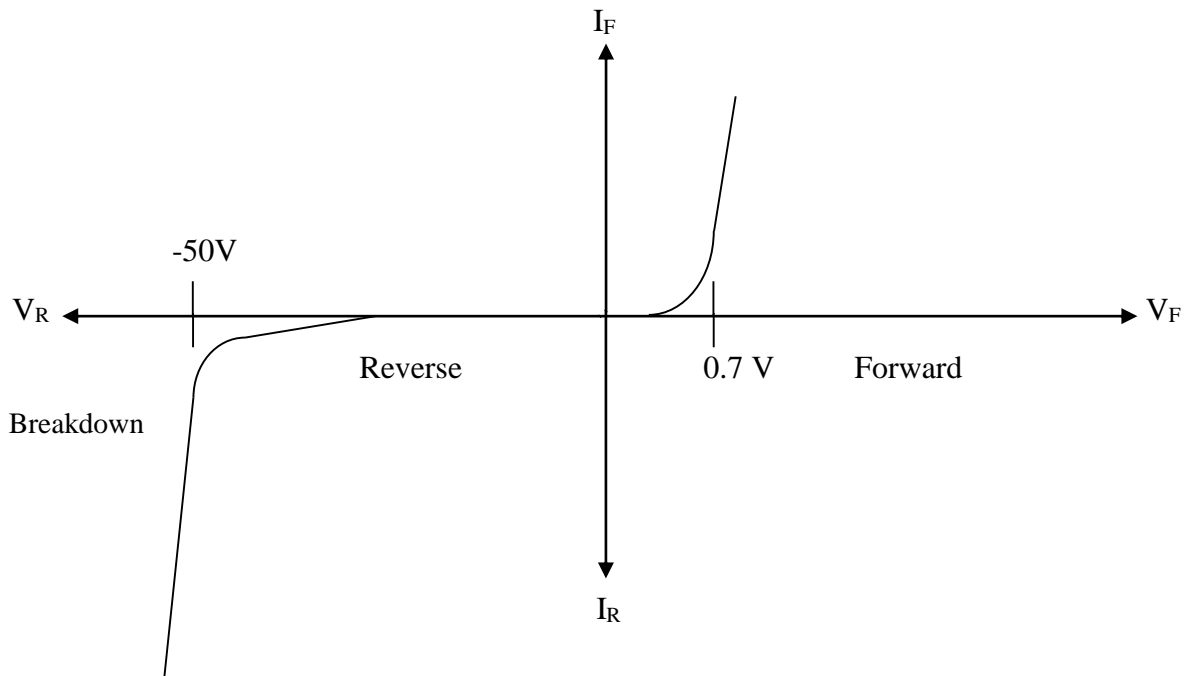
Fig 2.1 Forward Biased diode and Reverse Biased diode

Fig 2.2 Forward and Reverse V-I Characteristics of diode

Observations:
Task-1:
Forward Biased Results:

V_S (V)	V_F (V)	V_{Res} (V)	I_F (A)
0.1			
0.2			
0.3			
0.4			
0.5			
0.6			
0.7			
0.8			
0.9			
1.0			

Table 2.1 Forward Biased diode

Task-2:
Reverse Biased Results:

V_S (V)	V_R (V)	V_{Res} (V)	I_R (A)
20			
40			
60			
80			
100			
120			
140			
160			
180			
200			

Table 2.2 Reverse Biased diode

Graph:

Forward VI-Characteristics:

Reverse VI-Characteristics:

Precautions:

- While diassembling circuit first remove source of power
- Check continuity of wires
- Test diode before making circuit
- Check continuity of breadboard
- Check continuity of DMM
- Connection should be proper and tight
- DC Supply should be increase slowly in steps
- Always connect voltmeter in parallel and ammeter in series

Conclusion and Comments:

Lab Session 03

Half Wave Rectifier With and Without Filters

Objectives:

Implement half-wave rectifier circuit and investigate filtering effects on rectifier circuit outputs to find ripple factor.

Equipments and Components Required:

- Oscilloscope
- Function Generator
- Digital Multimeter
- Breadboard
- Diode
- Resistor (1kΩ)
- Capacitors
- Connecting wires

Theory:
The primary objective of rectification is to establish a DC level from a sinusoidal input signal that has zero average (DC) level. Most of the electronic equipment requires DC voltage for their operation. Yet our electrical distribution system is an AC system. Therefore it must be changed to DC before the electronic equipment can be operated. The diode, because of its one-way conduction characteristic, is the basic element for rectification process.

Single Phase Half-Wave Rectification:
A half wave rectifier is a special case of a clipper. In half wave rectification, either the positive or negative half of the AC wave is passed easily, while the other half is blocked, depending on the polarity of the rectifier. Because only one half of the input waveform reaches the output, it is very inefficient if used for power transfer. Half-wave rectification can be achieved with a single diode in a single phase supply.

Average Value of Half Wave-Rectified Output:
The average value of half -wave rectified output is:

$$V_{av(out-HWR)} = V_{DC} = \frac{1}{2\pi} \int_0^{2\pi} V_P \sin\theta d\theta = \frac{V_P}{\pi} = 0.318V_P = 31.8\% \text{ of } V_P.$$

Capacitor Input Filter:
The output from the rectifier circuit is a pulsating DC. This pulsating DC cannot be utilized in most electronic circuits because of the fluctuation of the output voltage. To make this output voltage useable; it must be smoothed out to a steady DC output with very little fluctuation. To perform this, a filter circuit is utilized. The filter circuit is placed between the rectifier and the output load; it uses capacitors, resistors and inductors to smooth or decrease the ripple voltage.

Ripple Factor:

The ripple factor (r) is an indication of the effectiveness of the filter and is defined as:

$$r = \frac{V_{P-P(\text{triangular ripple})}}{V_{av(out-HWR)} = V_{DC}}$$

Where

$V_{P-P(\text{triangular ripple})}$: is the peak-to-peak output ripple voltage. The ripple factor can be lowered by increasing the value of the filter capacitor or increasing the load resistance.

Procedure:

1. Connect the circuit on breadboard as shown in Fig 3.1. Adjust the function generator as required.
2. Use the dual mode operation of the oscilloscope to display both waveforms simultaneously. Measure the frequencies of input signal (CH1) and output signal (CH2). Note these frequencies:

$$f_{input} = f_i = \cdots\cdots \qquad\qquad f_{output} = f_o = \cdots\cdots$$

3. Plot both waveforms on the graph.
4. Measure the peak voltage of the output "V_P" for Fig 3.1 as shown by CH2 of Oscilloscope. Now calculate the following value:

$$V_{av(out-HWR)} = V_{DC} = \frac{V_P}{\pi} = \cdots\cdots\cdots$$

5. Now use DMM to measure $V_{av(out-HWR)} = V_{DC}$.

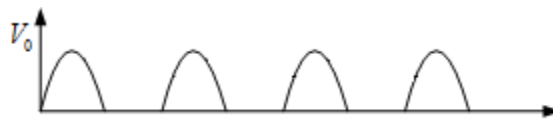$$V_{DC} = \cdots\cdots$$
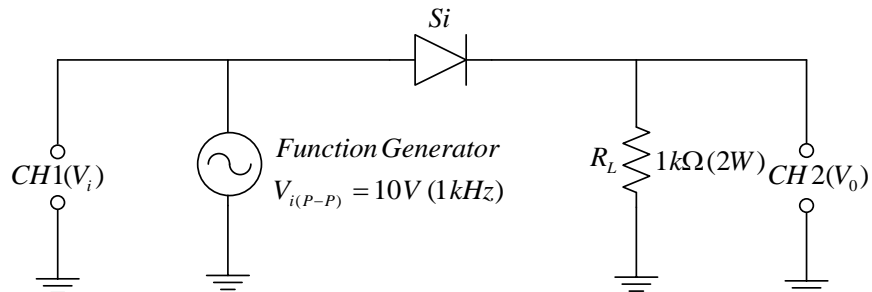
Fig 3.1 Half wave rectifier

Fig 3.2 Output of half wave rectifier

6. Now connect the circuit as shown in Fig 3.3.

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7.Different values of capacitor C are mentioned in Table 3.1.
8.After connecting certain value of capacitor C in the practical circuit of Figure 3.3, now measure the average voltage of output signal
9.Measure DC value by CRO use Coupling difference.
9.Now measure the peak to peak value of the triangular ripple of output signal.
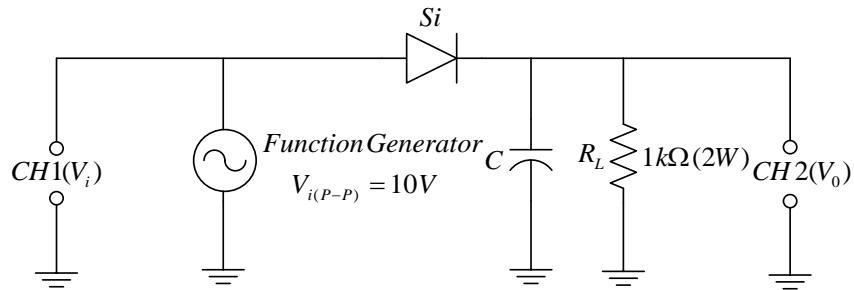10.Finally calculate the ripple factor and note the values in Table 3.1.
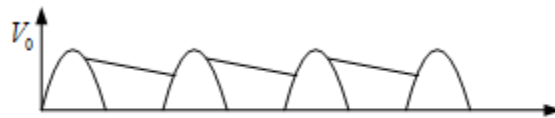

Fig 3.3 Half wave rectifier with capacitor filter

Fig 3.4 Output waveform of half wave rectifier with capacitor filter

Observations:
Half wave Rectifier with Capacitors:
Task:

f (Hz)	Capacitors	$V_{av(out-HWR)}$ (V)		$V_{P-P(triangular\ ripple)}$ (V)	Ripple Factor $r = \dfrac{V_{P-P(triangular\ ripple)}}{V_{av(out-HWR)} = V_{DC}}$
		Value by CRO	Value by DMM		
50	$10\mu F$				
	$100\mu F$				
	$470\mu F$				
	$1000\mu F$				

Table 3.1 Half wave Rectifier with Capacitors

Precautions:

- While diassembling circuit first remove source of power
- Check continuity of wires
- Test Diode before making circuit
- Check continuity of breadboard
- Check continuity of DMM
- Connection should be proper and tight

Conclusions & Comments:

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Lab Session 04

Full-Wave Rectifier With and Without Filters

Objectives:

Implement full-wave rectifier circuit and investigate filtering effects on rectifier circuit outputs to find Ripple factor.

Equipments and Components Required:

- Oscilloscope
- Function Generator
- Digital Multimeter
- Breadboard
- Diode
- Resistor (1kΩ)
- Capacitors
- Connecting wires

Theory:
The primary objective of rectification is to establish a DC level from a sinusoidal input signal that has zero average (DC) level. Most of the electronic equipment requires DC voltage for their operation. Yet our electrical distribution system is an AC system. Therefore it must be changed to DC before the electronic equipment can be operated. The diode, because of its one-way conduction characteristic, is the basic element for rectification process.

Single Phase Full-Wave Rectification:
Full-wave rectification converts both polarities of the input waveform to DC(direct current), and is more efficient. A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output by reversing the negative (or positive) portions of the alternating current waveform. The positive (or negative) portions thus combine with the reversed negative (or positive) portions to produce an entirely positive (or negative) voltage waveform.

Average Value of Full Wave-Rectified Output:
The average value of full -wave rectified output is:

$$V_{av(out-FWR)} = V_{DC} = \frac{1}{\pi} \int_0^\pi V_P \sin\theta d\theta = \frac{2V_P}{\pi} = 0.667V_P = 66.7 \% \text{ of } V_P$$

Ripple Factor:

The ripple factor (r) is an indication of the effectiveness of the filter and is defined as:

$$r = \frac{V_{P-P(triangular\ ripple)}}{V_{av(out-FWR)} = V_{DC}}$$

Where $V_{P-P(triangular\ ripple)}$: is the peak-to-peak output ripple voltage. The ripple factor can be lowered by increasing the value of the filter capacitor or increasing the load resistance.

Procedure:

1.Connect the circuit as shown in Fig 4.1. Adjust function generator as required before connecting it to the circuit.

2.Measure the frequencies of the input and output signals. Note these frequencies:

$$f_{input} = f_i = \cdots\cdots \qquad\qquad\qquad f_{output} = f_o = \cdots\cdots$$

3.Measure the peak voltage of the output "V_P" by Oscilloscope. Now calculate the following values:

$$V_{av(out-FWR)} = V_{DC} = \frac{2V_P}{\pi} = \cdots\cdots\cdots$$

4.Now use DMM to measure $V_{av(out-HWR)} = V_{DC}$.

$$V_{DC} = \cdots\cdots..$$
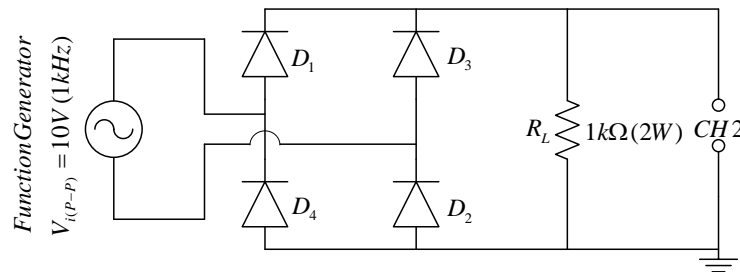
Fig 4.1 Full wave rectifier
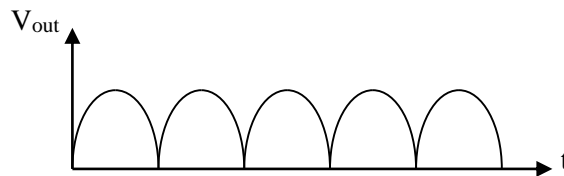
Fig 4.2 Output of full wave rectifier

5.Now connect the circuit as shown in Fig 4.3 and place capacitors as required by table 4.1.

6.Measure the average value by CRO using Coupling difference.

7.Now use DMM to measure $V_{av(out-HWR)} = V_{DC}$.

$$V_{DC} = \cdots\cdots..$$

8.Now measure V_{p-p} triangular ripple and find ripple factor for table 4.1
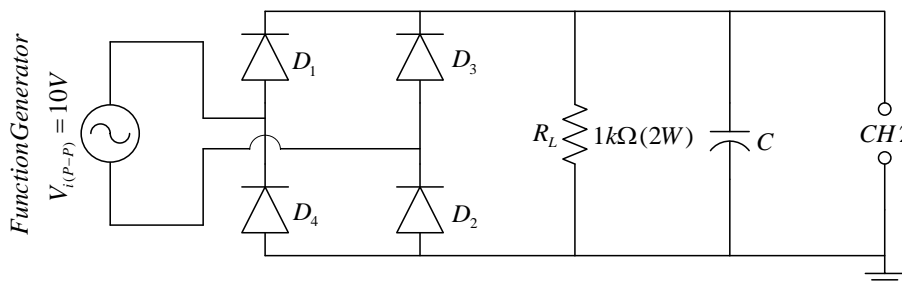

Fig 4.3 Full wave rectifier with capacitor filter
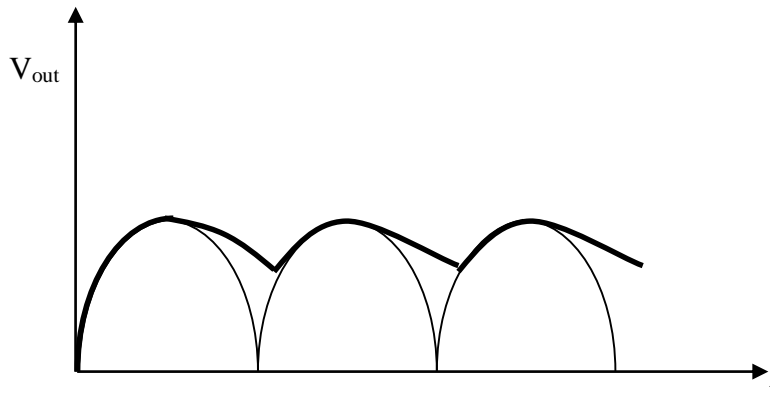
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Fig 4.4 Output waveform of full wave rectifier with capacitor filter

Observations:

Full Wave Rectifier with Capacitors:

Task:

Frequency (Hz)	Capacitances	Average value of output voltage $V_{av(out-FWR)}$ (V)		Peak-peak output ripple voltage measured by CRO $V_{P-P(triangular\ ripple)}$ (V)	Ripple Factor $r = \dfrac{V_{P-P(triangular\ ripple)}}{V_{av(out-FWR)}} = V_{DC}$
		Value by CRO	Value by DMM		
50	$10\mu F$				
	$20\mu F$				
	$100\mu F$				
	$470\mu F$				

Table 4.1 Full wave rectifier with Capacitors

Precautions:

- While diassembling circuit first remove source of power
- Check continuity of wires
- Test Diode before making circuit
- Check continuity of breadboard
- Check continuity of DMM
- Connection should be proper and tight

Conclusion & Comments:

Lab Session 05

Biased series and parallel Clipper circuits

Objectives:

Implement series and parallel diode clipper circuits and plot output waveforms.

Equipments and Components Required:

- Function generator
- Breadboard
- Digital Multimeter
- Diodes
- Resistors
- Oscilloscope

Theory:

A clipping circuit in which diode is in series with input voltage and resistance is called series clipping circuits.

Biased series clippers:
Biased Negative series clipper:
  Case(i) When $V_{in} < V$
D will be reverse bias and act as open circuit
$$V_o = V$$
  Case(ii) When $V_{in} > V$
D will be forward bias and act as short circuit
$$V_o = V_{in}$$
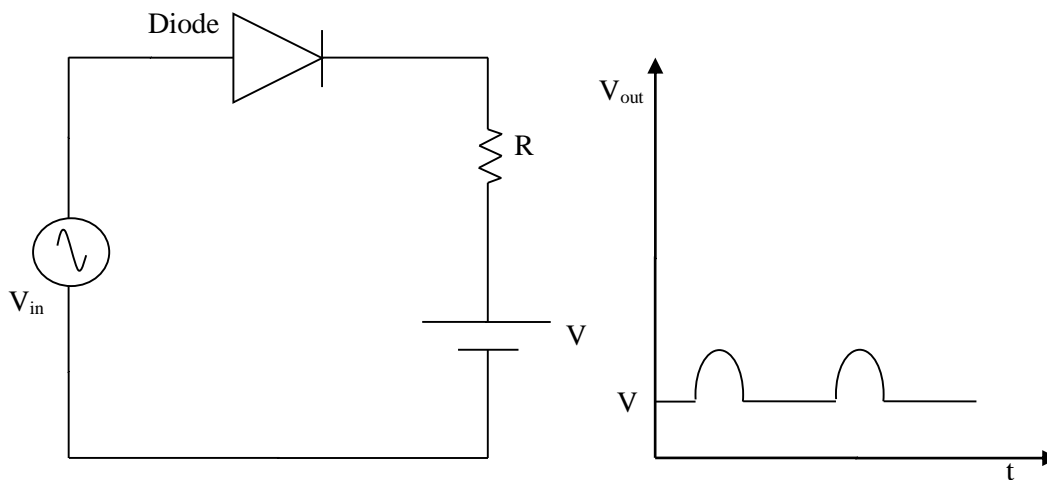
Fig 5.1 Negative series clipper circuit and output waveform

Biased Positive series clipper:

    Case(i) When $V_{in}>V$
 D will be reverse bias and act as open circuit
          $V_o= -V$
    Case(ii)When $V_{in}<V$
 D will be forward bias and act as short circuit
          $V_o=V_{in}$
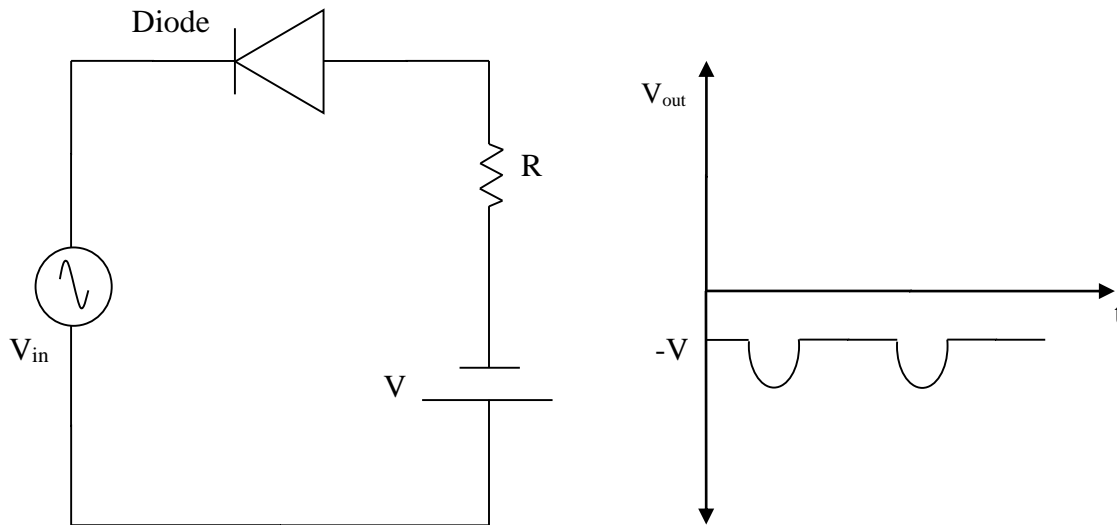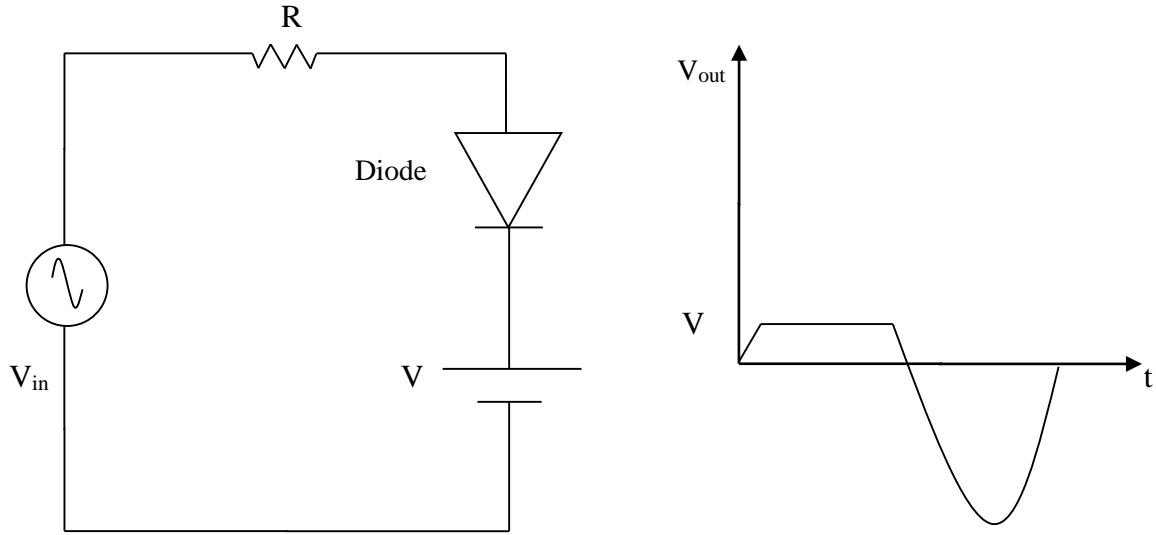

Fig 5.2 Biased Positive series clipper circuit and output waveform

Biased Positive parallel clipper:
    Case(i) When $V_{in}<V$
 D will be reverse bias and act as open circuit
          $V_o= V_{in}$
    Case(ii)When $V_{in}>V$
 D will be forward bias and act as short circuit
          $V_o= V$

Fig 5.3 Biased Positive parallel clipper and output waveform

Biased Negative parallel clipper:

Case(i) When $V_{in} > V$

D will be reverse bias and act as open circuit

$$V_o = V_{in}$$

Case(ii)When $V_{in} < V$

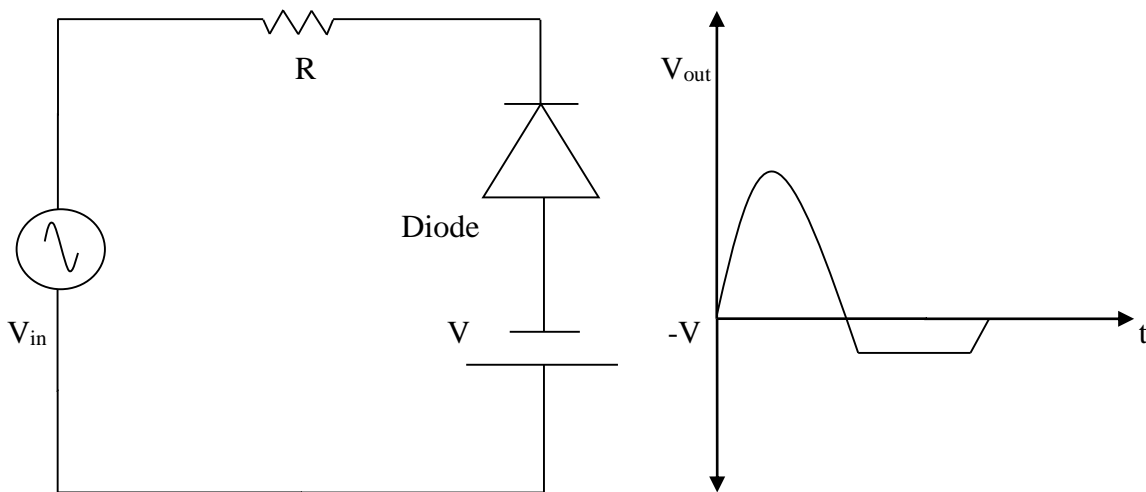D will be forward bias and act as short circuit

$$V_o = -V$$

Fig 5.4 Biased Negative parallel clipper and output waveform

Observations:
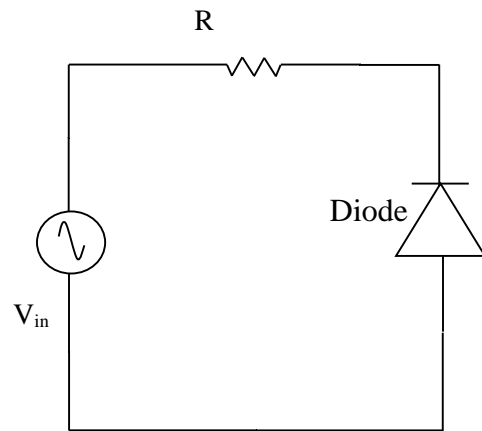Procedure:
1.Connect circuits in Fig 5.5 given below:

Fig 5.5 Unbiased parallel clipper circuit

Use R=10kΩ.
2.Set signal generator output to 5V peak 1kHz, Sine wave.
3.Set oscilloscope, record output waveform. Note that coupling switch is at dc position.

4.Reverse diode direction and observe waveform.

5.Connect circuit as shown in Fig 5.6 below:
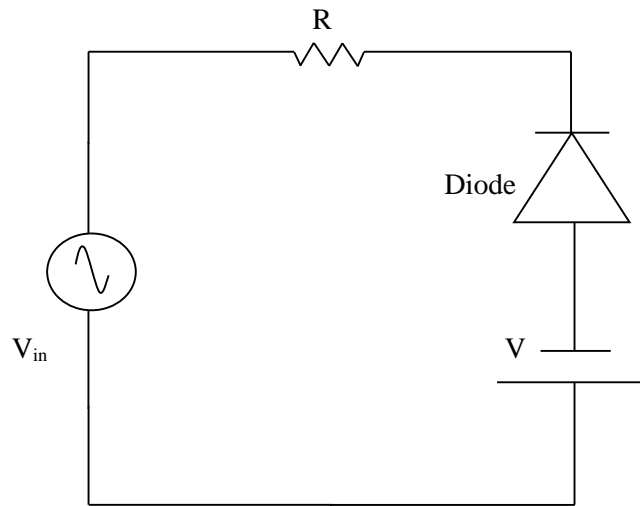

Fig 5.6 Biased Negative parallel clipper

6.Set variable dc voltage source to 3V dc, function generator 1kHz,10V$_{p-p}$ and place Resistor 1kΩ.
7.Observe and record output waveform.

8.Reverse diode and record waveform.

9.Reverse polarity of dc source and record the waveform.

10.Reverse diode again and record ouput.

Precautions:

- While diassembling circuit first remove source of power
- Check continuity of wires
- Test Diode before making circuit
- Check continuity of breadboard
- Connection should be proper and tight

Conclusion & Comments:

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Lab Session 06

Biased Positive and Negative Clamper circuits

Objectives:

Implement positive and negative diode clamper circuits and plot output waveforms.

Equipments and Components Required:

- Digital Multimeter

- DC power supply

- Breadboard

- Function generator

- Capacitor

- Diode

- Resistor (1kΩ)

Theory:
It add a DC level to an AC voltage. They are also known as DC restorers.
Diode Clampers:
Negative Clamper:
The Negative Clamping circuit consists of a diode connected in parallel with the load. It add negative DC voltage level to input signal.
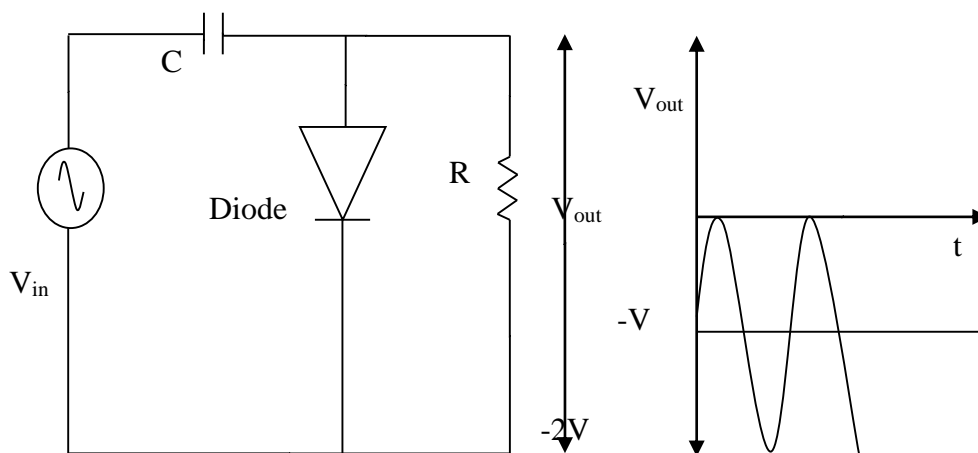

Fig 6.1 Negative Clamper Circuit and output waveform

Positive Clamper:
The circuit of the positive clamper is similar to the negative clamper but the direction of the diode

is inverted in such a way that the cathode of the diode is connected to the capacitor. The output waveform of the positive clamper shifts towards the positive direction above the 0 volts.
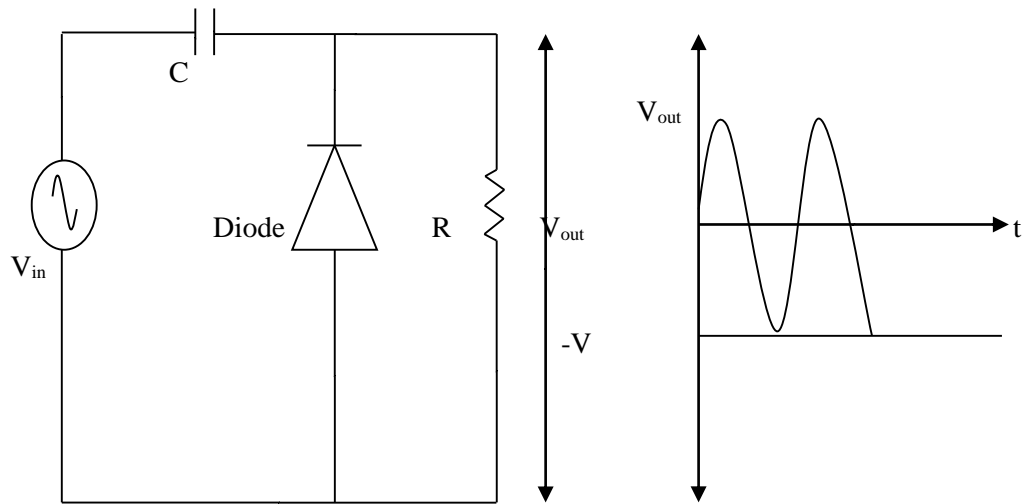

Fig 6.2 Positive Clamper Circuit and output waveform

Diode Clampers With Biased Voltage:
Negative Clamper With Positive Reference Voltage:
The circuit arrangement is very similar to the Negative clamper circuit, but a DC reference supply is connected in series with the diode. The output waveform is also similar to the Negative clamper output waveform, but it is shifted towards the positive direction by an amount equal to the reference voltage at the diode.
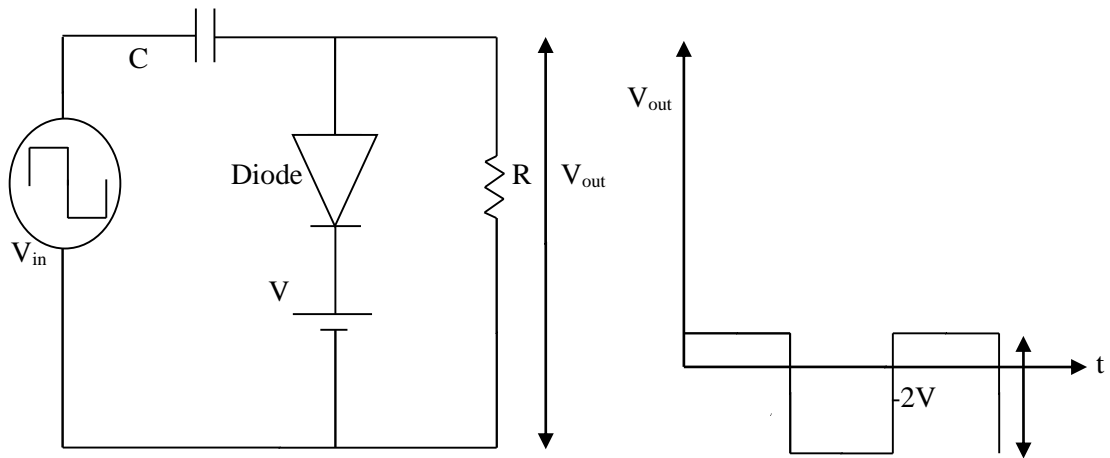

Fig 6.3 Biased Negative Clamper Circuit and output waveform
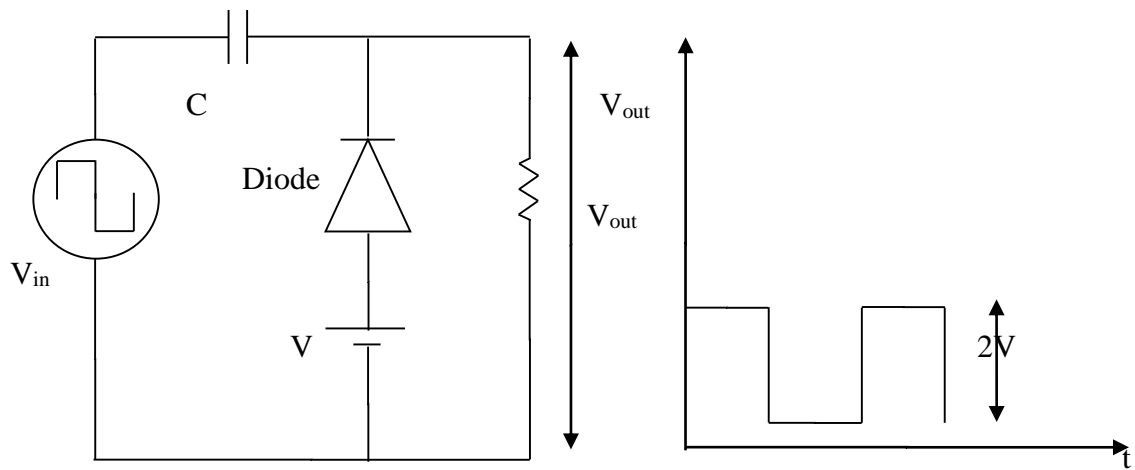
Positive Clamper with Negative Reference Voltage:

Fig 6.4 Biased Positive Clamper Circuit and output waveform

Observations:
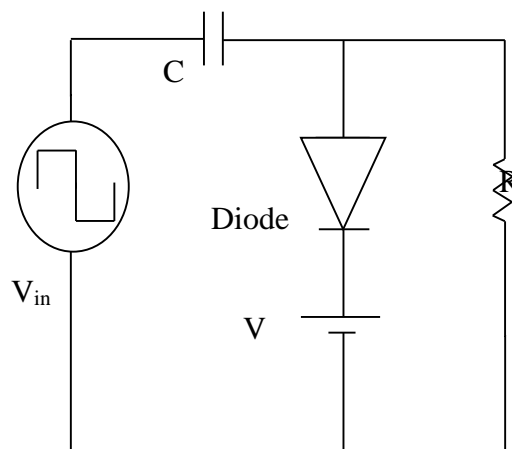Task:
Procedure:
1.Connect circuit as shown in Fig 6.5 below:

Fig 6.5 Biased Negative Clamper circuit

2. Set Dc voltage source to 3V, function generator 1kHz,10V$_{p-p}$ and place Resistor 1kΩ.

3.Set Oscilloscope At Dc Position. Observe and plot output Waveform.

4.Reverse diode plot waveform.

5.Reverse battery and plot waveform.

6.Reverse diode and plot waveform.

7.Reverse battery and plot waveform.

Precautions:

- While diassembling circuit first remove source of power
- Check continuity of wires
- Test Diode before making circuit
- Check continuity of breadboard
- Connection should be proper and tight

Conclusion & Comments:

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Lab Session 07

Characteristics of Zener Diode and Regulations

Objectives:
- To observe and plot Forward and Reverse V-I Characteristics of zener diode.
- To construct a zener voltage regulator and determine the range over which the zener maintains a constant output voltage.

Equipments and Components Required:

- DC Power Supply
- Digital Multimeter
- Breadboard
- Zener diode
- Resistors
- Potentiometer

Theory:

The Zener diode is a special type of PN junction diode. Zener diode is designed to operate in the reverse breakdown region. Once the reverse bias potential reaches a specific voltage level zener breakdown voltage, the ideal zener diode starts behaving as a fixed voltage source with zero internal resistance. If forward biased, Zener diode behaves like a normal diode.
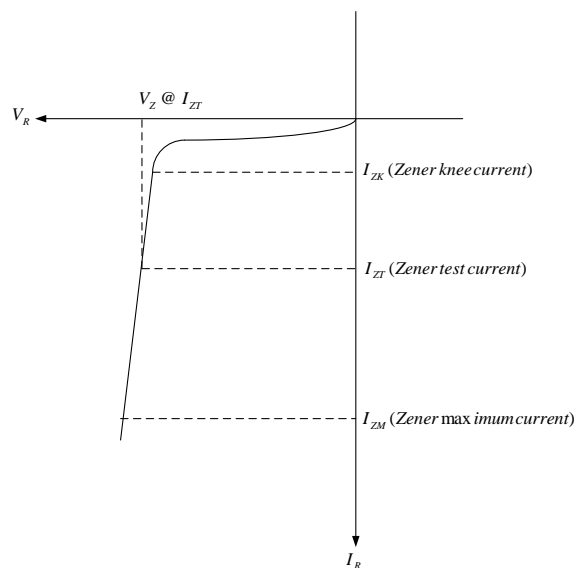

Fig 7.1 Reverse characteristics of Zener diode

Voltage Regulation:

When the supply voltage changes the operation of the circuit may be adversely affected. Consequently, some types of equipment must have power supplies that produce the same output voltage regardless of changes in the load resistance or changes in the ac line voltage. This constant output voltage may be achieved by adding a circuit called the Voltage Regulator at the output of the filter. There are many different types of regulators in use today.

Zener Diode as Voltage Regulator:

The largest use of zener diodes is for voltage regulation in power supply applications. Fig 7.2 illustrates a simple zener regulated power supply. The diode will begin to conduct as the Zener voltage is reached. At this point the voltage across the zener will remain constant. For the load connected in parallel with Zener, the load voltage is equal to the zener voltage, and thus load voltage also remains constant. Because the Zener voltage does not change despite changes in the source voltage, the load voltage also does not change and thus is said to be regulated. From Fig 7.2, the voltage drop across the series resistor R is:

$$V_R = I_T \times R$$
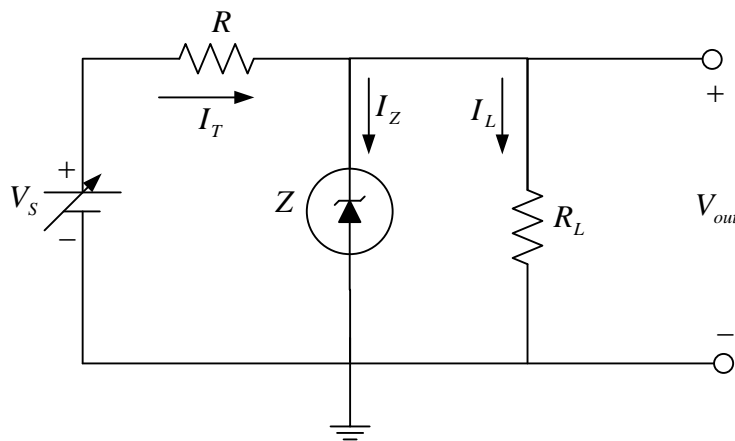
$$\Rightarrow V_R = (I_Z + I_L) \times R$$

Fig 7.2 Zener diode as Voltage regulator

Procedure:
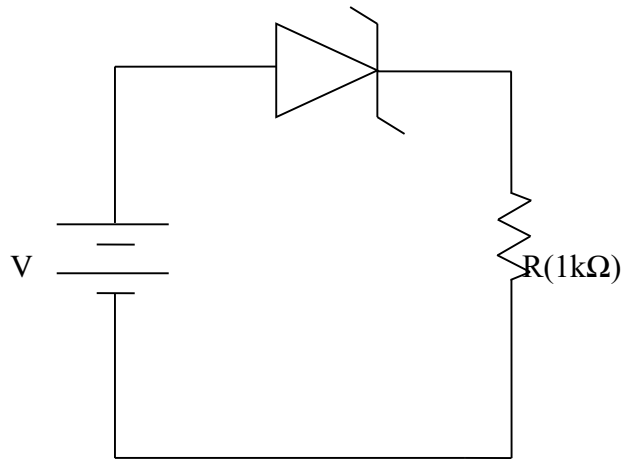Forward Biased:
1.Draw circuit diagram of Fig 7.3 on breadboard.

Fig 7.3 Forward zener diode circuit

2.Measure voltage drop across diode when it is forward biased for 0.2-2Volts step by step as shown in   table 7.1.

3.Measure voltage drop across load resistance.

4.Measure current flowing through diode.

Reverse Biased:

1.Draw circuit diagram of Fig 7.4 on breadboard.

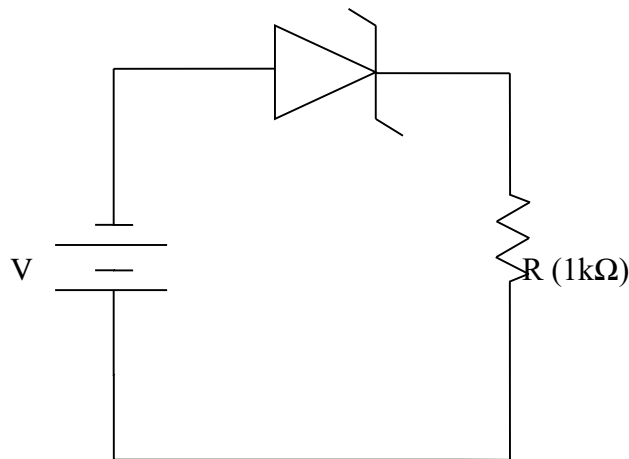2.Now measure voltage drop across diode when it is reverse biased for 2-16Volts step by step as given in table 7.2.

Fig 7.4 Reverse zener diode circuit

3.Now measure current through diode and note down values in table 7.2

Zener voltage regulator:

1.Connect circuit as shown in Fig 7.5

2.Slowly increase power supply until voltage=20V change value of resistors as shown in table 7.3 and note down corresponding values in table.
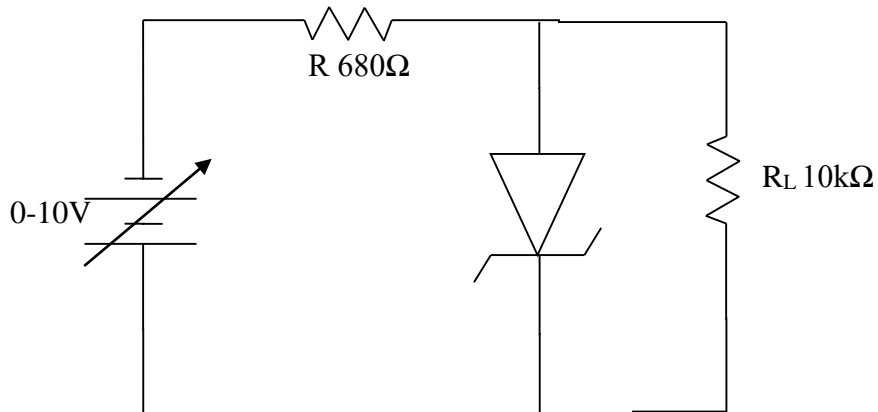
Fig 7.5 Zener voltage regulator

Observations:
Task-1:
Zener diode in forward bias:

S #	V_{in} (V)	$V_{Z(forward)} = V_o$ (V)	V_R (V)	$I_{Z(forward)} = \dfrac{V_R}{R}$ (mA)
1	0			
2	0.2			
3	0.4			
4	0.6			
5	0.8			
6	1			
7	1.2			
8	1.4			
9	1.6			
10	1.8			
11	2			

Table 7.1 Forward biased zener diode

Zener diode in reverse bias :

S #	V_{in} (V)	$V_{Z(reverse)} = V_o$ (V)	V_R (V)	$I_{Z(reverse)} = \dfrac{V_R}{R}$ (mA)
1	2			
2	4			
3	6			
4	8			
5	10			
6	12			
7	14			
8	16			
9	18			
10	20			

Table 7.2 Reverse biased zener diode

Zener diode as Voltage regulator:

Vin	I_Z (A)	I_L(A)	V_L(V)
0			
2			
4			
6			
8			
10			

Table 7.3 Zener diode as voltage regulator

Precautions:

- Check continuity of wires
- While diassembling circuit first remove source of power
- Test Diode before making circuit
- Check continuity of breadboard
- Check continuity of DMM
- Connection should be proper and tight
- DC Supply should be increase slowly in steps

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Conclusion & Comments:

Lab Session 08

Output Characteristics and Operating Regions of BJTs

Objectives:

- Determine output characteristics of BJTs and plot it on graph.

Equipments and Components Required:

- DC Power Supply

- Digital Multimeter

- Breadboard

- Transistors

- Resistors

- Potentiometer: $10\ k\Omega$

- Connecting wires

Theory:

Transistors are three terminal active devices made from different semiconductor materials that can act as either an insulator or a conductor by the application of a small signal voltage. The transistor's ability to change between these two states enables it to have two basic functions: "switching" or "amplification".

There are two basic types of bipolar transistor construction, PNP and NPN, which basically describes the physical arrangement of the P-type and N-type semiconductor materials from which they are made.

Bipolar transistor basic construction consists of two PN-junctions producing three connecting terminals with each terminal being given a name to identify it from the other two. These three terminals are emitter, base and collector.

Bipolar transistors are current regulating devices that control the amount of current flowing through them in proportion to the amount of biasing voltage applied to their base terminal acting like a current controlled switch. The principle of operation of the two transistor types PNP and NPN, is exactly the same the only difference being in their biasing and the polarity of the power supply for each type.

Output Characteristics and Operating Regions of BJTs:

The output characteristics and operating regions for common emitter configuration of transistor are shown in Fig 8.1
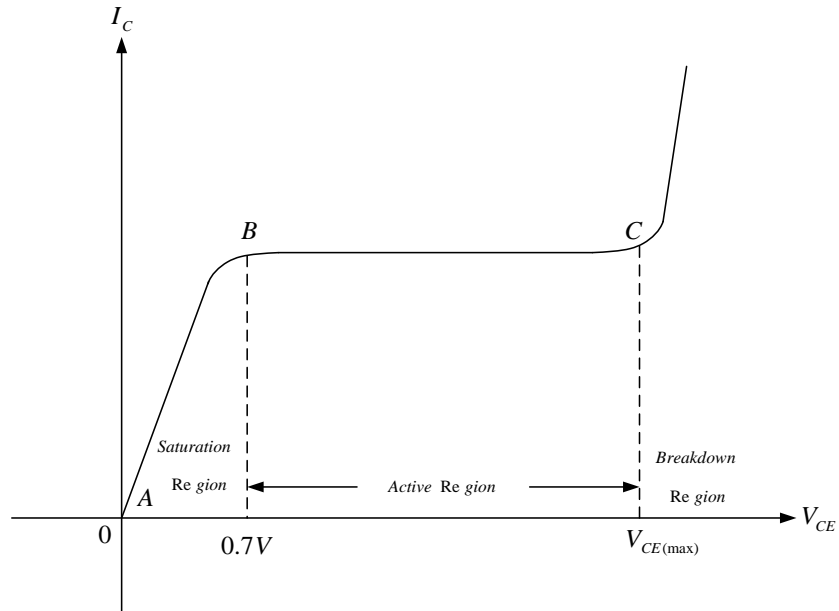
Fig 8.1 Operating characteristics BJT

Procedure:
1. Connect circuit as shown in Fig 8.2 Set $V_{CC} = 0$ V.
2. Now adjust the base current $I_B = 10 \ \mu A$ by changing V_{BB}.
3. Now for measurements of values of table 8.1 at base current $I_B = 10 \ \mu A$ ($donot \ change \ V_{BB}$), obtain the values of V_{CE} (as indicated in Table 8.1) by changing V_{CC}.
4. Plot the output characteristics between V_{CE} and I_C for $I_B = 10 \ \mu A$.
5. Now reconnect the same circuit for the PNP transistor. Remember to reverse the power supply polarity for correct connections.
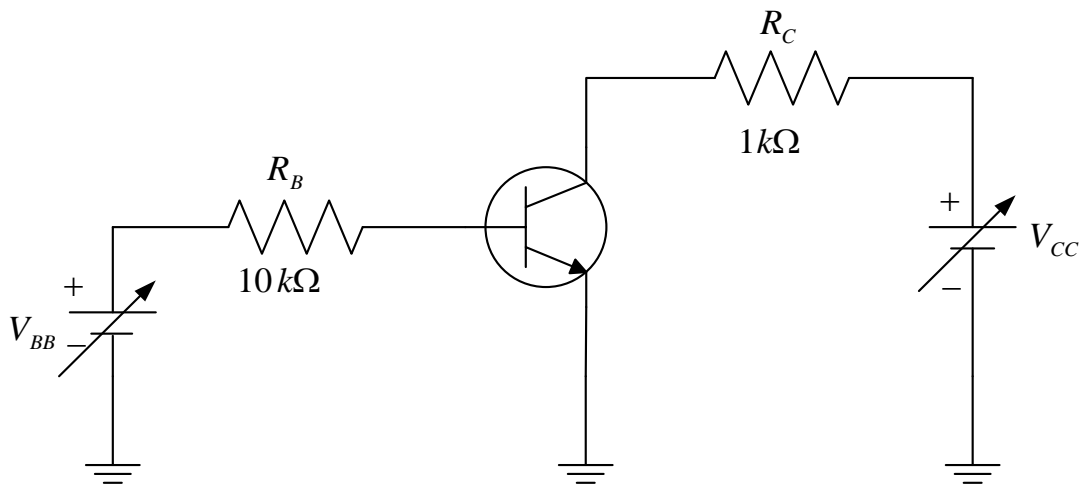6. Repeat the above procedure steps 2-5 for PNP transistor.

Fig 8.2 Circuit Diagram

7. Now plot output characteristics.

Observations:

Task:

Output characteristics of BJTs:

sr	Ib (uA)	Vbe	Vcc	Ic (mA)
1				
2				
3				
4				
5				
6				

Table 8.1 Output Characteristics of NPN

Graph for NPN:

Precautions:

- While performing the experiment do not exceed the ratings of the BJT. This may lead to damage of BJT
- Connect voltmeter and ammeter with correct polarities as shown in the circuit diagram
- Do not switch ON the power supply unless the circuit connections are checked as per the circuit diagram
- Properly identify the Base, Emitter and Collector terminals of the transistor

Conclusion & Comments:

Lab Session 09

Common Emitter Amplifier Configuration

Objectives:
- Determine output gain of CE Amplifier and plot its frequency response.

Equipments and Components Required:

- DC Power Supply
- Oscilloscope
- Function Generator
- DMM
- Breadboard
- Transistor
- Resistors
- Potentiometer
- Connecting wires

Theory:

Transistors are utilized for three main purposes: amplification, oscillation, and switching. Amplification is commonly accomplished by electronic circuits called amplifiers, which are used to increase signal power by increasing the voltage or current of the given signal. One important requirement during amplification is that only magnitude of signal should increase and there should be no change in signal shape.

Common Emitter (CE) Amplifier operation:

When capacitors are regarded as short circuits, it is seen that circuit input terminals are transistors base and emitter and output terminal are collector and emitter, so called Common emitter configuration. The common emitter configuration is an inverting amplifier circuit. This means that the resulting output signal is 180°"out-of-phase" with the input voltage signal.

CE Amplifier frequency response:

Voltage gain of an amplifier varies with signal frequency. It is because reactance of capacitors in circuit changes with signal frequency and hence effect output voltage. The curve between voltage gain and signal frequency of an amplifier is known as Frequency Response. It is clear that voltage drops off at low and high frequencies whereas it is uniform over midrange frequency.
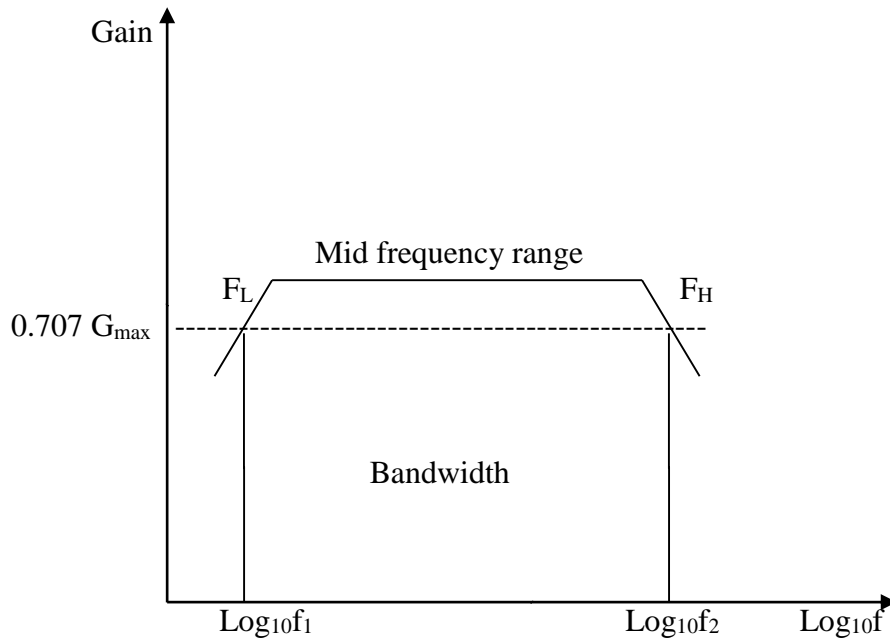
Fig 9.1 Frequency response of Amplifier

DC Voltage measurement:
For DC Voltage measurements disconnect all capacitors from circuit. The EB should be forward biased. The V_{CB} may range from approximately half the supply voltage.

Procedure:
1.Connect the circuit components as shown in Fig 9.2. After connecting the circuit components apply V_{CC} and then set $V_{CC} = 12\ V$
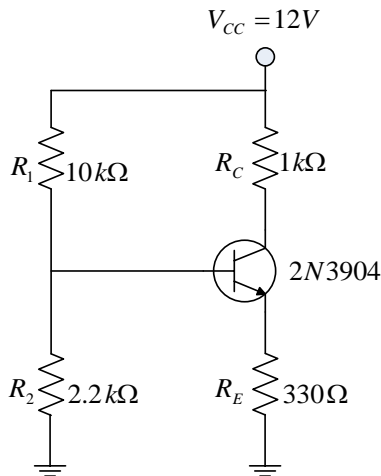

Fig 9.2 Circuit diagram

2.For frequency measurement feed 100mV and apply frequency 1kHz.

3.Now increase frequency from 1kHz to 1MHz and measure voltage gain of amplifier at each frequency.

4.Determine F_L and F_H and calculate voltage gain also find voltage gain in decibels as shown in table 9.3.
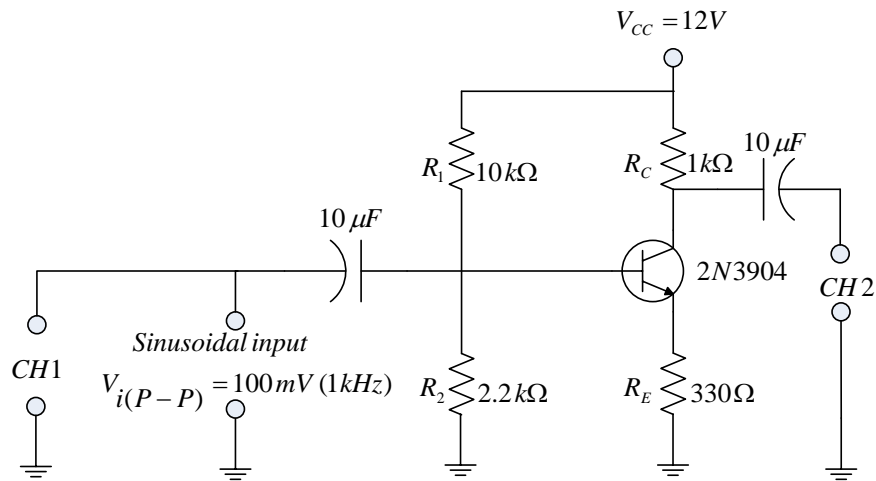
5.Plot Gain versus Frequency find Bandwidth.

Fig 9.3 Common Emitter Amplifier Circuit

Frequency response of CE:

Frequency	V_O	Gain(A_V)
1k		
10k		
50k		
100k		
200k		
300k		
500k		
700k		
1M		
2M		

Table 9.1 Frequency response

Determine F_L & F_H and calculation of BW:

Frequency (Hz)	Output volts (V_O)	Voltage gain (V_O/V_S)	Voltage gain in db $20\log_{10}(V_O/V_S)$

Table 9.2 Estimation of Bandwidth

Plot Gain versus frequency:
Bandwidth=F_H-F_L

Precautions:

- While performing the experiment do not exceed the ratings of the BJT. This may lead to damage of BJT
- Connect voltmeter and ammeter with correct polarities as shown in the circuit diagram
- Do not switch on power supply unless the circuit connections are checked as per the circuit diagram
- Properly identify the Base, Emitter and Collector terminals of the transistor

Conclusion & Comments:

Lab Session 10

Transistor as switch

Objective:

- Performing experiment of transistor as a switch on multisim

Equipment and components required:

- Switch S1
- LED red
- Ground
- DC Power
- 1K resister
- PNP: BC548A

Theory

When used as an AC signal amplifier, the transistors Base biasing voltage is applied in such a way that it always operates within its "active" region, that is the linear part of the output characteristics curves are used.

However, both the NPN & PNP type bipolar transistors can be made to operate as "ON/OFF" type solid state switch by biasing the transistors Base terminal differently to that for a signal amplifier.

Solid state switches are one of the main applications for the use of transistor to switch a DC output "ON" or "OFF". Some output devices, such as LED's only require a few milliamps at logic level DC voltages and can therefore be driven directly by the output of a logic gate. However, high power devices such as motors, solenoids or lamps, often require more power than that supplied by an ordinary logic gate so transistor switches are used.

If the circuit uses the Bipolar Transistor as a Switch, then the biasing of the transistor, either NPN or PNP is arranged to operate the transistor at both sides of the "I-V" characteristics curves we have seen previously.

The areas of operation for a transistor switch are known as the **Saturation Region** and the **Cut-off Region**. This means then that we can ignore the operating Q-point biasing and voltage divider circuitry required for amplification, and use the transistor as a switch by driving it back and forth between its "fully-OFF" (cut-off) and "fully-ON" (saturation) regions as shown below.
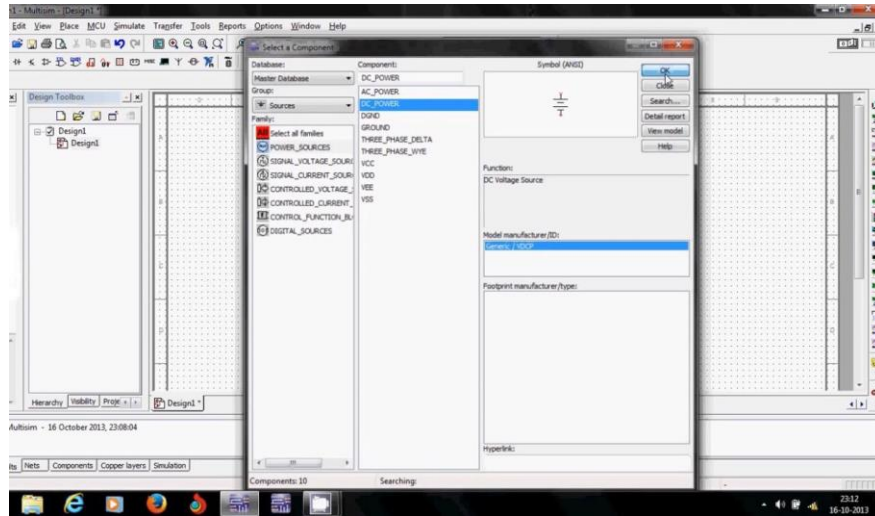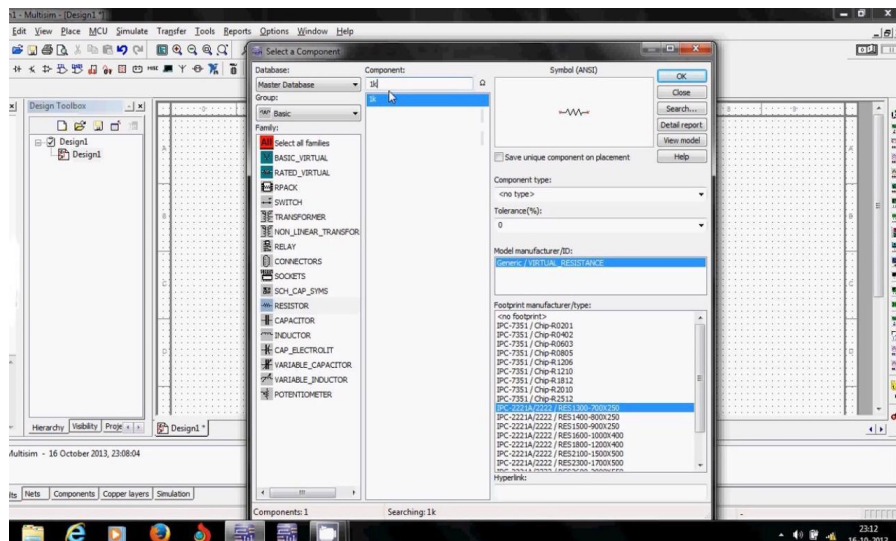
Operating region:
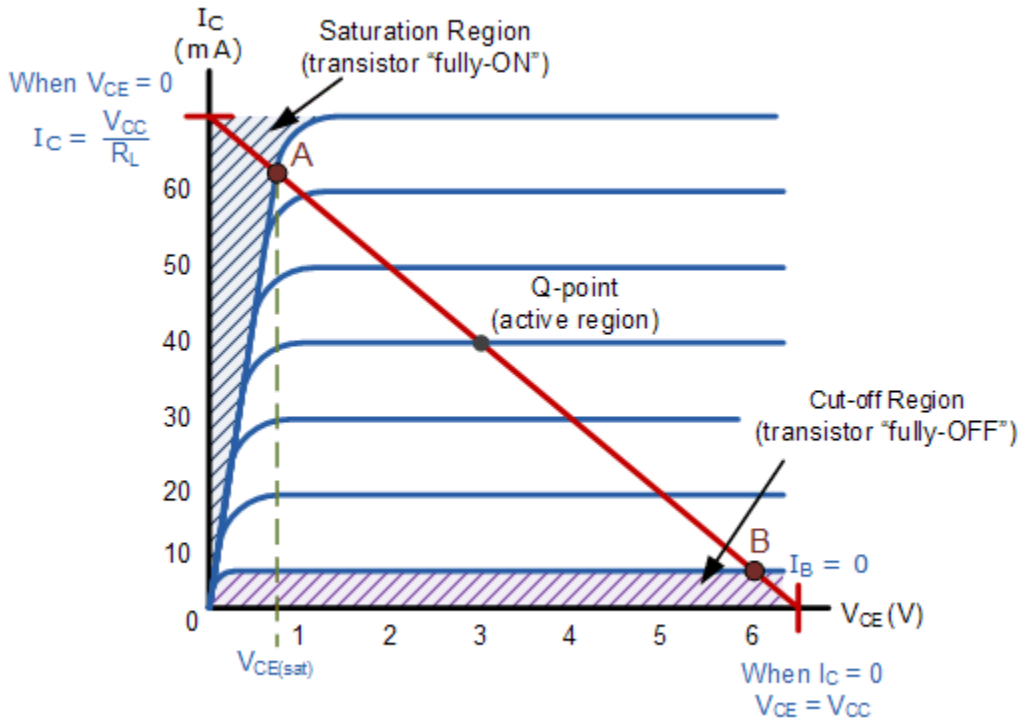
Procedure

1. Firstly open multisim then click right button and then select place component.
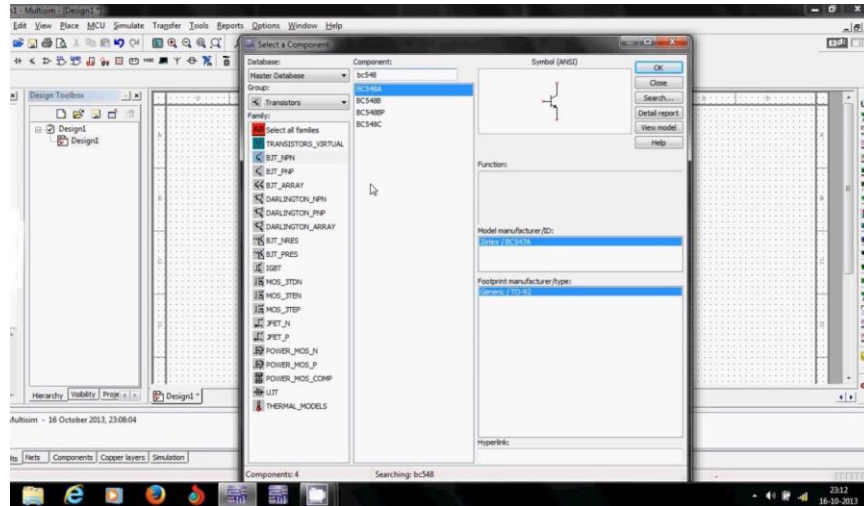2. Place the switch S1.
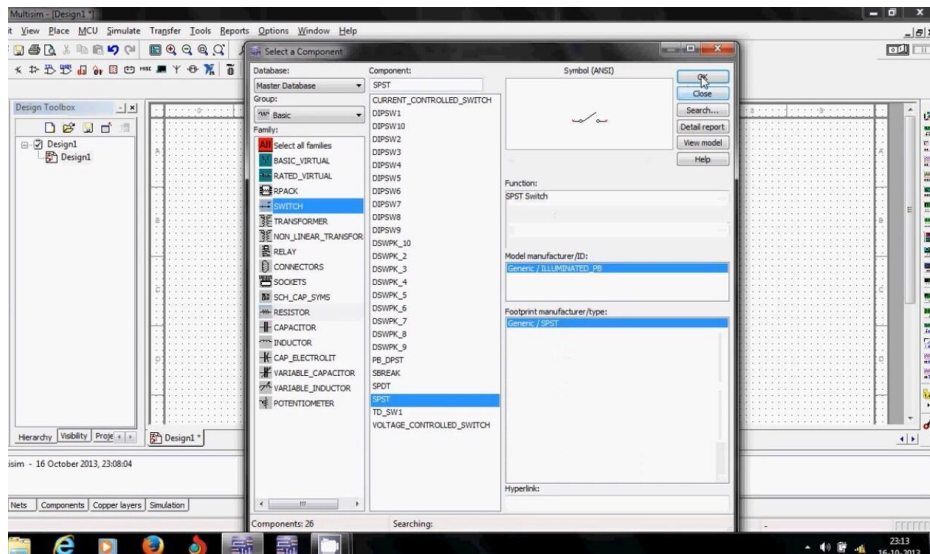
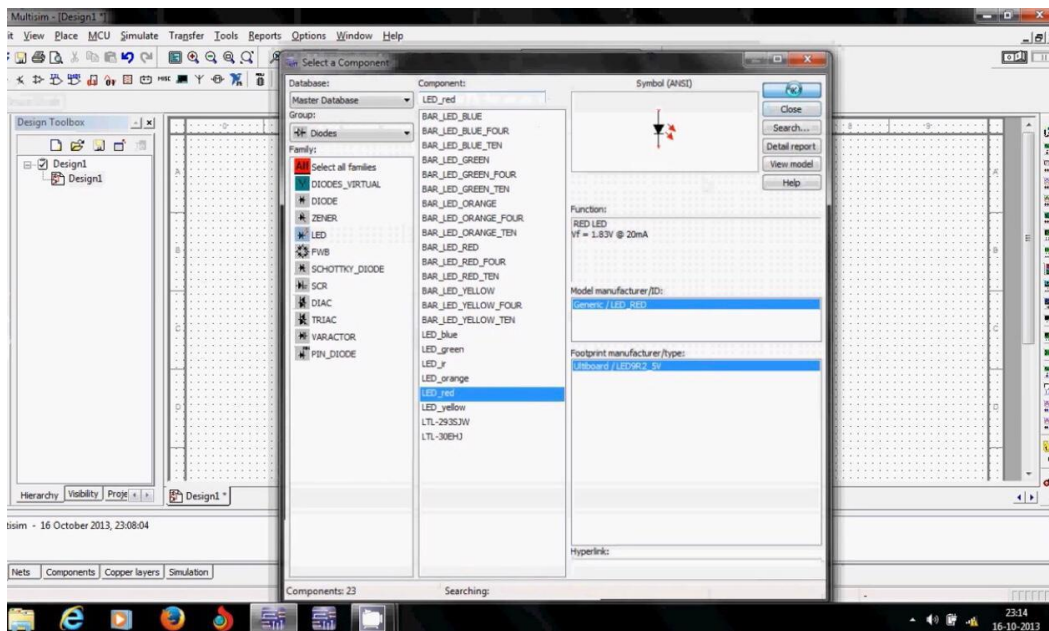3. Then place a DC power supply of 12v to give the power supply to the circuit.

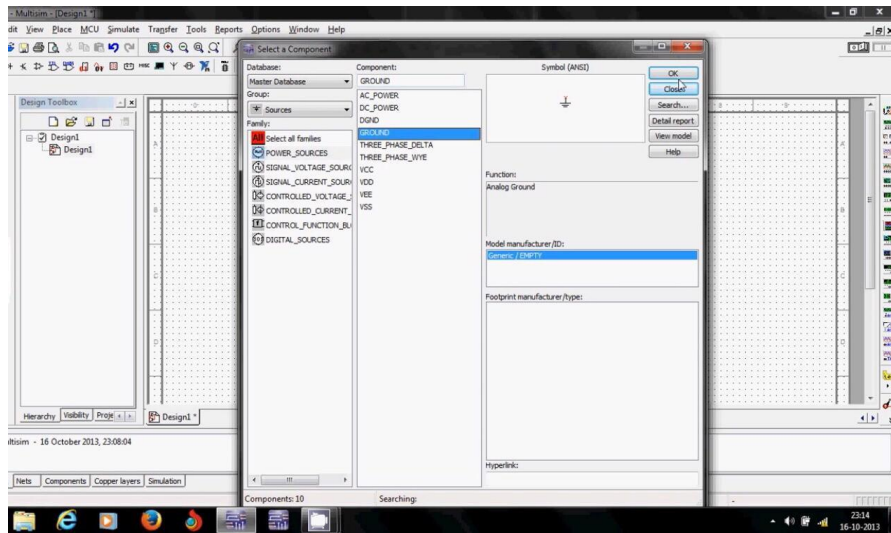4. Now we place a 1K ohm of resister.

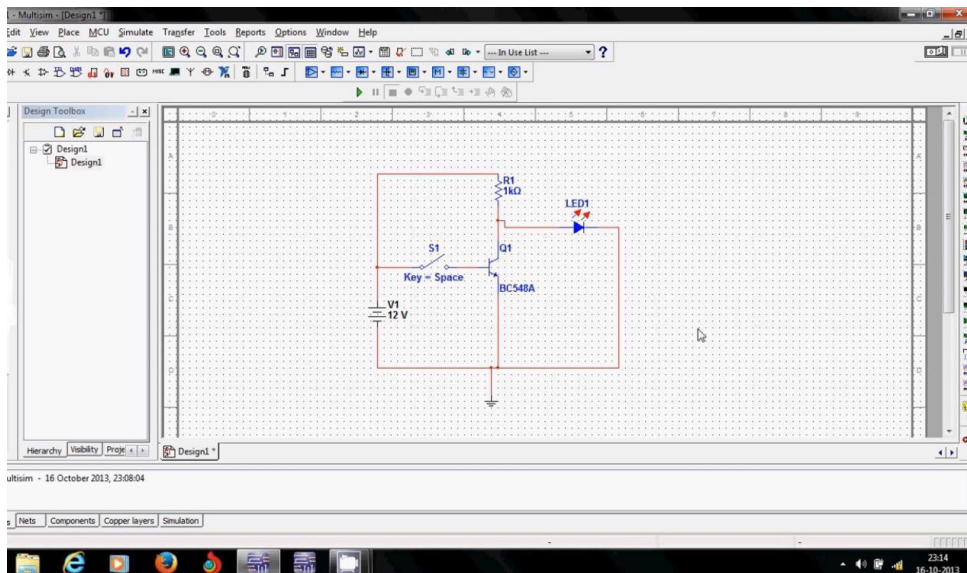5. Place a BC548A PNP junction transistor in the circuit.

6. Now place the LED RED to get the output. When the red color blinks in the LED then the circuit works.

7. At the end place GROUND in the circuit and then connect the whole circuit through wire.

8. When the LED blinks red the switch S1 close we also place oscilloscope in parallel to LED to get the output.

Observation and comments:

Lab Session 11

JFET Drain and Transfer Characteristics

Objectives:
- Determine Drain and Transfer characteristics of JFET and plot it

Equipments & Components Required:

- JFET

- Resistors

- Breadboard

- DC power supply

- DMM

- Connecting wire (Single strand)

Theory:
In linear region the drain to source voltage is small and drain current in nearly proportional to the drain to source voltage. When a positive drain to source voltage is applied, this voltage increases from zero to a small value, the depletion region width remain very small and under this condition the semi conductor bar behaves just like a resistor. So, drain current increases almost linearly with drain to source voltage.

In saturation region drain current is almost constant and it is not dependent on the drain to source voltage actually. When the drain to source voltage continuous to increase the channel resistance increases and at some point, the depletion regions meet near the drain to pinch off the channel. Beyond that pinch off voltage, the drain current attains saturation.

In breakdown voltage drain current increases rapidly with a small increase of the drain to source voltage. Actually for large value of drain to source voltage, a breakdown of the gate junction takes place which results a sharp increase of the drain current.
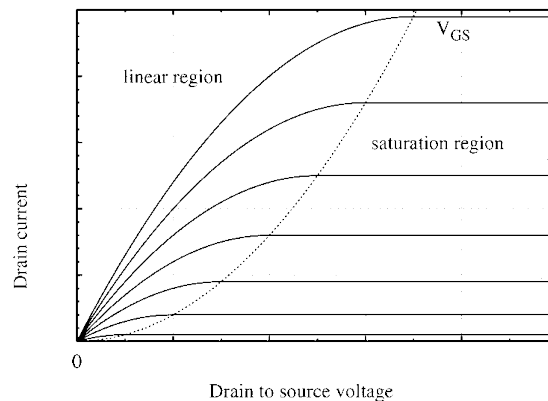

Fig 10.1 JFET Output Characteristics

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Transfer characteristics:
The graphical characteristics plot of the saturation drain current against the gate to source voltage is known as the transfer characteristics of JFET.
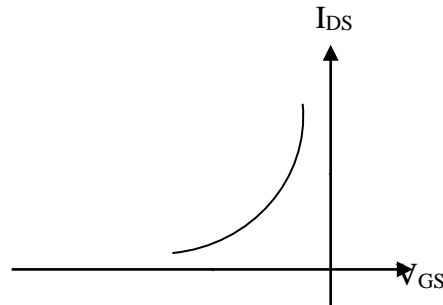The transfer characteristics of an n- channel is shown below in Fig 10.2 .

Fig 10.2 Transfer Characteristics JFET

Procedure:
Drain Characteristics:
1.Connect the circuit as shown in the Figure10.3.
2.Keep V_{GS} = 0V by varying V_{GG}.
3.Varying V_{DD} gradually in steps of 1V up to 10V note down drain current I_D and drain to source voltage (V_{DS}).
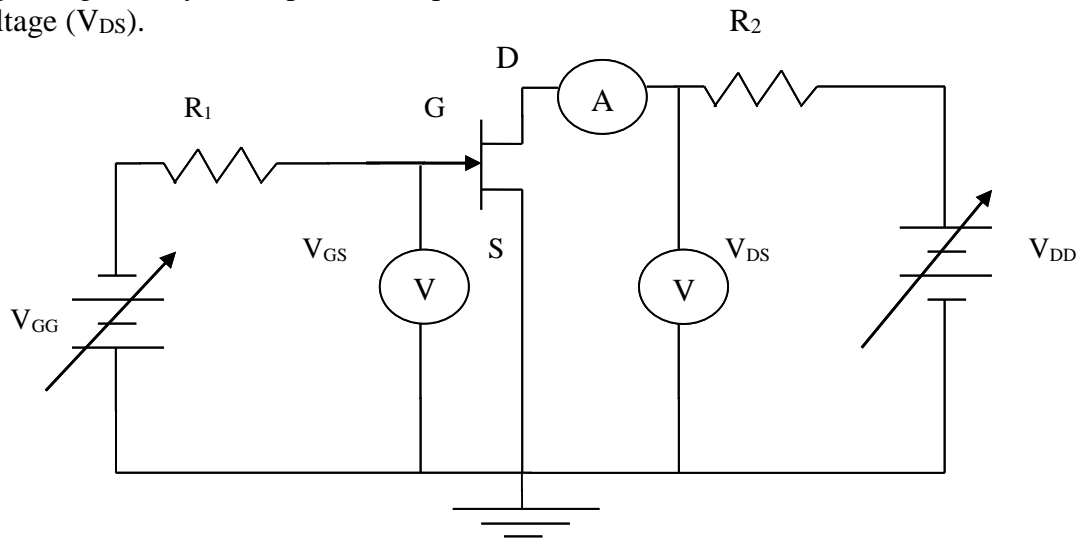

Fig 10.3 Circuit diagram

4.Repeat above procedure for V_{GS} = -1V

Transfer Characteristics:
Procedure:
1.Connect the circuit as shown in the Figure 10.3
2.Set voltage V_{DS} = 2Vand 5V.
3.Varying V_{DD} in steps of 0.5V until the current I_D reduces to minimum value.
4.Varying V_{GG} gradually, note down both drain current I_D and gate-source voltage(V_{GS}).

5.Repeat above procedure steps for $V_{DS} = 4V$ and 8V.

Observations:
Drain Characteristics:
Task:

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

Table 10.1 Drain Characteristics

Transfer Characteristics:

Transfer Characteristics				
	V_{DS}=2V/5V		V_{DS}=4V/8V	
V_{GG}(Volts)	V_{GS}(Volts)	I_D(mA)	V_{GS}(Volts)	I_D(mA)

Table 10.2 Transfer Characteristics

Precautions:

- While performing the experiment do not exceed the ratings of the FET. This may lead to damage of FET
- Connect voltmeter in parallel and ammeter in series and with correct polarities
- Do not switch ON the power supply unless the circuit connections are checked as per the circuit diagram

- Properly identify the Source, Drain and Gate terminals of the transistor

Conclusion & Comments:

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