Experiment 1: OSCILLOSCOPE AND FUNCTION GENERATOR OPERATION

Objective:-

To become familiar with the operation and use of the oscilloscope and function generator

Equipment:-

Oscilloscope

Function Generator

Digital Multimeter (DMM)

Introduction:-

Since students come from different backgrounds; therefore, this section may seem easy for some, while others may want to spend more time becoming familiar with the equipment. If you have not used the equipment before, spend some time with the equipment in this lab to insure you know how to correctly use it.

Oscilloscope:-

The oscilloscope is the most widely used general-purpose measuring instrument because it allows you see a graph of the voltage as a function of time in a circuit. Many circuits have specific timing requirements or phase relationships that can be measured with a two-channel oscilloscope. One can measure almost anything with the two-dimensional graph drawn by an oscilloscope like the average value, rms value, frequency and period of a sinusoidal or a non-sinusoidal signal. The screen is divided into centimeter divisions in vertical and horizontal directions. Vertical sensitivity is set in volts/cm while horizontal sensitivity is set in time (sec)/cm.

If a particular signal occupies 6 vertical divisions and vertical sensitivity is set to 5 mV/cm, the magnitude of the signal can be determined from the following equation:

Signal voltage = voltage sensitivity (V/cm) x deflection (cm)

$$V_s = (5mV/s) \times (6\ cm) = 30\ mV$$

If one cycle of the same signal occupies 8 cm on horizontal scale with a horizontal sensitivity of 5µs/cm, the period and frequency of the signal can be determined by the following equations:

Period of waveform = horizontal sensitivity (s/cm) x deflection (cm)

$$T = (5\ \mu s/cm) \times (8cm) = 40\ \mu s$$

$$F = 1/T = 1/40\ \mu s = 25\ kHz$$

The GOS-6112 is a 100MHz, two-channel, dual-sweep, portable oscilloscope for general purpose use. A microprocessor-based operating system controls most of the functions of the instrument, including cursor readout and digitized panel setting. On-screen alphanumeric readout and cursor function for voltage, time, frequency and phase measurement provide extraordinary operational convenience.

The vertical deflection system has two input channels. Each channel has 11 basic deflection factors from 2mV to 5V per division. The horizontal deflection system provides single, dual or delayed sweeps from 0.5s to 50ns per division (delayed sweep, 50ms to 50ns per division). The trigger system provides stable triggering over the full bandwidth of the vertical deflection system.

In your own words, describe the function and use of the following.

Focus:

Intensity:

Vertical sensitivity:

Horizontal sensitivity:

Vertical mode selection:

AC-GND-DC switch:

Trigger section:

External trigger input:

Input resistance and capacitance of oscilloscope:

Probe:

Function Generator

Function Generator is a supply that typically provides a sinusoidal, square-wave and triangular waveform for a range of frequencies and amplitudes. Although the frequency of the function generator can be set by the dial position and appropriate multiplier, the oscilloscope can be used to precisely set the output frequency. The scope can also be used to set the amplitude of the function generator.

Setup

Turn on the oscilloscope and adjust the necessary controls to establish a clear, bright, horizontal line across the centre of the screen.

Connect the function generator to one vertical channel of the oscilloscope and set the output of the generator to a 1000 Hz sinusoidal waveform.

Set the vertical sensitivity of the scope to 1 V/cm and adjust the amplitude control of the function generator to establish a 4 V peak to peak (p-p) sinusoidal waveform on the screen.

Horizontal sensitivity

Set the horizontal sensitivity of the scope to 0.2 ms/cm. using the results of above part, calculate and predict the number of horizontal divisions required to properly display one full cycle of the 1000 Hz signal

Determine the period of 1000 Hz sinusoidal waveform in ms using the equation T=1/f. Show all your calculations:

Calculated No. of divisions = _____________

Using the oscilloscope, measure the number of required divisions and insert below:

Measured No. of divisions = _____________

Change the horizontal sensitivity of the oscilloscope to 0.5 ms/cm without touching any of the controls of the function generator. Using the results of part (d) above, how many horizontal divisions will now be required to display one full cycle of the 1000 Hz signal?

Calculated No. of divisions = ______________

Using the oscilloscope, measure the number of required divisions and insert below:

Measured No. of divisions = ______________

Change the horizontal sensitivity of the oscilloscope to 1 ms/cm without touching any of the controls of the function generator. Using the results of part (d) above, how many horizontal divisions will now be required to display one full cycle of the 1000 Hz signal?

Calculated No. of divisions = ______________

Using the oscilloscope, measure the number of required divisions and insert below:

Measured No. of divisions = ______________

What was the effect on the appearance of the sinusoidal waveform as the horizontal sensitivity was changed from 0.2 ms/cm to 0.5 ms/cm and finally to 1 ms/cm?

Did the frequency of the signal on the screen change with each horizontal sensitivity?

Give a sequence of steps to calculate frequency of a sinusoidal waveform appearing on the screen of oscilloscope.

Vertical sensitivity

Do not touch the controls of the function generator, but return the horizontal sensitivity of the scope to 0.2 ms/cm and change the vertical sensitivity to 2 V/cm. Calculate peak to peak value of the waveform on the screen.

Calculated peak to peak value = _______________

Change the vertical sensitivity of the oscilloscope to 0.5 V/cm and repeat part (j).

Calculated peak to peak value = _______________

What was the effect on the appearance of the sinusoidal waveform as the vertical sensitivity was changed from 2 V /cm to 0.5 V/cm?

Did the peak to peak value of the signal on the screen change with each horizontal sensitivity?

Can the peak or p-p output voltage of a function generator be set without the aid of an auxiliary instrument like an oscilloscope or a DMM? Explain:

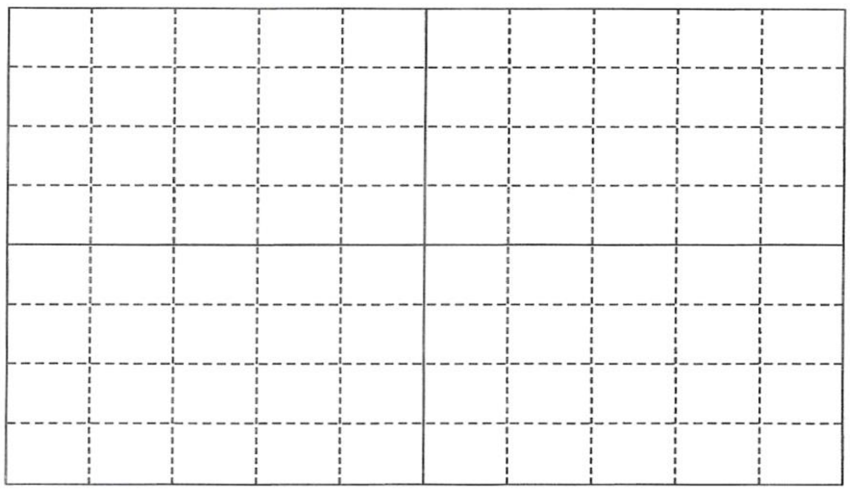
Exercise

Make all the necessary adjustments to clearly display a 5000 Hz, 6 V_{p-p} sinusoidal signal on the oscilloscope. Establish the zero volt line at the centre of the screen. Record the chosen sensitivities:

Vertical sensitivity = _____________

Horizontal sensitivity = _____________

Draw the waveform below clearly mentioning the dimensions:



Time/Div: __________ V/Div: __________

Calculate the period of the waveform on the screen using the resulting number of required horizontal divisions for a full cycle.

Calculated T = ________________

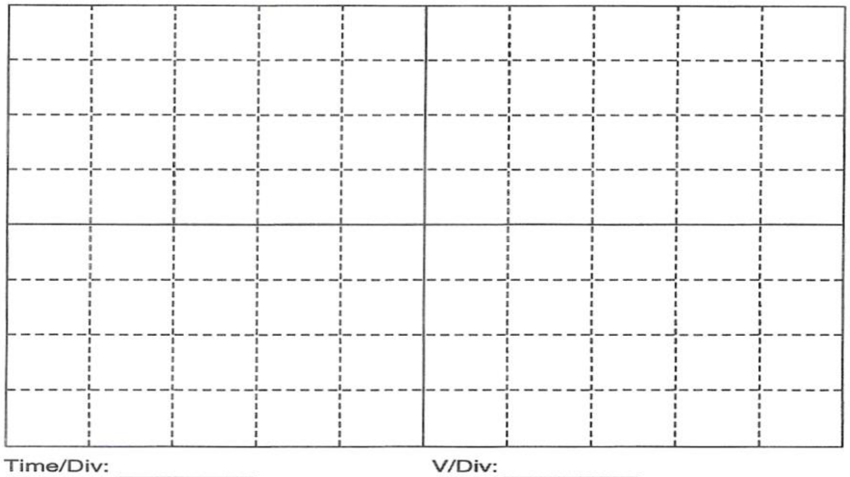
Repeat part (a) above for a 200 Hz 0.8 V_{p-p} sinusoidal waveform:

Vertical sensitivity = _____________

Horizontal sensitivity = _____________

Calculated T = _____________

Draw the waveform below clearly mentioning the dimensions:



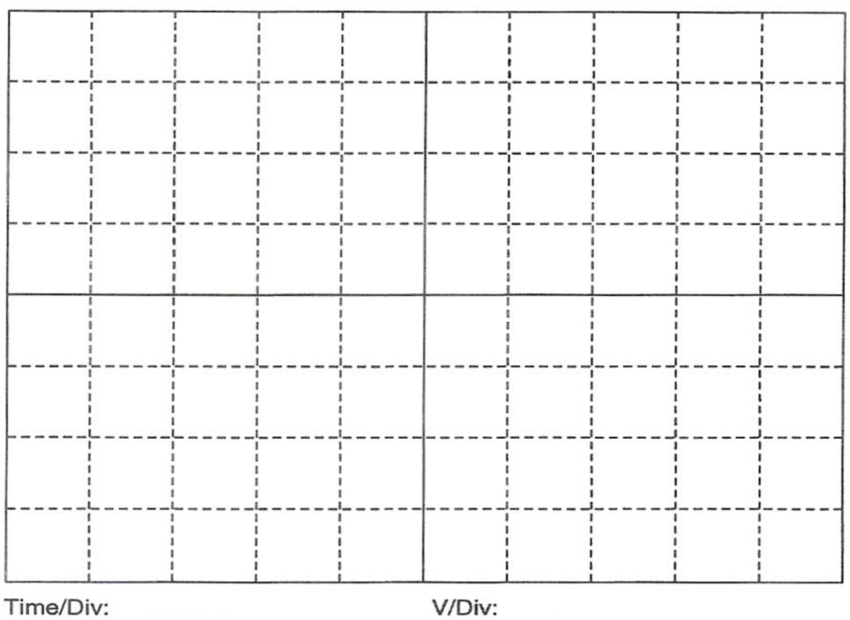
Repeat part (a) for a 100 kHz 4 Vp-p square waveform:

Vertical sensitivity = ______________

Horizontal sensitivity = ______________

Calculated T = ______________

Draw the waveform below clearly mentioning the dimensions:



Effect of DC Levels

Re-establish the 1 kHz 4 Vp-p sinusoidal waveform on the screen. Calculate the effective value of the sinusoidal waveform.

Calculated Vrms = _____________

Disconnect the function generator from the scope and measure the effective (rms) value of the output of the function generator using DMM.

Measured V_{rms} = ____________

Determine the magnitude of the percent difference between the calculated and measured levels using the following equation:

$$\% \text{ Difference} = [\{V(calc) - V(meas)\} \div V(calc)] \times 100\%$$

% Difference = ______________

Reconnect the function generator to the scope with the 1 kHz 4 $V_{p\text{-}p}$ signal and switch the AC-GND-DC coupling switch of the vertical channel to GND. What is the effect?

Explain? How can this scope function be used?

Now move the AC-GND-DC coupling switch to AC position. What is the effect on the screen? Explain.

Then move the AC-GND-DC coupling switch to DC position. What is the effect on the screen? Explain.

Experiment No. 2: PROTEUS 8 Tutorial

Objectives:

In this lab we will learn the basics of Proteus Software and also we will make and simulate some basic circuits.

Theory:

Proteus:

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.

Main Window:

Main window when opened..

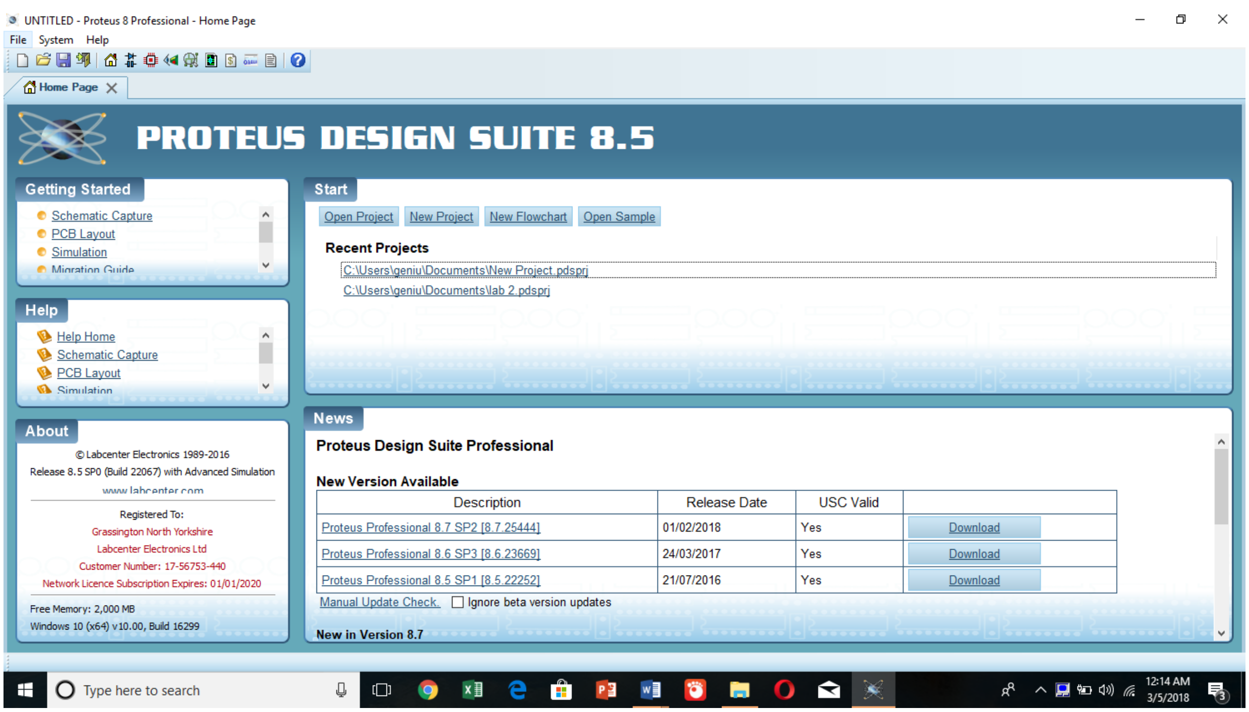


Figure 1 Main Window

To Open A New Project:

To open a new project, select circled icon in the given image…

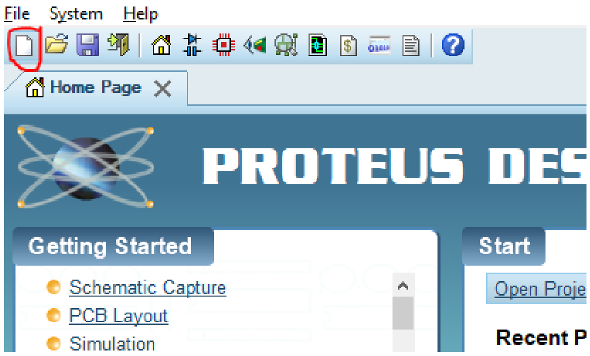


Figure 2 New Project

After that we will get this window…

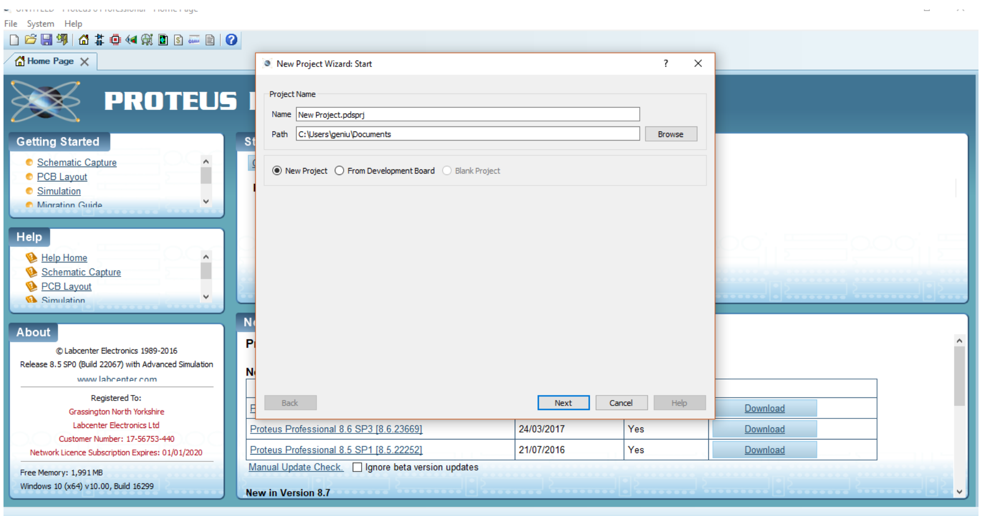


Figure 3 Option

After that select Potrait A4 from the options…

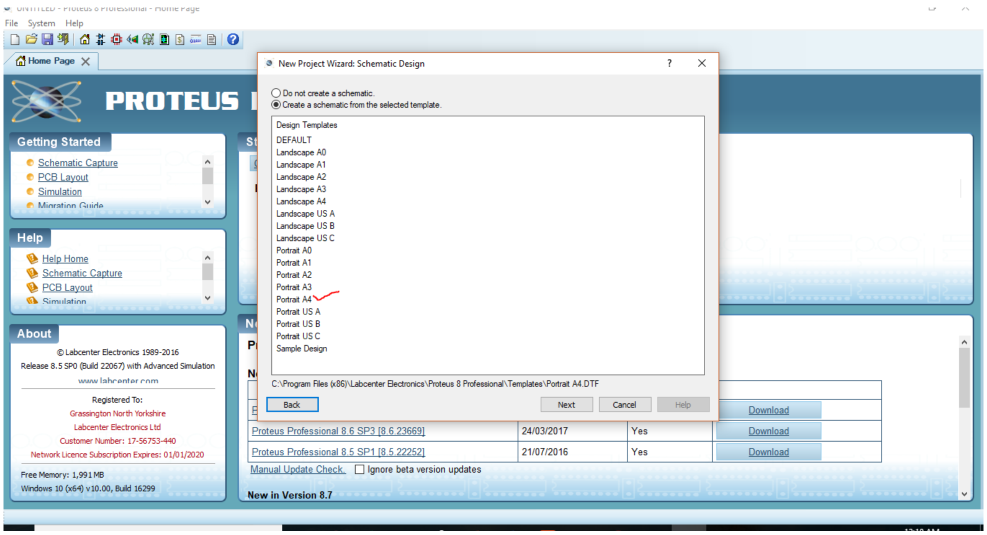


Figure 4 Options

After that select Single Eurocad (2 layer)…

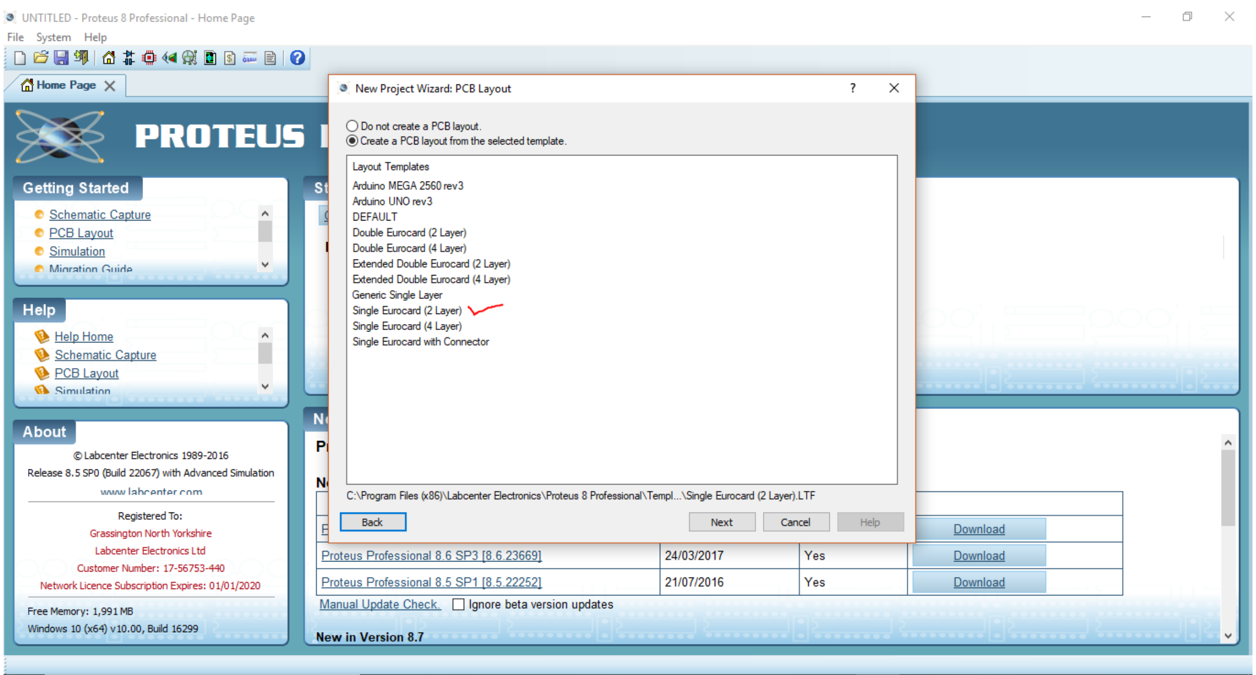


Figure 5 Options

So.. after finishing this we will get this screen …

If we want to Design a PCB layout we have to select this option (in the red)…

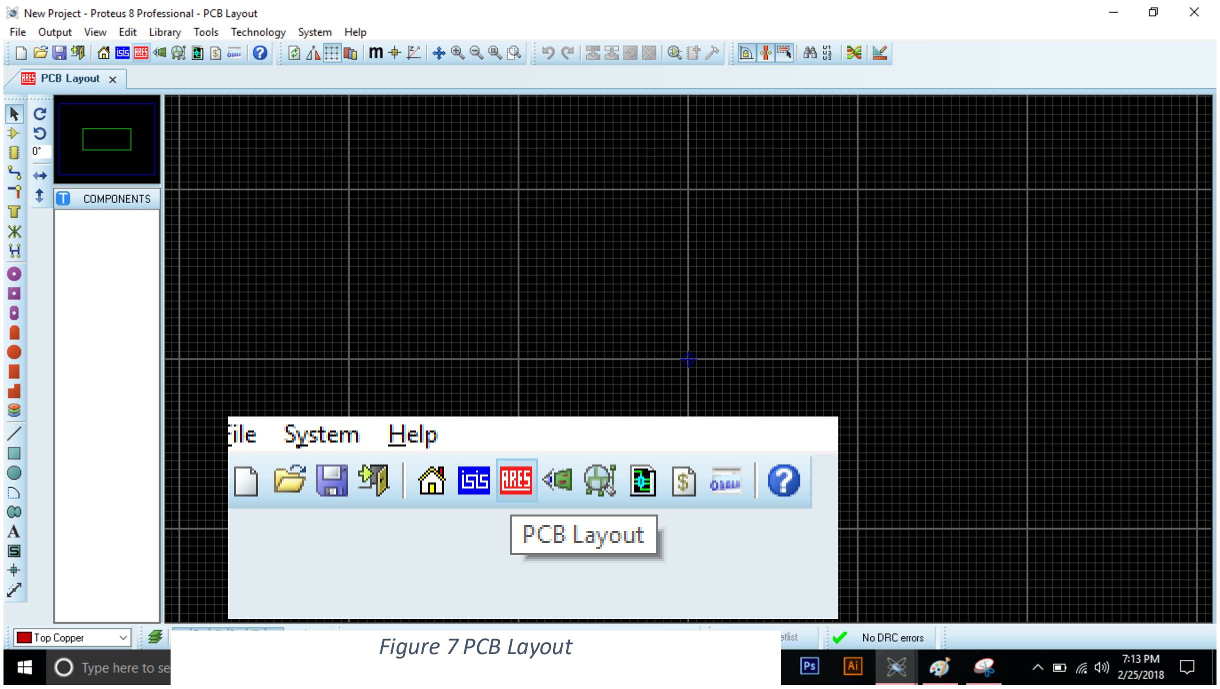


Figure 7 PCB Layout

Figure 6 Main Interface

If we want to Design Schematic we have to select this option (in the blue)…

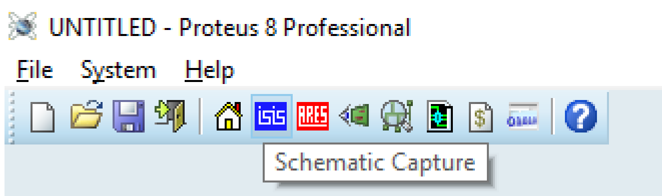


Figure 8 Schematic

Component Mode:

For designing a circuit we need components which can be selected from here below the arrow..

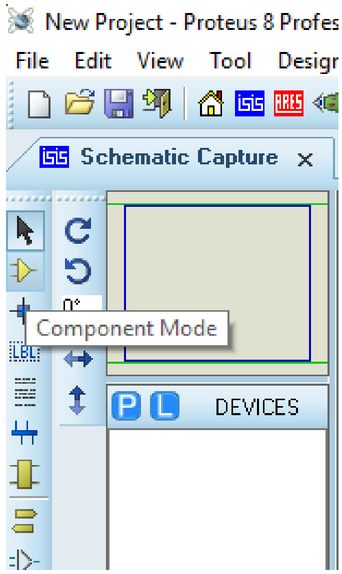


Figure 9 Component Mode

We will get this window to select or search for a specific component type the keyword of that component. We can select it form the category list or can search it directly by typing the keyword of element we want to search. E.g we have

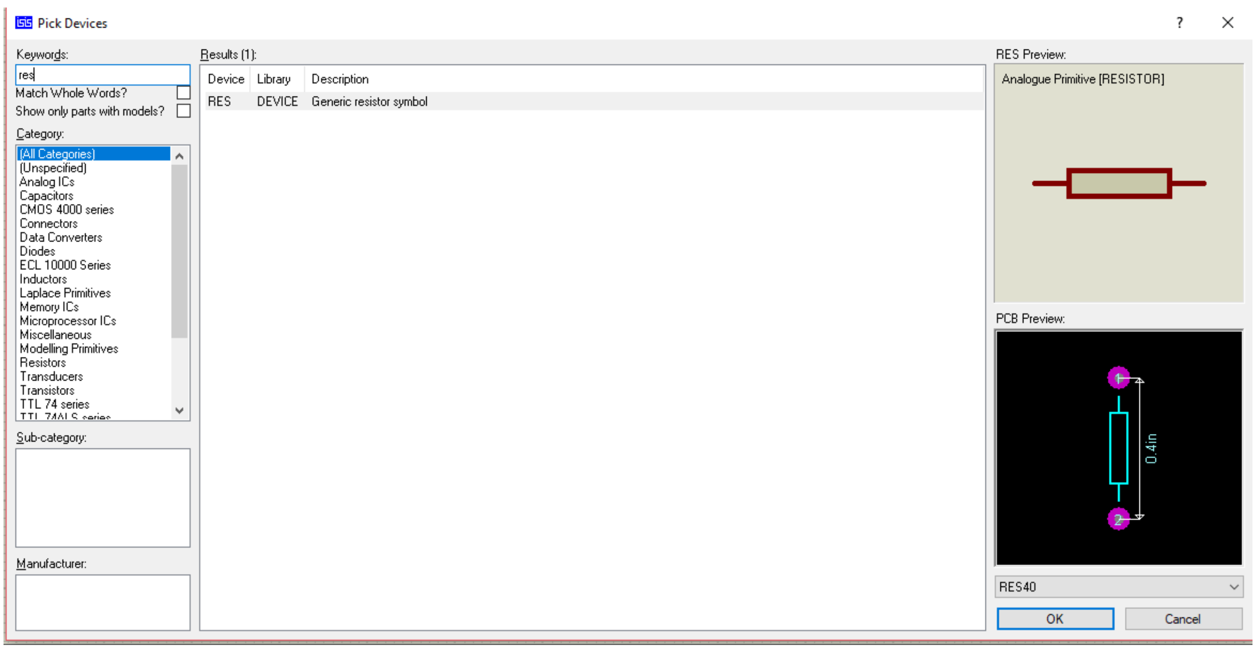
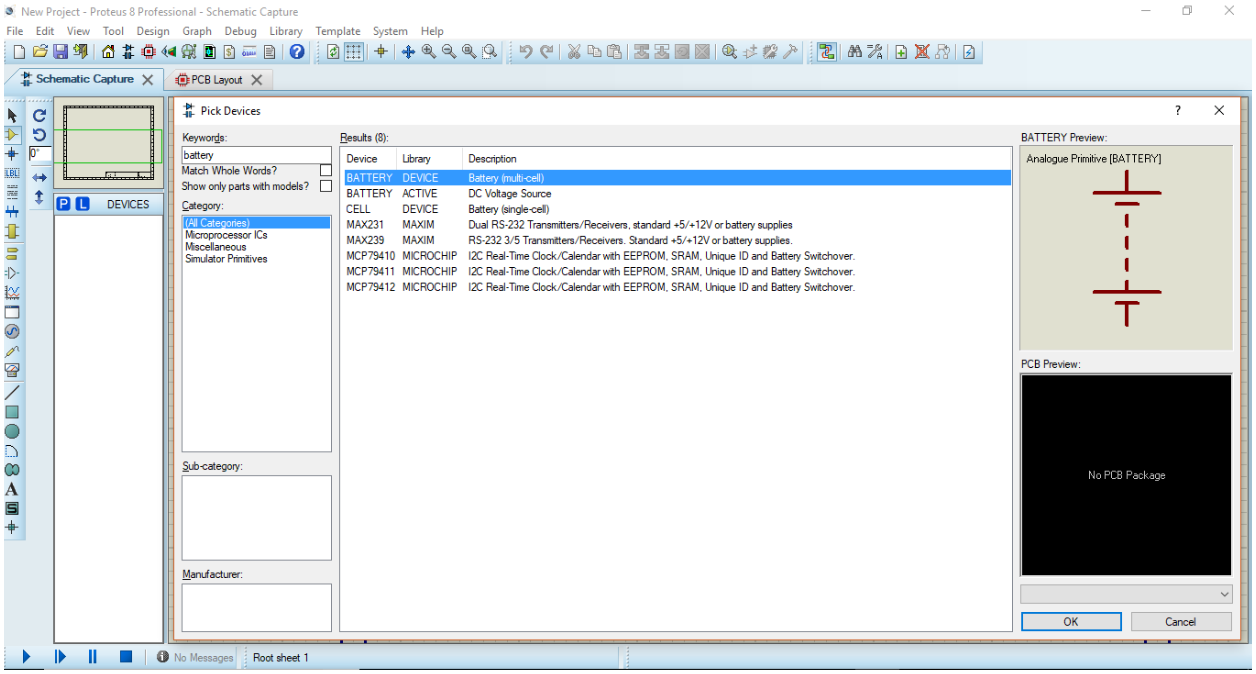


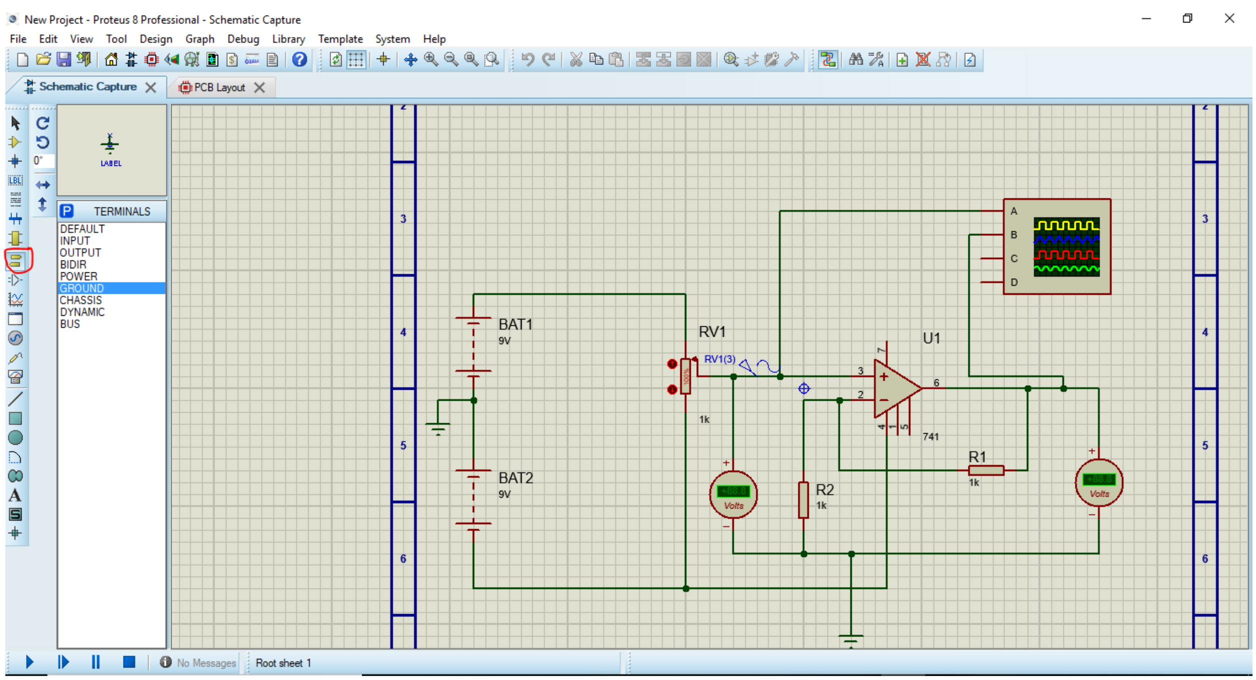
Figure 10 Pick Devices

searched for resistor. Keyword is res.

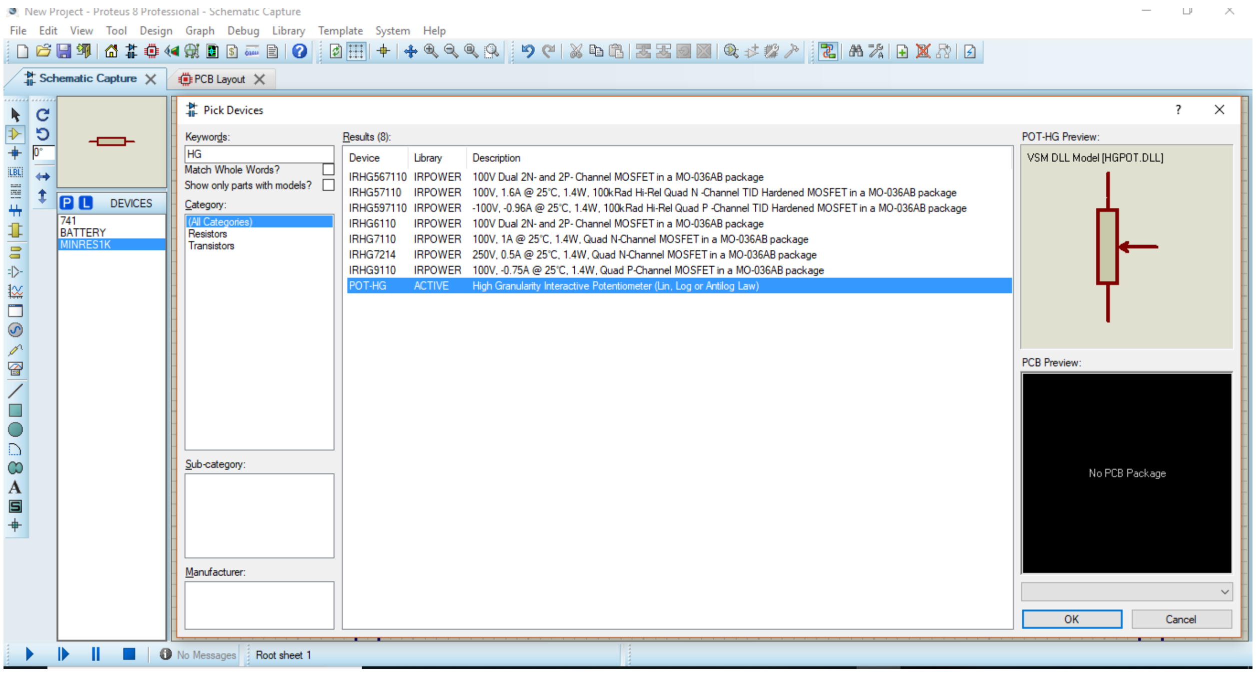
For selecting battery



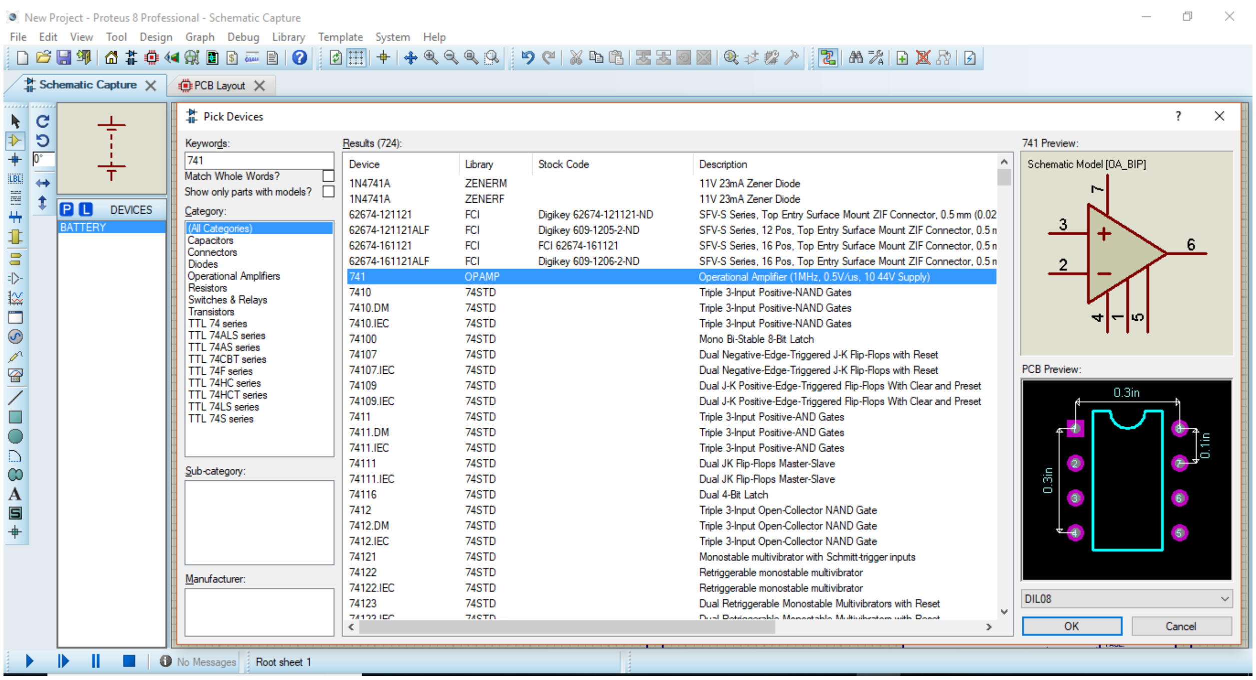
For selecting ground go to the Terminal Mode as shown below and Select GROUND



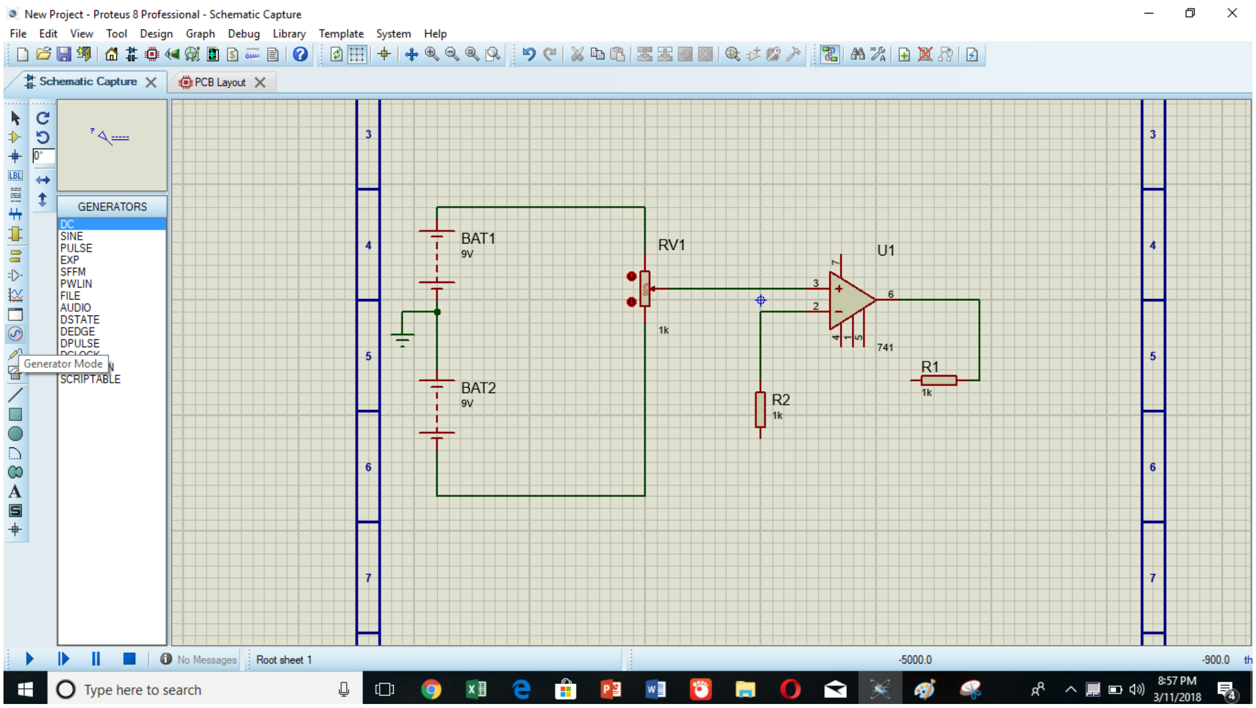
For potentiometer go to component mode and type HG



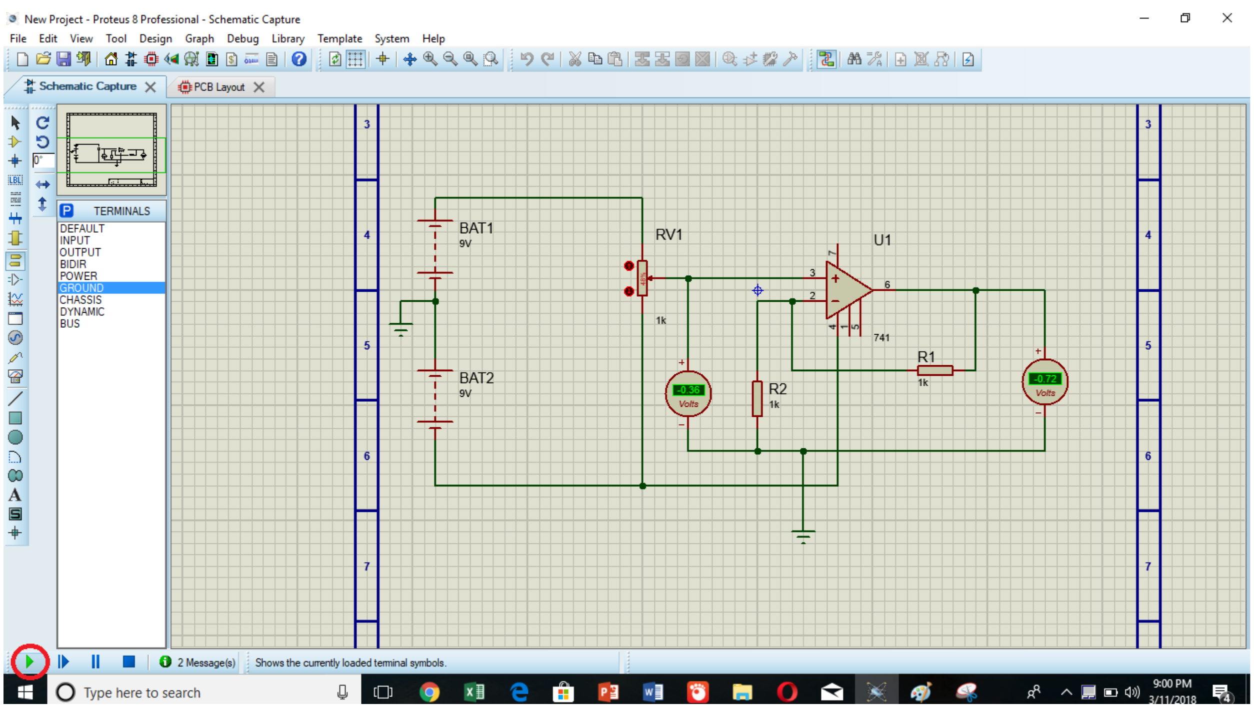
For OpAmp type 741 or any model number



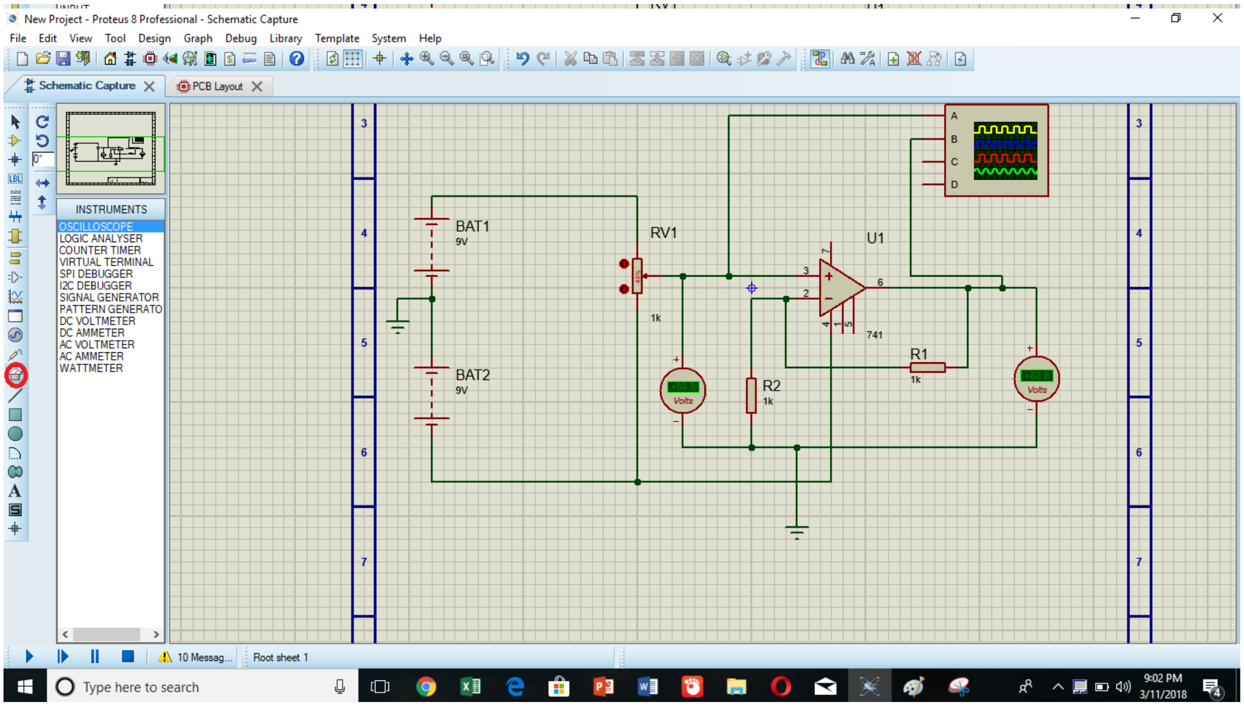
You can select DC or Sine in Generator mode as shown below



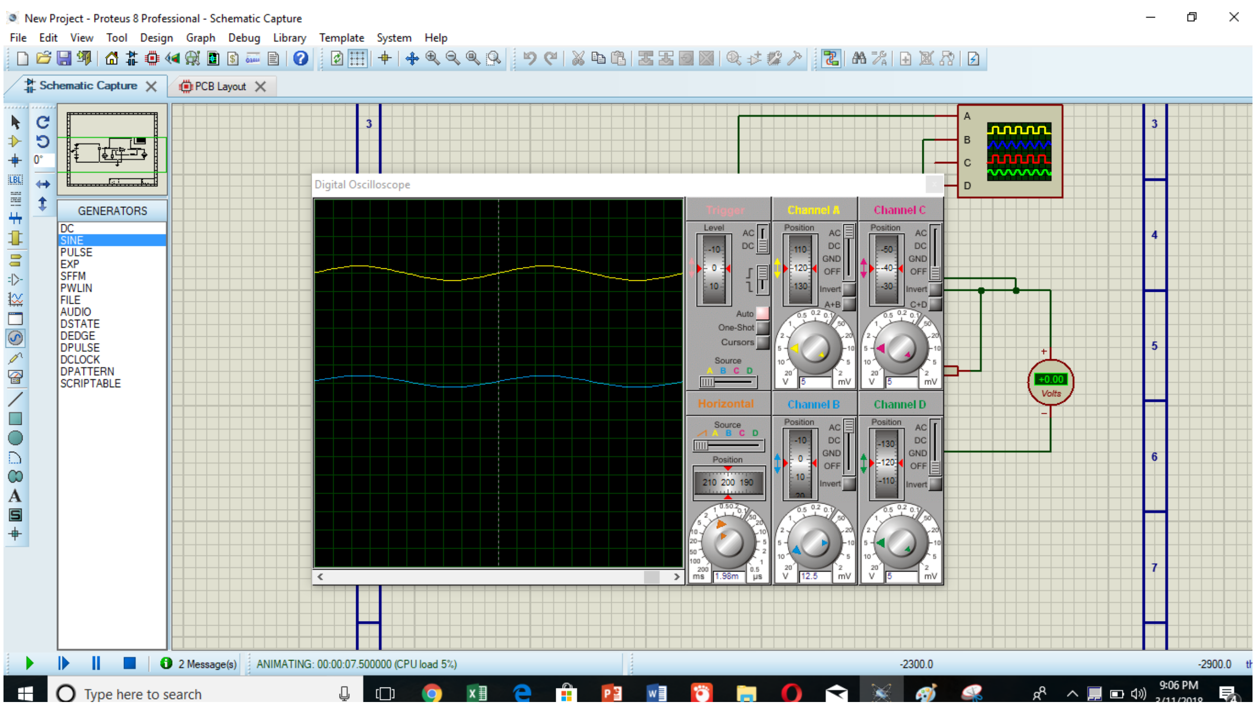
Click on the arrow in the bottom left for simulation



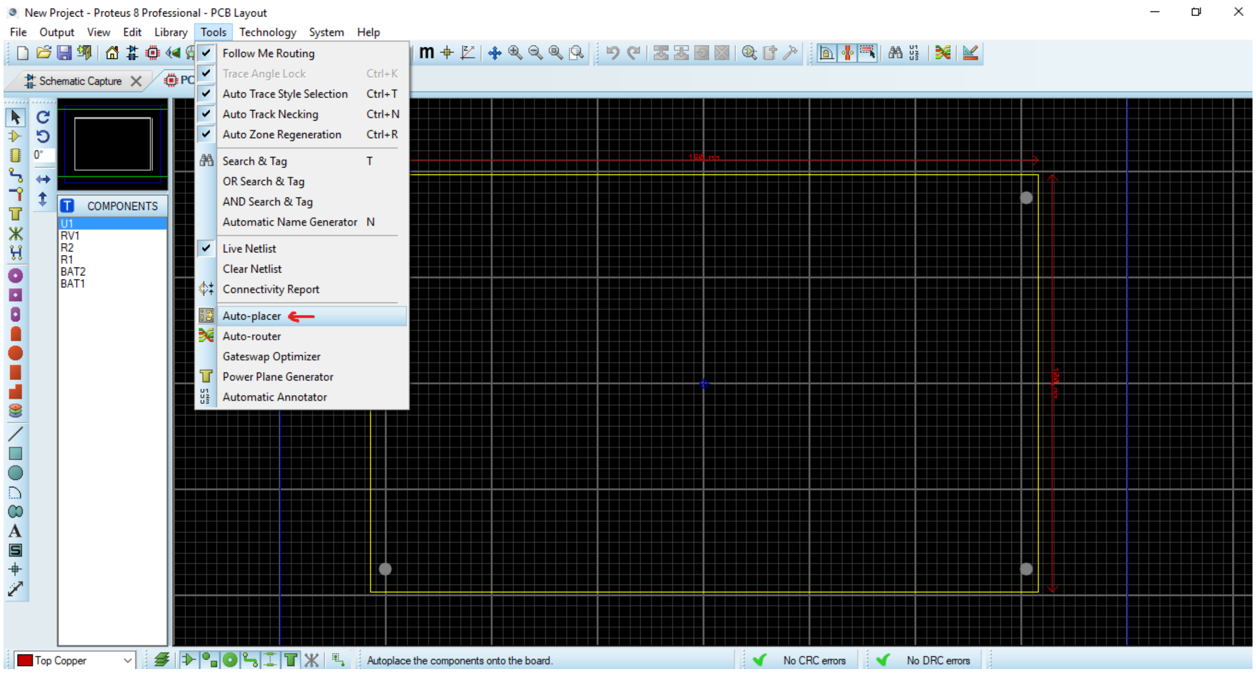
Now if you want to see the waves on oscilloscope you can select it from Instruments where you can also get voltmeter, ammeter etc



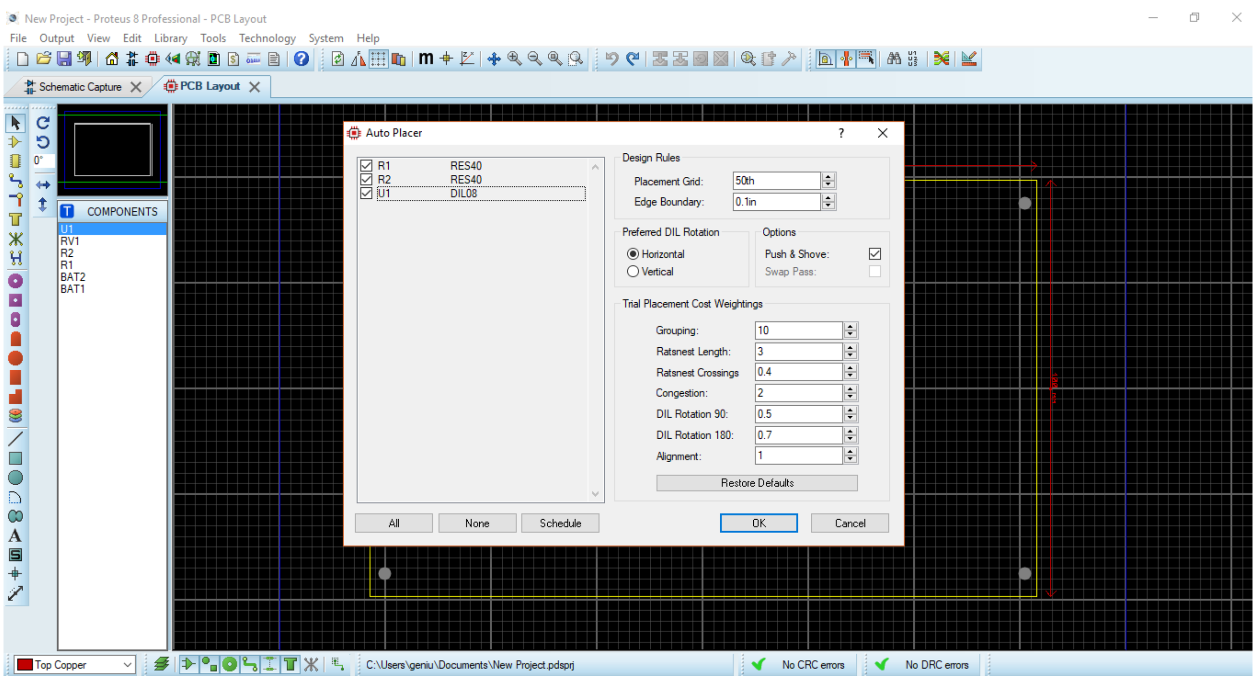
Here is the oscilloscope simulation



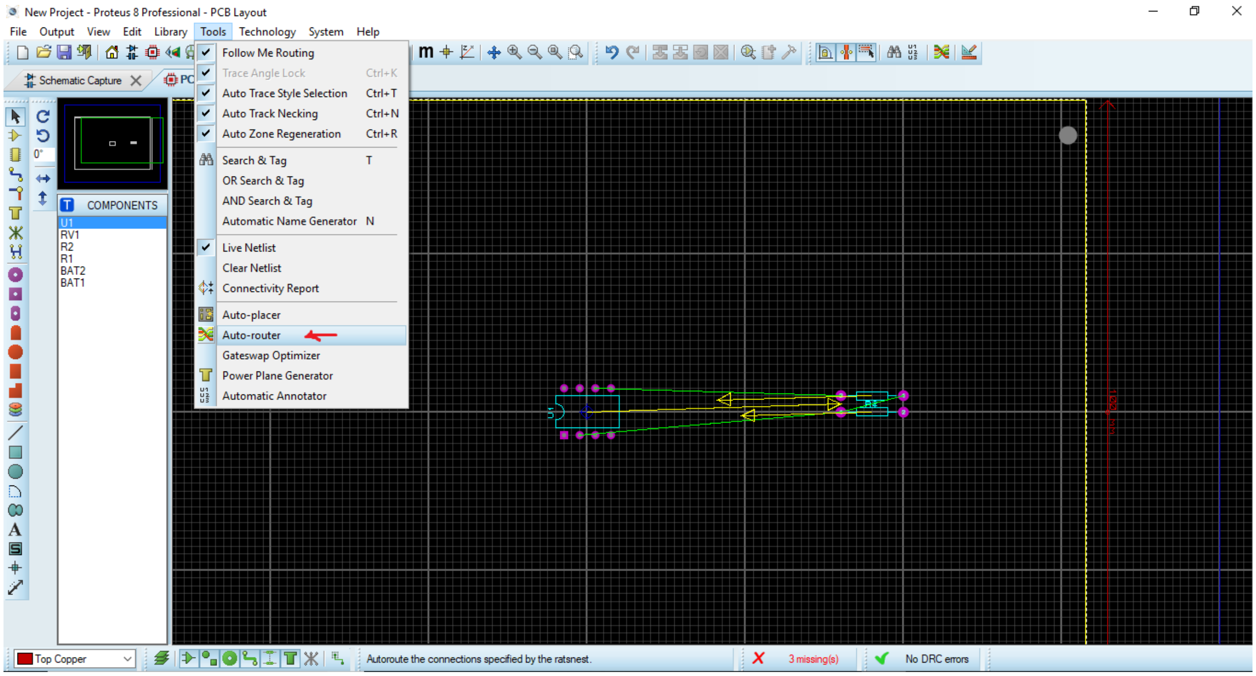
For PCB layout go to tools and click on auto placer



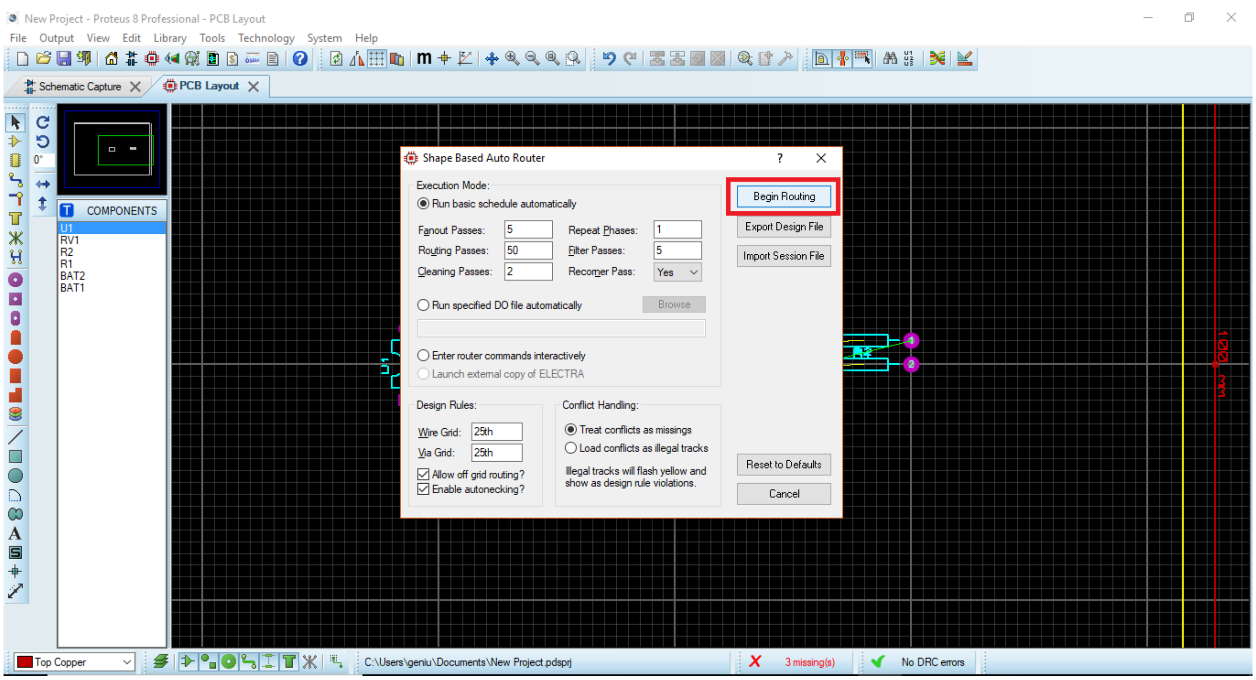
Then you will get this window and select all components then press ok



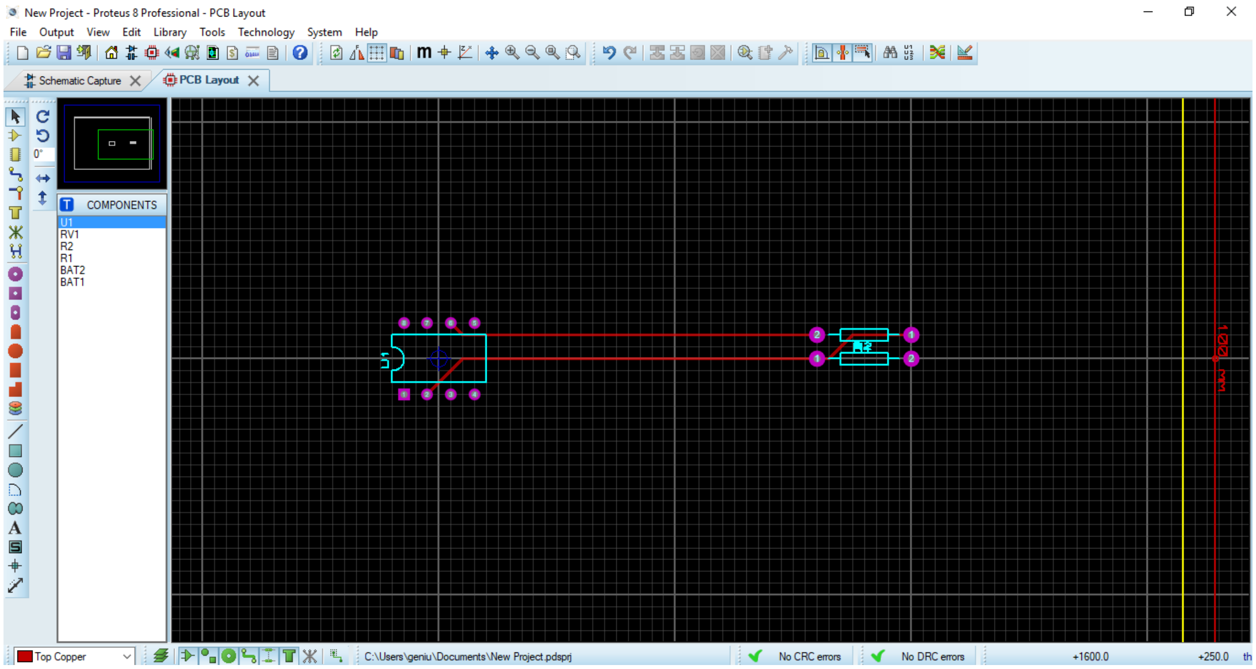
Now for routing purpose go to tools and select auto router



Click on begin routing



You will get the output result


New Project - Proteus 8 Professional - PCB Layout
File Output View Edit Library Tools Technology System Help
Schematic Capture
PCB Layout
COMPONENTS
U1
RV1
R2
R1
BAT2
BAT1
Top Copper
C:\Users\geniu\Documents\New Project.pdsprj
No CRC errors
No DRC errors
+1600.0
+250.0

Experiment No. 3: Diode Characteristics

Objectives:

To study the characteristics of silicon and germanium diodes.

Equipment:

DC power supply

Function Generator

Digital Multimeter (DMM)

Components

Diodes: Silicon (D1N4002), Germanium (D1N4148)

Resistors: 1kΩ, 1MΩ

Theory:

Diode:

A diode is a two-terminal electronic component that conducts current primarily in one direction; it has low resistance in one direction, and high resistance in the other.

Characteristics:

- Three important characteristics of a diode are,
- first of all, the forward voltage drop. Under a forward bias condition, this should be about 0.7 volts.
- Then there is the reverse voltage drop. In the reverse, when we reverse bias the diode the depletion layer widens and usually, the applied voltages are felt across the diode.
- Then there is the reverse breakdown voltage. Reverse voltage drop that will reverse current flow and in most cases destroy the diode.

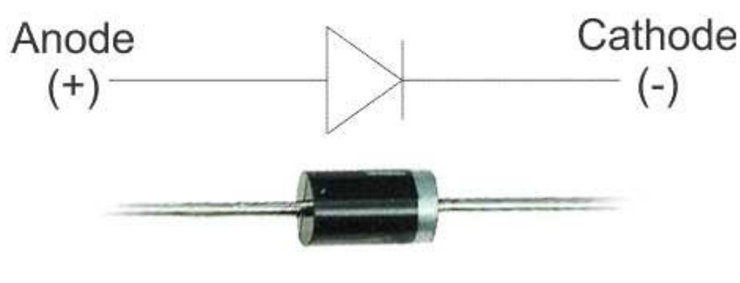


Figure 11 Diode

Function Generator

A function generator is usually a piece of electronic test equipment or software used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms produced by the function generator are the sine, square, triangular and saw tooth shapes.

Figure 2 Function Generator

Power Supply

A *power supply* is an electronic device that supplies electric energy to an electrical load. The primary function of a *power supply* is to convert one form of electrical energy to another and, as a result *power* supplies are sometimes referred to as electric *power* converters.

Figure 3 DC Power Supply

Digital Multimeter

A digital multimeter (DMM) is a test tool used to measure two or more electrical values principally voltage (volts), current (amps) and resistance (ohms). It is a standard diagnostic tool for technicians in the electrical/electronic industries.

Figure 4 Digital Multimeter

Procedure

Part A: Forward-bias Diode Characteristics

1. Construct the circuit of *Fig. 3.1* with the supply (E) is set at 0 V. Record the measured value of the resistor.

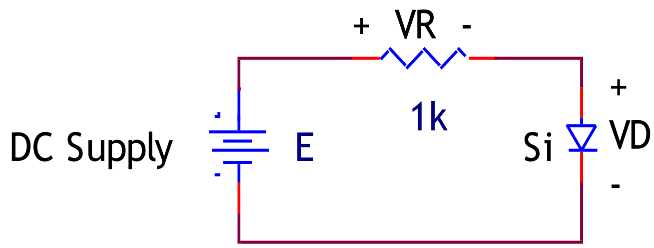


Fig. 3.1

2. Increase the supply voltage until V_D reads 0.1 V. Then measure current I_D and record the results in Table 3.1
3. Repeat step 2 for the remaining settings of V_D shown in the Table 3.1.
   Plot on a graph paper I_D versus V_D for the silicon. Complete the curves by extending the lower region of each curve to the intersection of the axis at I_D = 0 mA and V_D = 0 V.

Part B: Reverse-bias Diode Characteristics

1. Construct the circuit of *Fig. 3.2* with E is set at 20V. Record the measured value of the resistor.

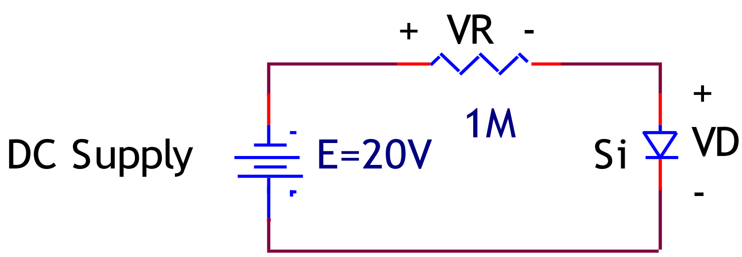
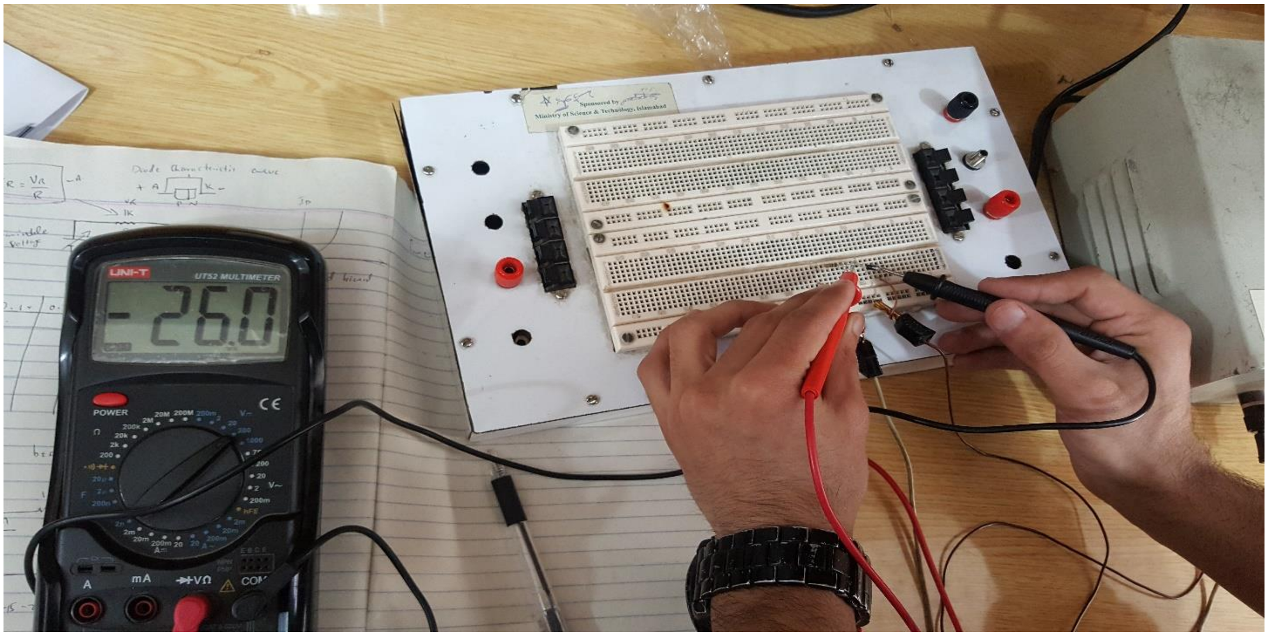


Fig. 3.2

2. Measure the voltage V_D. Measure the reverse saturation current, I_s.

Results and Calculations:



Part A (Forward Bias):

R (measured) = **1k Ω**

I_D (measured). Fill in Table 3.1

V_D (V)	0.13	0.21	0.37	0.42	0.51	0.60
V_R (V)	0.5 mV	0.7 mV	14.5 mV	26.2 mV	2V	12.72V
I_D (mA)	0.0005mA	0.0007mA	0.0145mA	0.0262mA	2mA	12.72mA

Table 3.1(Silicon Diode)

Part B (Reverse Bias):

R (measured) = **1M Ω**

<u>Silicon Diode</u>

V_D (V)	-10.77	-15.21	-20.8	-25.0
V_R (V)	-4.3 mV	-5.3 mV	-5.6 mV	-5.9 mV

I_D (nA)	-4.3 nA	-5.3 nA	-5.6 nA	-5.9 nA

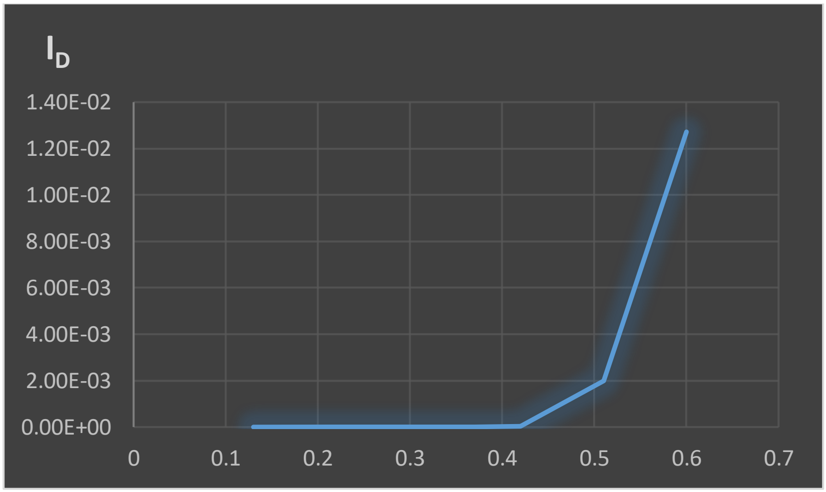


Figure 4 Forward Biased

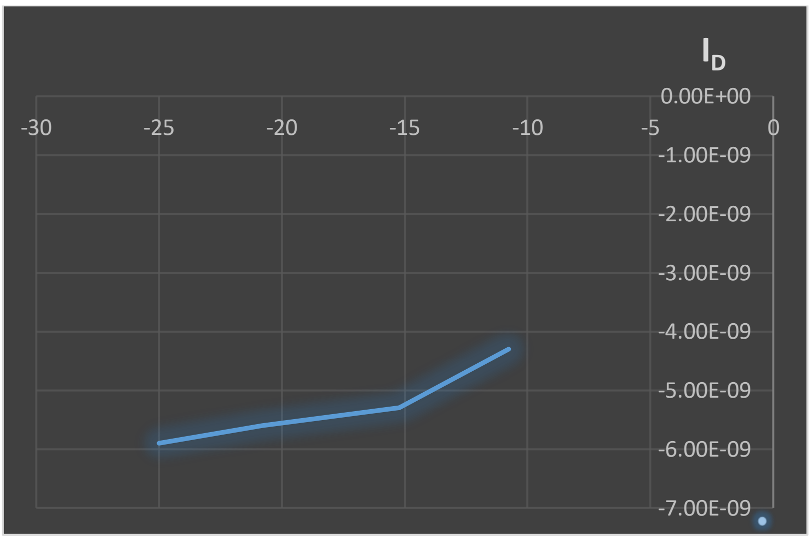


Figure 5 Reverse Biased

Conclusion:

Hence we practically observed the characteristics of diode in both forward and reversed biased using digital multimeter. In forward biased we saw the gradual increase in current I_D with the increase in voltage V_D. whereas in reverse biased we selected V_D from -10.77V to -25.0V on which we got the values of current I_D from -4.3 nA to -5.9 nA.

Experiment No. 4: Series and Parallel Diodes

Objectives:

To study the characteristics of silicon diodes in series and in parallel.

Equipment:

DC power supply

Function Generator

Digital Multimeter (DMM)

Components

Diodes: Silicon (D1N4002)

Resistor: 1.8 kΩ,

Theory:

Diode:

A diode is a two-terminal electronic component that conducts current primarily in one direction; it has low resistance in one direction, and high resistance in the other.

Series Configuration

Series connection means a side by side connection. When two components are connected in series, they have one common junction. The variation of voltage and current in a series connection is as follows:

- Potential difference across every component is different.
- The current across every component connected in series remains the same.

Diode Characteristics in Series Configuration

When connected in series, we observe the following properties to hold true among the diodes:

- Resultant diode's forward voltage increases.
- Reverse blocking capabilities of diodes are increased in series connection.

Parallel configuration

Parallel connection means the components are connected across each other, having two common points. Current differs across each component while voltage drop is same. When diodes are connected in parallel, this same trend is observed.

Diode Characteristics in Parallel Configuration

- Current carrying capacity increases.
- No conduction in resultant diode in both sides.

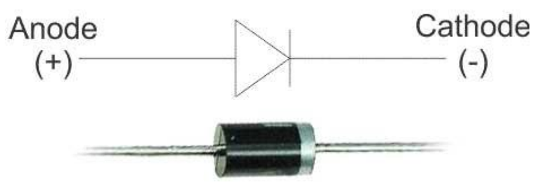


Figure 12 Diode

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Figure 2 Function Generator

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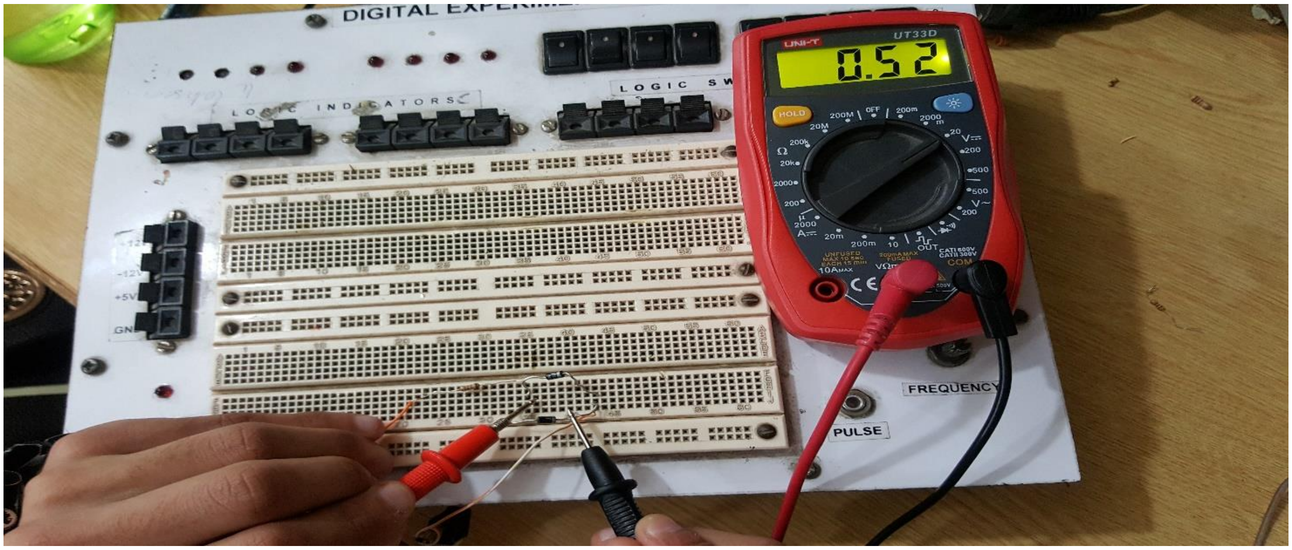
Digital Multimeter

A digital multimeter (DMM) is a test tool used to measure two or more electrical values principally voltage (volts), current (amps) and resistance (ohms). It is a standard diagnostic tool for technicians in the electrical/electronic industries.

Figure 4 Digital Multimeter

Procedure



Part 1: Diode in Series

4. Construct the circuit of *Fig.1.0* with the supply (E) is set at 5 V. Record the measured value of the resistor.

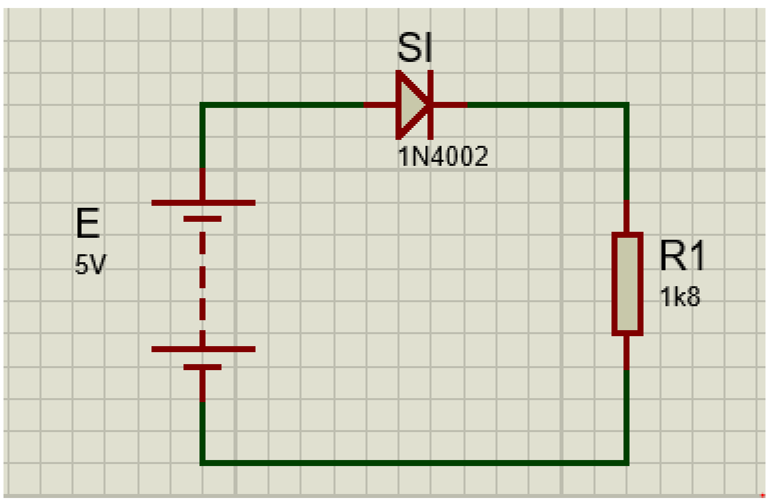


Figure 1.0

5. Measure the value of voltage across diode V_D and V_O.
6. Also calculate the current I_D.

Results:

Calculated:

Supplied Voltage = **5.22 V**

Voltage V_D = **0.63 V**

Resistance R **= 1.76 kΩ**

Voltage V_O **= 5.22 – 0.63 = 4.59 V**

Current I_D = **2.60 mA**

Measured:

Supplied Voltage = **5.22 V**

Voltage V_D = **0.56 V**

Resistance R = **1.76 kΩ**

Voltage V_O = **4.67 V**

Current I_D = **2.65 mA**

Part 2: 2 Diodes in Series

1. Construct the circuit of *Fig.1.1* with the supply (E) is set at 5 V. Record the measured value of the resistor.

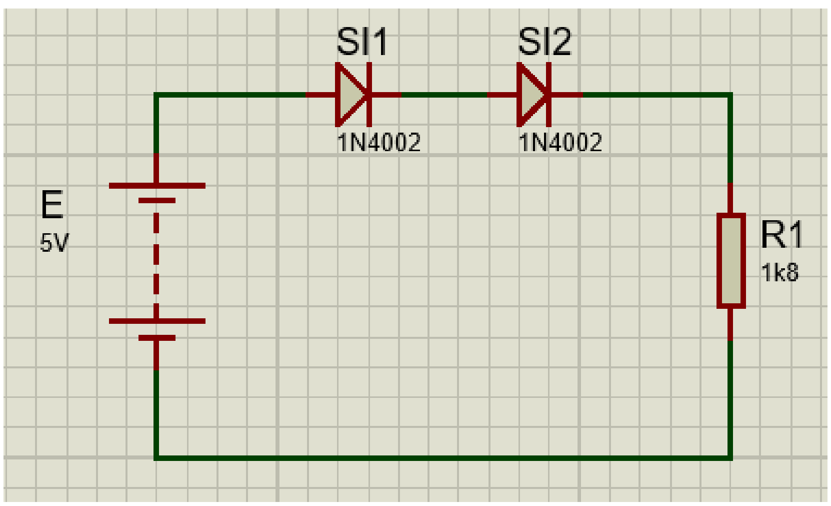


Figure 1.1

2. Measure the value of voltage across diode V_D and V_O.
3. Also calculate the current $I_{D.}$

Results:

Calculated:

Supplied Voltage = **5.22 V**

Voltage V_{T1} = **0.63 V**

Voltage V_{T2} = **0.60 V**

Voltage $V_D = V_{T1} + V_{T2} =$ **1.23 V**

Resistance R = **1.76 kΩ**

Voltage V_O **= 5.22 – 1.23 = 3.99 V**

Current I_D **= 2.62 mA**

Measured:

Supplied Voltage = **5.22 V**

Voltage $V_D =$ **1.23 V**

Resistance R = **1.76 kΩ**

Voltage V_O **= 4.13 V**

Current I_D **= 2.34 mA**

--

Part 3: Diodes in Parallel

1. Construct the circuit of *Fig.1.3* with the supply (E) is set at 5 V. Record the measured value of the resistor.

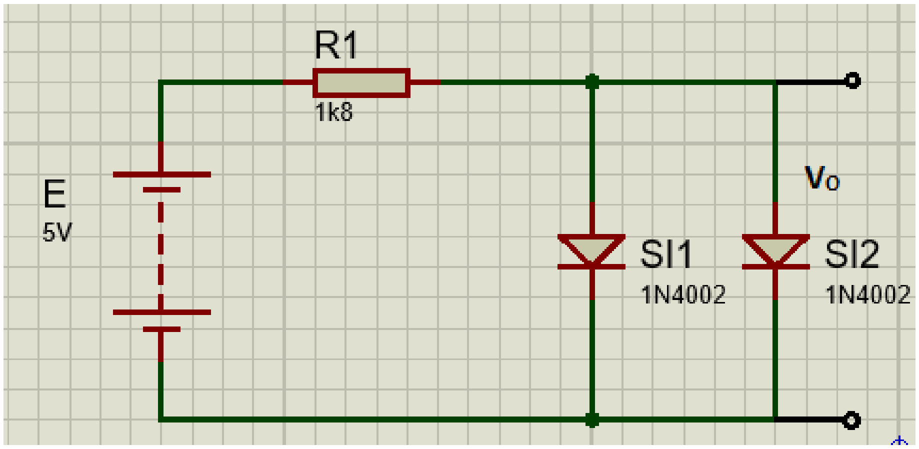


Figure 1.3

2. Measure the value of voltage across diode V_D and V_O.
3. Also calculate the current I_D.

Results:

Calculated:

Supplied Voltage = **5.22 V**

Voltage V_{T1} = **0.63 V**

Voltage V_{T2} = **0.60 V**

Voltage V = $V_{T1} + V_{T2}$ = **1.23 V**

Resistance R **= 1.76 kΩ**

Voltage V_O **= 0.60 V**

Voltage V_R **= 5.22 – 0.60 = 4.62 V**

Measured:

Voltage V_O = **0.53 V**

Voltage V_R **= 4.70 V**

Part 4: AND Gate

1. Construct the circuit of *Fig.1.4* and verify the truth table.

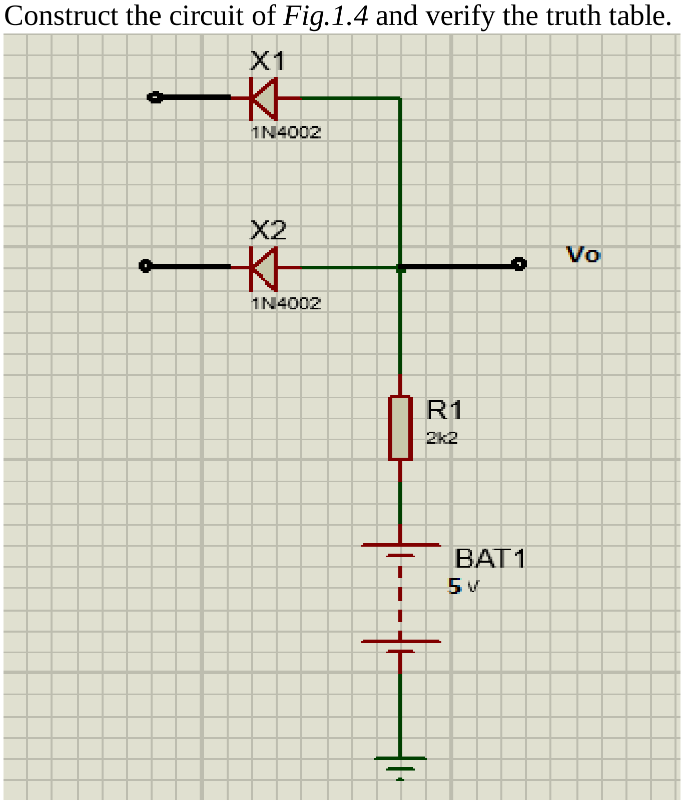


Figure 1.4 AND Gate

TRUTH TABLE

X_1	X_2	V_0
0	0	0
0	1	0
1	0	0
1	1	1

4.1 When X1=0 , X2=0

Calculated

Voltage V_{T1} **= 0.49 V**
Voltage V_{T2} **= 0.50 V**
Resistor R **= 2.17 kΩ**
Voltage V_{DC} **= 5.25 V**
Voltage V_o **= 0.49 V**

Measured:

Voltage V_o **= 0.51 V**

4.2 When X1=5.25V , X2=0

Calculated

Voltage V_{T2} **= 0.50 V**
Voltage V_{DC} **= 5.25 V**
Voltage V_o **= 0.50 V**

Measured:

Voltage V_o **= 0.55 V**

4.3 When X1 = 5.25V , X2 = 5.25V

Calculated

Voltage V_{DC} **= 5.25 V**
Voltage V_o **= 5.25 V**

Measured:

Voltage V_o = **5.22 V**

Part 5: Bridge Rectifier

1. Construct the circuit of *Fig.1.5* with the supply (E) is set at 5 V. Record the calculated and measured values of the voltages.

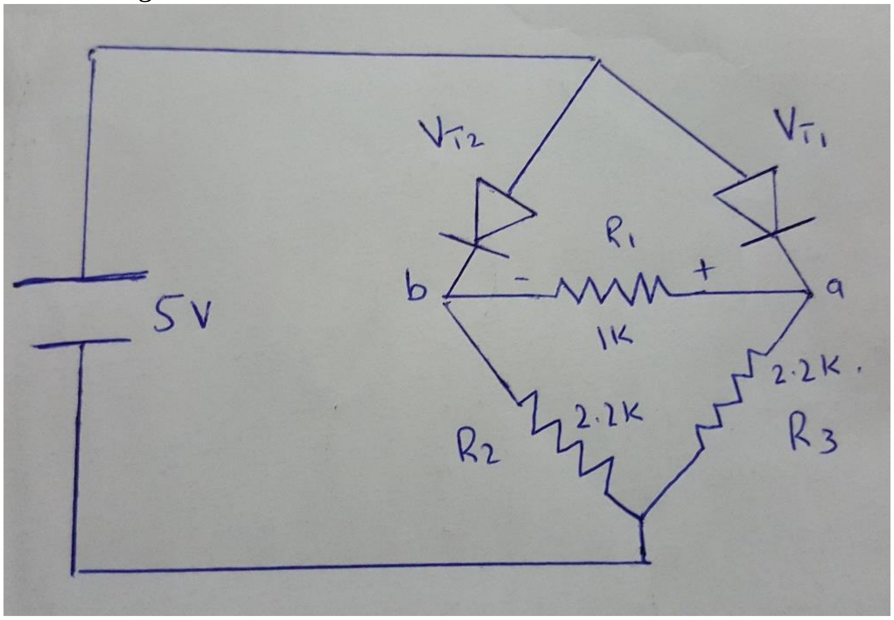
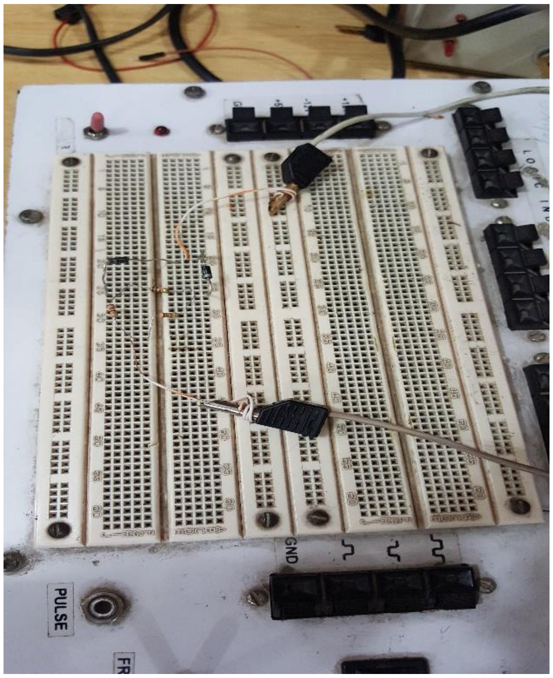


Figure 1.5 Bridge Rectifier



Calculated

Resistor R1 = **1 kΩ**

Resistor R2 = **2.17 kΩ**

Resistor R3 = **2.17 kΩ**

Voltage V_{T1} = **0.49 V**

Voltage V_{T2} = **0.50 V**

Voltage V_{DC} = **5.25 V**

Voltage V_a = **5.25V- 0.49 V**

Voltage V_b = **5.25V- 0.50 V**

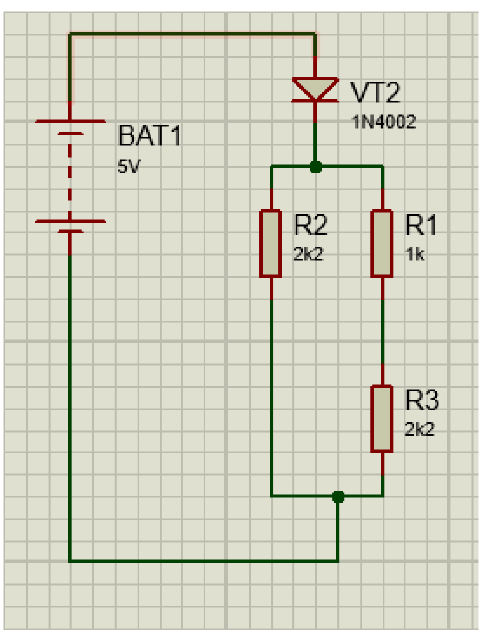
Voltage V_o = V_a **-** V_b **= 5.~~25~~V- 0.49 V - 5. ~~25~~V- 0.50 V = 0.01V**

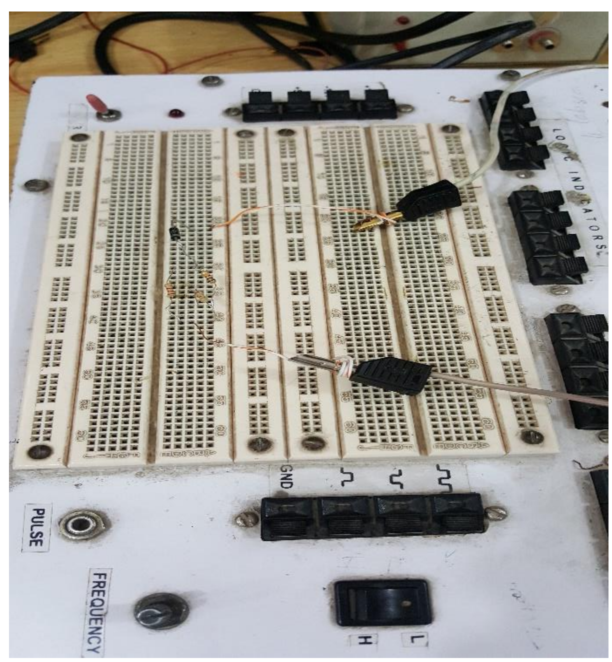
Measured:

Voltage V_o = **0.01 V**

Part B:

When V_{T1} is open circuit





Calculated:

$$Vo = \frac{R1}{R1+R3}\ (5.25 - V_{T2}) = \mathbf{1.44\ V}$$

$$V_{R3} = \frac{R3}{R1+R3}\ (5.25 - V_{T1}) = \mathbf{3.166\ V}$$

Measured:

V_O = **1.48 V**

V_{R3} = **3.17 V**

Conclusion:

Hence we practically observed the behavior of diodes in both series and parallel. We saw that,

- Connecting diodes in series will increase the forward voltage of the resultant diode.
- Connecting diodes in series will cause an open circuit until peak inverse voltage (smallest diode) is applied on total resultant.

- Connecting diodes in parallel will increase the current carrying capacity of the diode.
- Connecting diodes in parallel will not get you a resultant diode conduction in both sides.

Experiment No. 5: Diode As Rectifier

Objectives:

To become familiar with Full wave and Half wave rectification.

Equipment:

Oscilloscope

Function Generator

Digital Multimeter (DMM)

Components

Diodes: Silicon (D1N4002)

Resistor: 2.2 kΩ,

Theory:

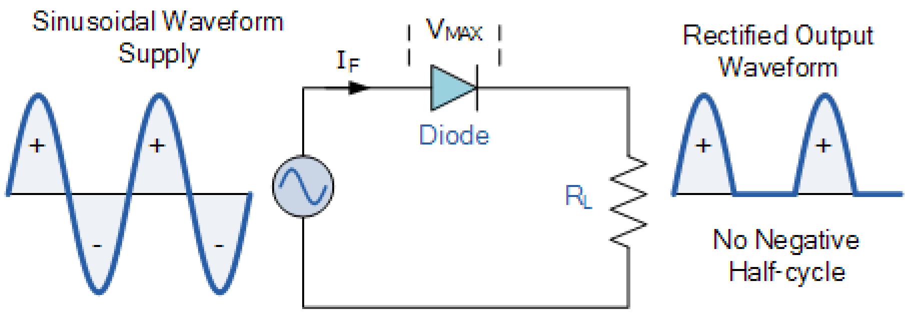
Diode:

A diode is a two-terminal electronic component that conducts current primarily in one direction; it has low resistance in one direction, and high resistance in the other.

A widely used application of this feature and diodes in general is in the conversion of an alternating voltage (AC) into a continuous voltage (DC). In other words, *Rectification.*

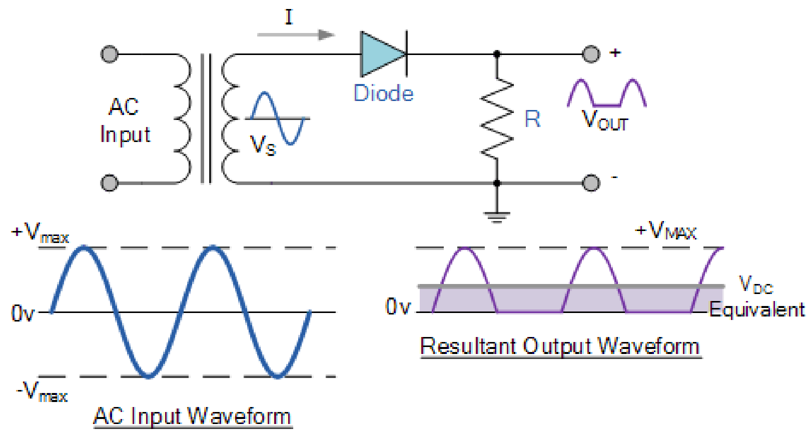
Power diodes can be used individually as above or connected together to produce a variety of rectifier circuits such as "Half-Wave", "Full-Wave" or as "Bridge Rectifiers".

Half Wave Rectification

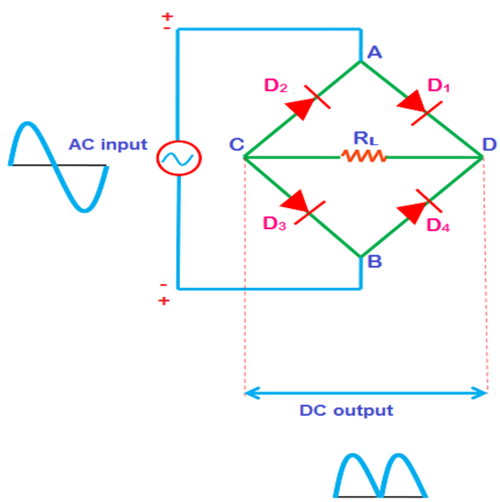


A rectifier is a circuit which converts the *Alternating Current* (AC) input power into a *Direct Current* (DC) output power. The input power supply may be either a single-phase or a multi-phase supply with the simplest of all the rectifier circuits being that of the **Half Wave Rectifier**.

The power diode in a half wave rectifier circuit passes just one half of each complete sine wave of the AC supply in order to convert it into a DC supply. Then this type of circuit is called a "half-wave" rectifier because it passes only half of the incoming AC power supply as shown.

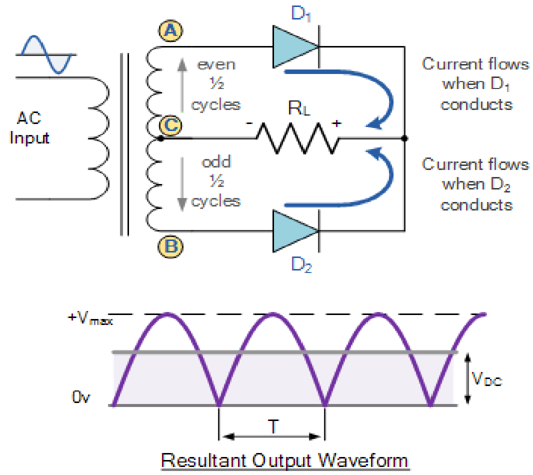


Full Wave Rectifier Circuit



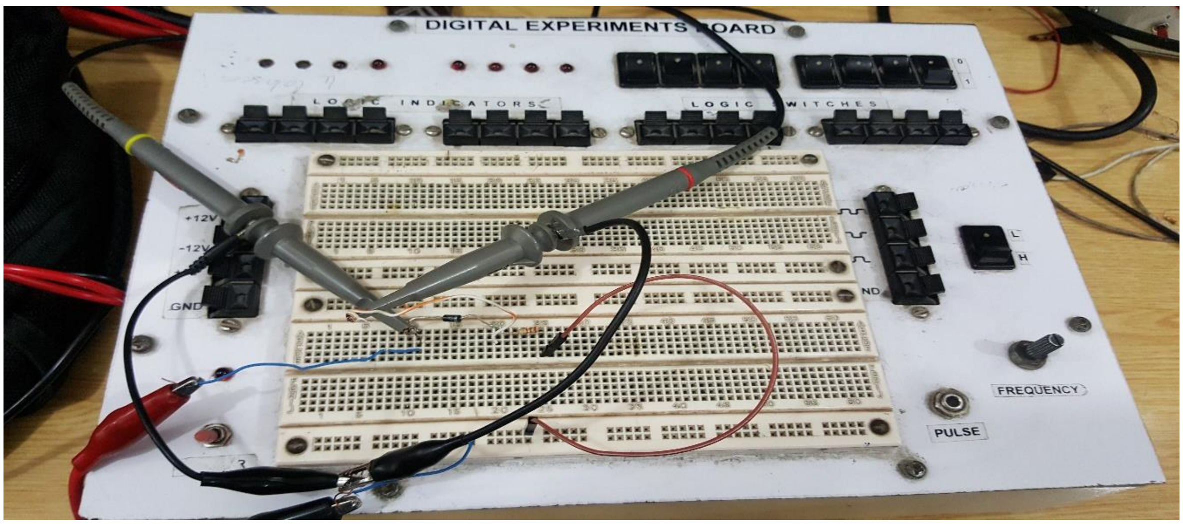
The full wave rectifier circuit consists of two *power diodes* connected to a single load resistance (R_L) with each diode taking it in turn to supply current to the load. When point A of the transformer is positive with respect to point C, diode D_1 conducts in the forward direction as indicated by the arrows.

When point B is positive (in the negative half of the cycle) with respect to point C, diode D_2 conducts in the forward direction and the current flowing through resistor R is in the same direction for both half-cycles. As the output voltage across the resistor R is the phasor sum of the two waveforms combined, this type of full wave rectifier circuit is also known as a “bi-phase” circuit.

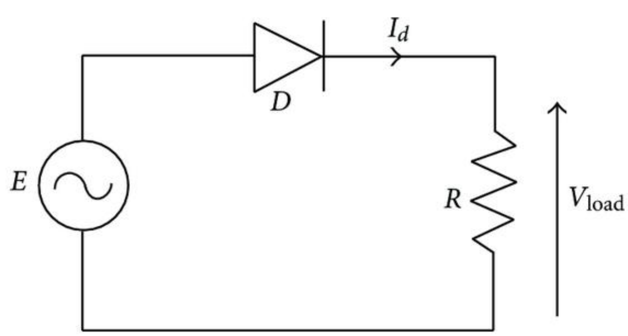


Procedure

Part 1



1. Construct the circuit of *Fig* . Record the measured values as well as calculated values.



Results:

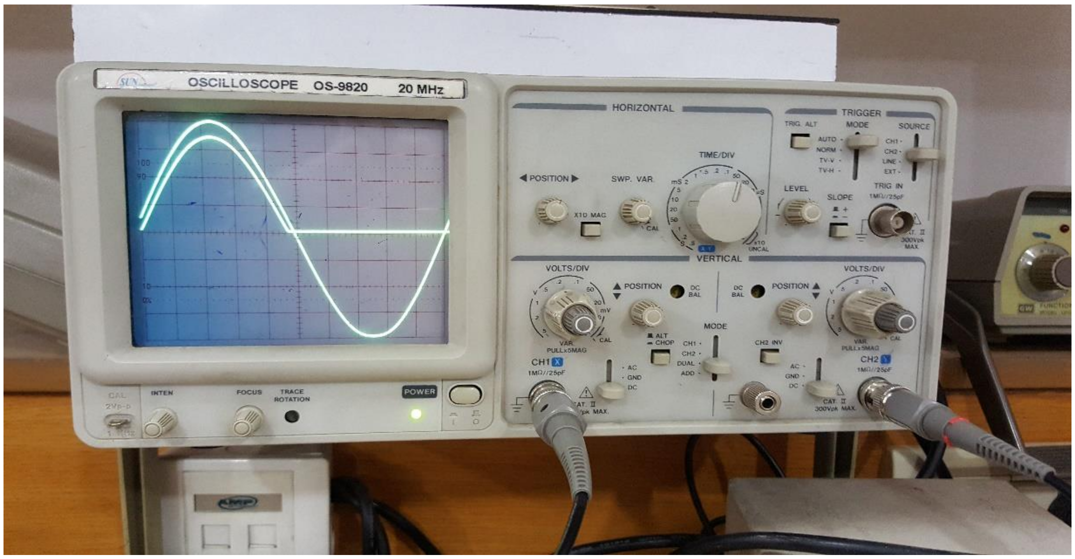
Calculated:

V_T = **0.49 V**

Voltage $V_D = \frac{Vm - VT}{\pi} = \frac{4 - 0.49}{\pi}$ =1.117 V

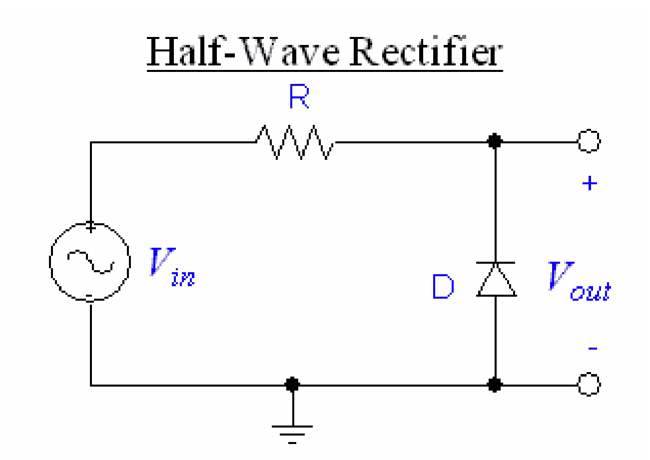
Measured:

Voltage V_D = **1V**



Part 2:

Construct the circuit of *Fig* . Record the measured values as well as calculated values.



Results:

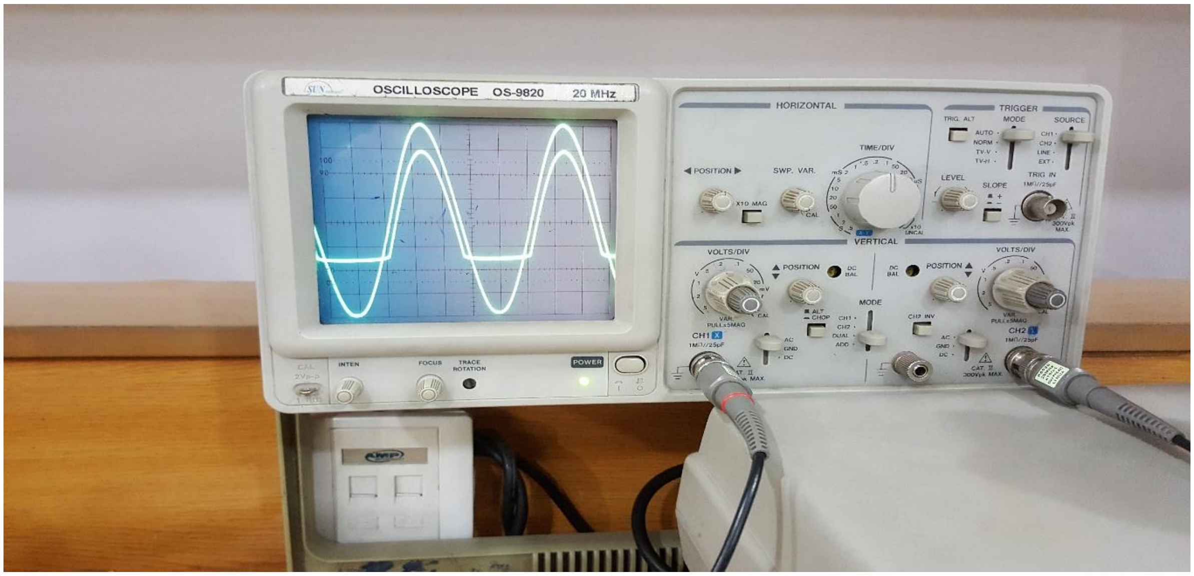
Calculated:

Voltage V_{T1} = **0.51 V**

Voltage $V_D = \frac{Total\ Area}{2\pi} = \frac{Vm}{\pi} - \frac{Vt}{2} = 0.945$ V

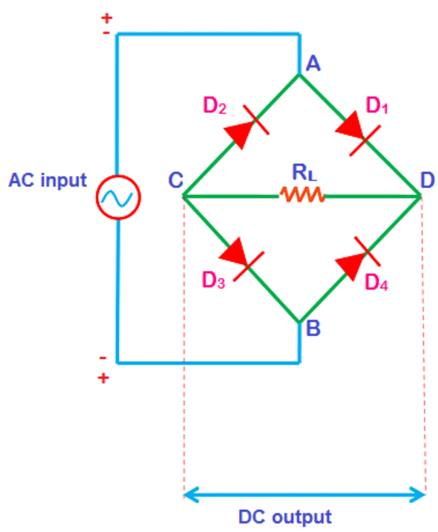
Measured:

Voltage V_D = **0.93 V**



Part 3:

4. Construct the circuit of *Fig.* Record the measured as well as calculated values.



Results:

Calculated:

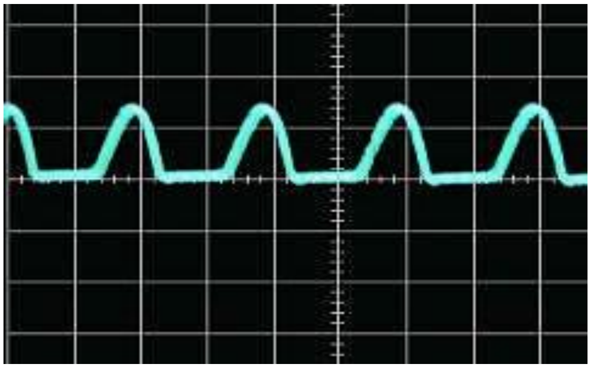
Voltage $V_T = \frac{VT1 + VT2 + VT3 + VT4}{4} = 0.495$ V

Resistance R = **2.2 kΩ**

Voltage $V_D = \frac{2}{\pi}(Vm - 2Vt)$ = 0.636 (4 – 2(0.495)) =1.91 V

Measured:

Voltage V_D = **1.58 V**

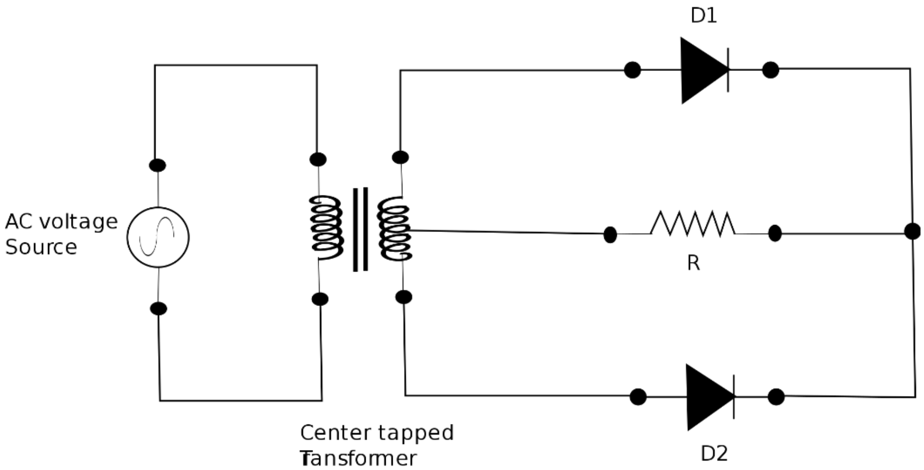


Percentage Error:

(V_{DC} **Cal -** V_{DC} **Measured/** V_{DC} **Cal) x 100 = 17.7 %**

Part 4: Center Tapped Rectifier

1. Construct the circuit of *Fig.* Record the measured as well as calculated values.



Results:

Calculated:

Voltage $V_T = \frac{VT1 + VT2}{2}$ = 0.485 V

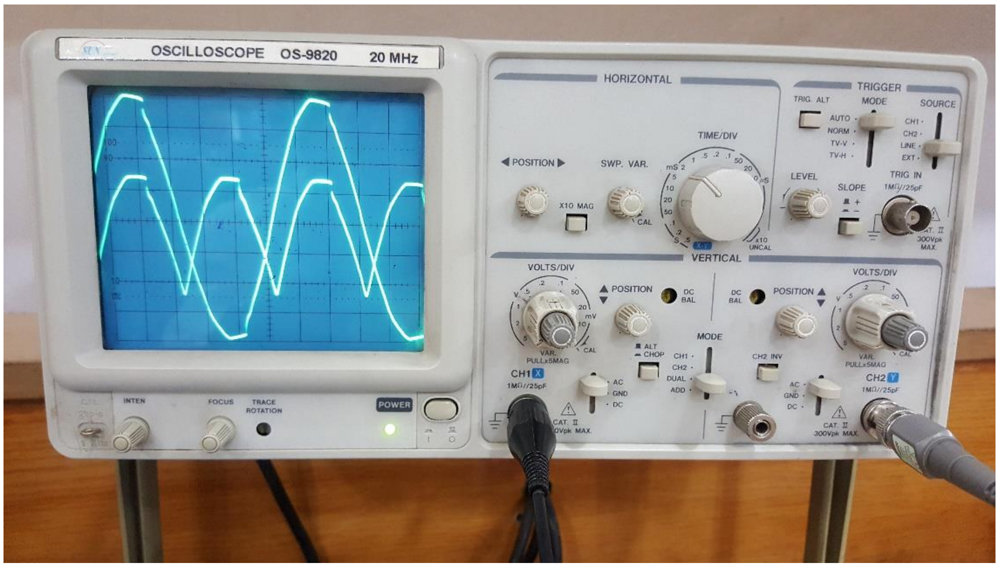
Resistance R = **3.3 kΩ**

Vm = $\sqrt{2}\,Vrms$ = $\sqrt{2}\,(14.2) = \mathbf{0.585\ V}$

Voltage V_D = $\frac{2}{\pi}\,(Vm - Vt)$ = 0.636 (20.08 – 0.485) =**12.46 V**

Measured:

Voltage V_D **= 11.90 V**



Percentage Error:

(V_{DC} **Cal -** V_{DC} **Measured/** V_{DC} **Cal) x 100 = 4.49 %**

Conclusion:

Hence we practically observed the behavior of diodes as rectifiers.

- In half wave rectification we saw that only half of every cycle of an alternating current is made to flow in one direction only.
- In full wave rectification we saw that it converted both half cycles of the AC signal into pulsating DC signal.

Experiment No. 6: Parallel Clippers

Objectives:

To calculate and measure the output voltages of Parallel & Series clipper circuits.

Equipment:

Oscilloscope

Function Generator

Digital Multimeter (DMM)

DC power supply

Components

Diode: Silicon (D1N4002)

Resistors: 2.2kΩ, 3.3kΩ

Theory:

Diode:

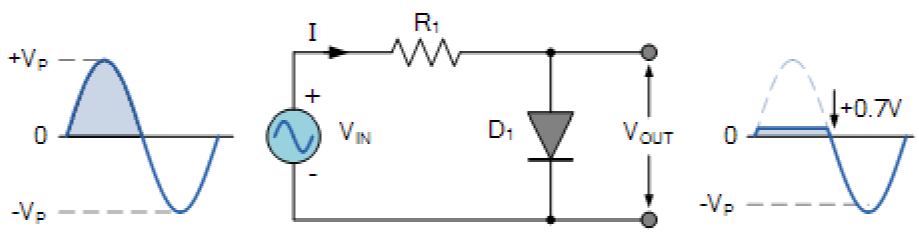
A diode is a two-terminal electronic component that conducts current primarily in one direction; it has low resistance in one direction, and high resistance in the other.

Clipper:

a **clipper** is a device designed to prevent the output of a circuit from exceeding a predetermined voltage level without distorting the remaining part of the applied waveform.

A clipping circuit consists of linear elements like resistors and non-linear elements like junction diodes or transistors, but it does not contain energy-storage elements like capacitors. Clipping circuits are used to select for purposes of transmission, that part of a signal wave form which lies above or below a certain reference voltage level.

Thus a clipper circuit can remove certain portions of an arbitrary waveform near the positive or negative peaks. Clipping may be achieved either at one level or two levels. Usually under the section of clipping, there is a change brought about in the wave shape of the signal.



Procedure:

Part A: Parallel Clippers

Construct the circuit in *Fig.1*. The input signal is an 16 V p-p square wave at frequency of 1000 Hz. Record the measured resistance value.

Set the oscilloscope in DC mode.

Put the oscilloscope probes at function generator and sketch the input waveform obtained.

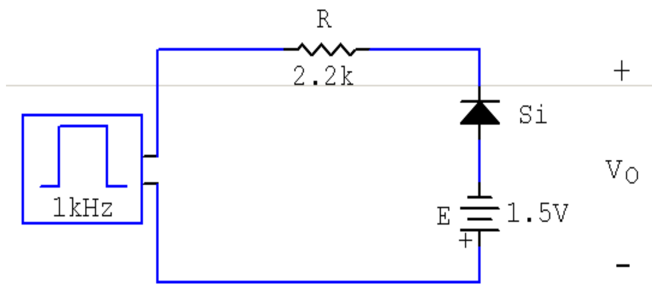
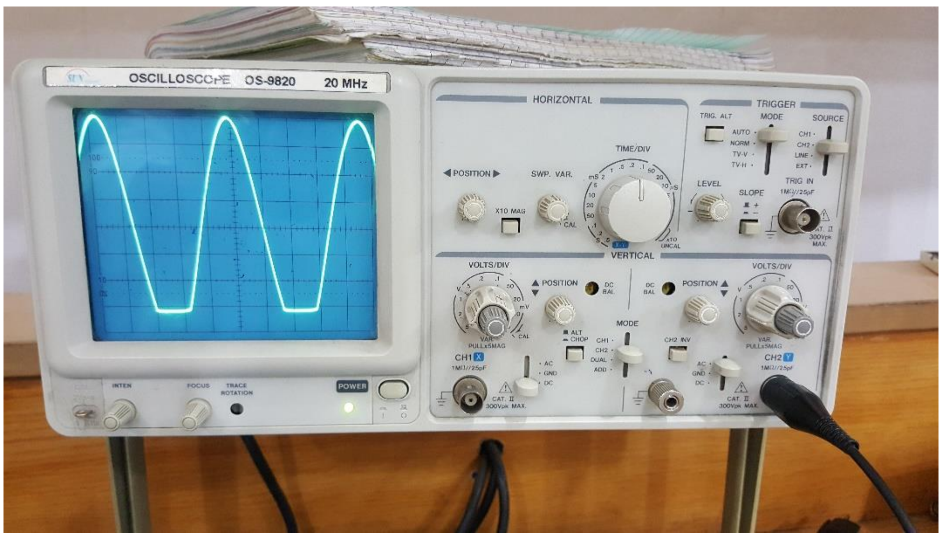


Figure 13



Results:

Calculated

Resistor R = **2.14KΩ**

V_T = **0.49 V**

E = **-5.21 V**

V_O = -5.21 – 0.49 = **-5.7 V**

Measured

V_O = **-6.1 V**

%error = **1.93%**

Part B: Series Clippers:-

Construct the circuit in *Fig.2*. The input signal is an 8 V p-p square wave at frequency of 1000 Hz. Record the measured resistance value.

Set the oscilloscope in DC mode.

Put the oscilloscope probes at function generator and sketch the input waveform obtained.

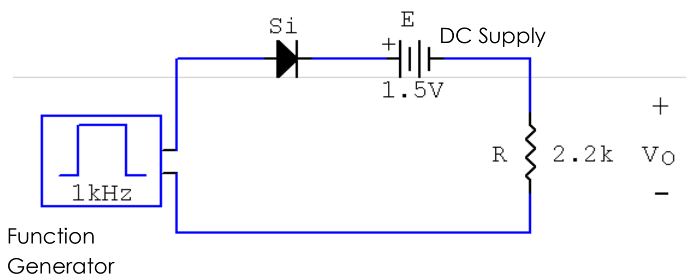
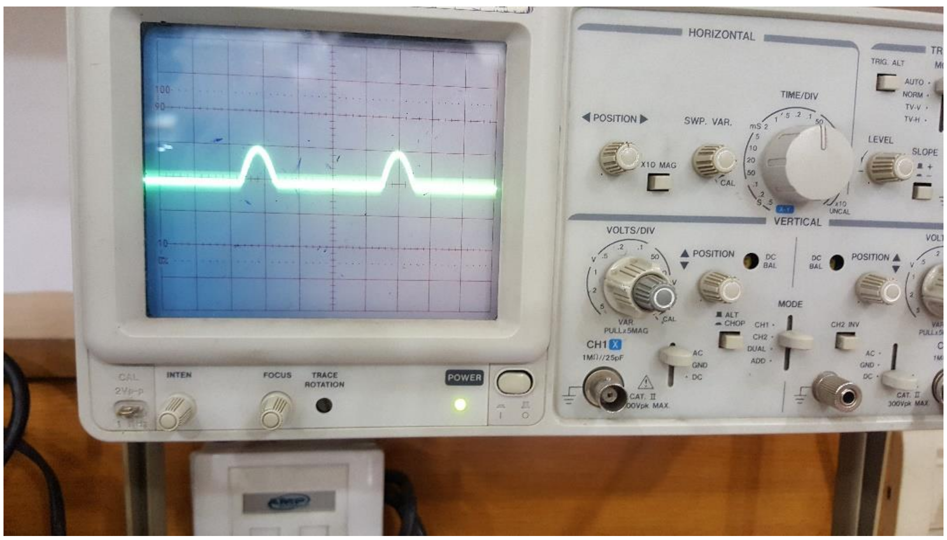


Figure 14



Results:

Calculated

Resistor R = **1.01 KΩ**

V_T = **0.49 V**

DC Supply = **5.22 V**

KVL

$V_i + 0.7 + 5 + V_O = 0$

$V_O = V_I - 5.7$

$V_O = V_M - 5.7$

$V_O = 8 - 5.7 =$ **2.3 V**

8 – (5.22 + 0.49) = **2.29 V or 2.3 V**

Measured

$V_O =$ **2.3 V**

Conclusion:

- **Positive series clipper:** During positive half of cycle input voltage is positive therefore diode is reversed biased and act as open circuit hence output is zero. During negative half input voltage is negative, diode is forward biased and act as a closed switch and hence all the input voltage drop appear across the resistor.
- **Negative series clipper:** During positive half cycle of input voltage is positive therefore diode is forward biased and act as closed switch hence all the input voltage drop appear across the resistor. During negative half input voltage is negative therefore diode is reversed biased and act as open circuit hence output is zero .
- **Positive shunt clipper:** During positive half cycle of input voltage is positive therefore diode is forward biased and act as closed switch hence all the current flows through the diode and no voltage drop across the output and output is zero. During negative half cycle input voltage is negative hence diode is reverse biased and act as open switch hence there is direct connection between input and output
- **Negative shunt clipper:** During positive half cycle of input voltage is positive therefore diode is reverse biased and act as open switch hence there is direct connection between input and output hence during positive half we get output waveform. During negative half cycle input voltage is negative therefore diode is forward biased and act as closed switch hence all the current flows through the diode and no voltage drop across the output and output is zero.

Experiment No. 7: Clampers

Objectives:

To become famliar with the function and opeartion of clmpers

Equipment:

Oscilloscope

Function Generator

Digital Multimeter (DMM)

Components

Diode: Silicon (D1N4002)

Resistors: 100kΩ

Capacitor: 1 μF

Theory:

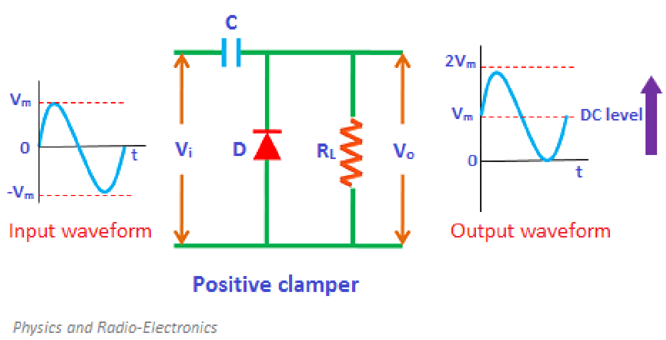
Diode:

A diode is a two-terminal electronic component that conducts current primarily in one direction; it has low resistance in one direction, and high resistance in the other.

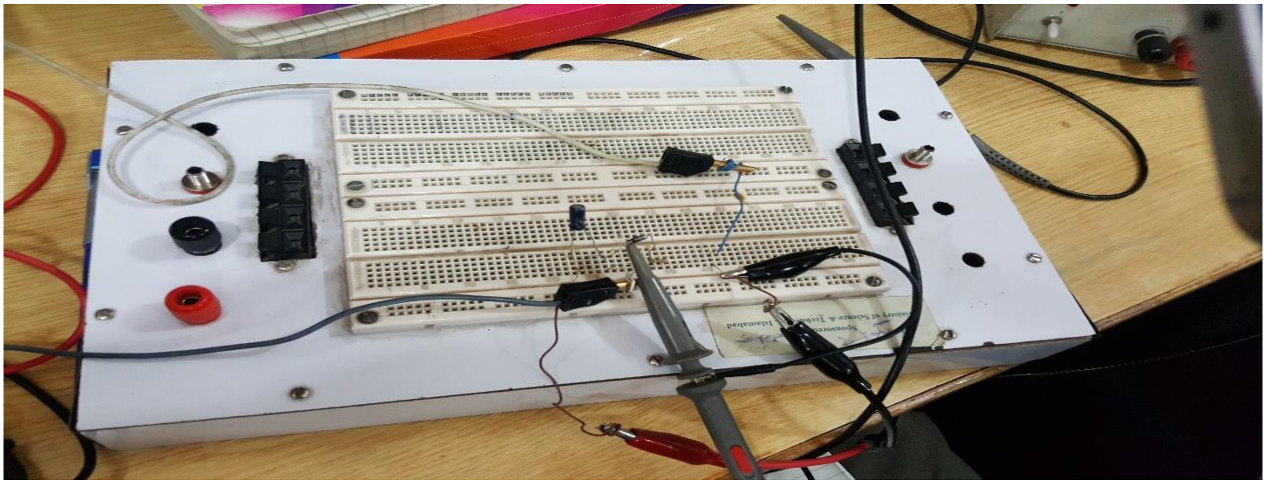
Clamper

A clamper is an electronic circuit that changes the DC level of a signal to the desired level without changing the shape of the applied signal. In other words, the clamper circuit moves the whole signal up or down to set either the positive peak or negative peak of the signal at the desired level.

The dc component is simply added to the input signal or subtracted from the input signal. A clamper circuit adds the positive dc component to the input signal to push it to the positive side. Similarly, a clamper circuit adds the negative dc component to the input signal to push it to the negative side.



Procedure:

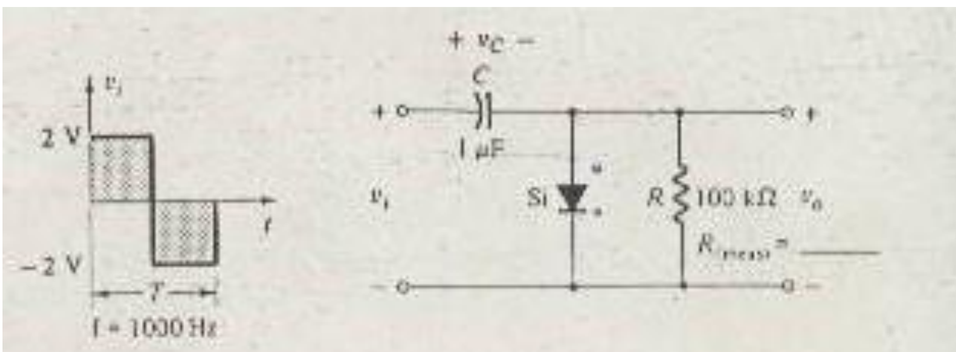


Part A: Clampers (R,C, Diode Combination)

Construct the circuit in *Fig.1*. The input signal is an 16 V p-p square wave at frequency of 1000 Hz. Record the measured resistance value.

Set the oscilloscope in DC mode.

Put the oscilloscope probes at function generator and sketch the input waveform obtained.



Results:

Calculated

Resistor R = **57.8KΩ**

V_T = **0.49 V**

$8V + V_C + V_O = 0$

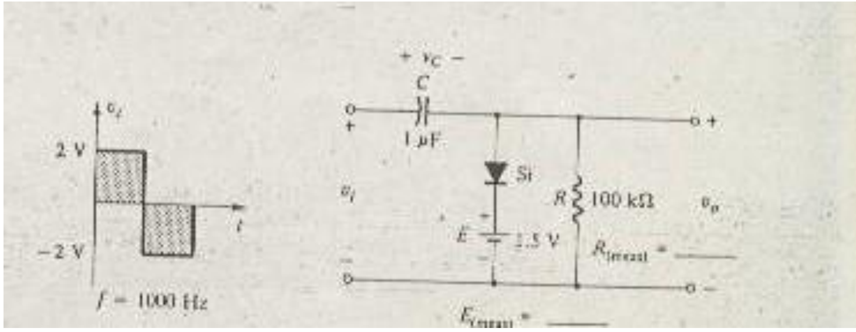
V_O = - 8 -2.29 = **-10.29 V**

Measured

V_O = **-10.19 V**

Part B Clampers with DC

Construct the network and record the measured values.



Results:

Calculated

Resistor R = **57.8 KΩ**

V_T = **0.49 V**

DC Supply = **5.22 V**

KVL

$-8V + V_c + V_T = 0$

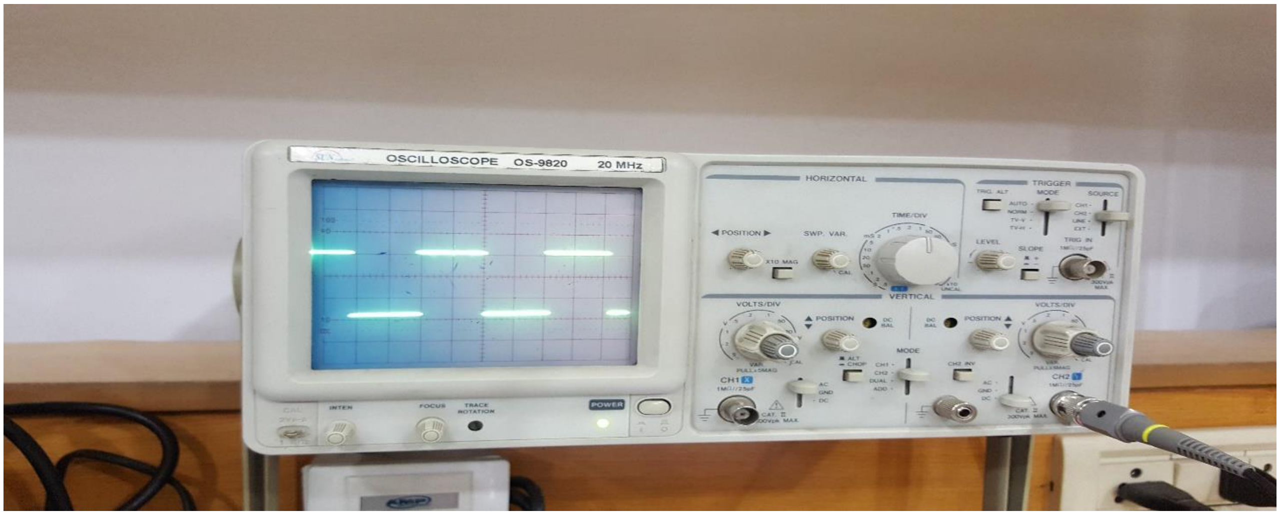
$V_C = 8-5.22-V_T$

V_C = 8-5.22-0.49 = **2.29V**

V_O = 5.22 + V_T = **5.71V**

Measured

V_O = **5.56 V**



Concusion:

1. Clampers can be used to increase the dc-value of the signal.5.

2. We connect a high value resistance in parallel with the diode to eliminate the distortion inthe output signal.6.

3. A dc source can be connected in the clamper network to change the dc-level.

Experiment No. 8: Zener Diode Characteristics

Objectives:

To study the characteristics of Zener diode.
To study the voltage regulation in Zener diode regulation circuit.

Equipment:

Oscilloscope

Function Generator

Digital Multimeter (DMM)

Components

Diode: Silicon (D1N4002)

Resistors: 100Ω

Potentiometer

Variable Voltage Source

Theory:

Diode:

A diode is a two-terminal electronic component that conducts current primarily in one direction; it has low resistance in one direction, and high resistance in the other.

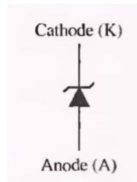
Zener diode

Zener diode is a P-N junction diode specially designed to operate in the reverse biased mode. It is acting as normal diode while forward biasing. It has a particular voltage known as break down voltage, at which the diode break downs while reverse biased. In the case of normal diodes the diode damages at the break down voltage. But zener diode is specially designed to operate in the reverse breakdown region.

The basic principle of zener diode is the zener breakdown. When a diode is heavily doped, it's depletion region will be narrow. When a high reverse voltage is applied across the junction, there will be very strong electric field at the junction. And the electron hole pair generation takes place. Thus heavy current flows. This is known as Zener break down.

So a zener diode, in a forward biased condition acts as a normal diode. In reverse biased mode, after the break down of junction current through diode increases sharply. But the voltage across it remains constant.

Zener Diode



Procedure:

Part A: Zener Diode Characteristics

Construct the circuit of *Fig. 1*. Set the DC supply to 0 V and record the measured value of R.

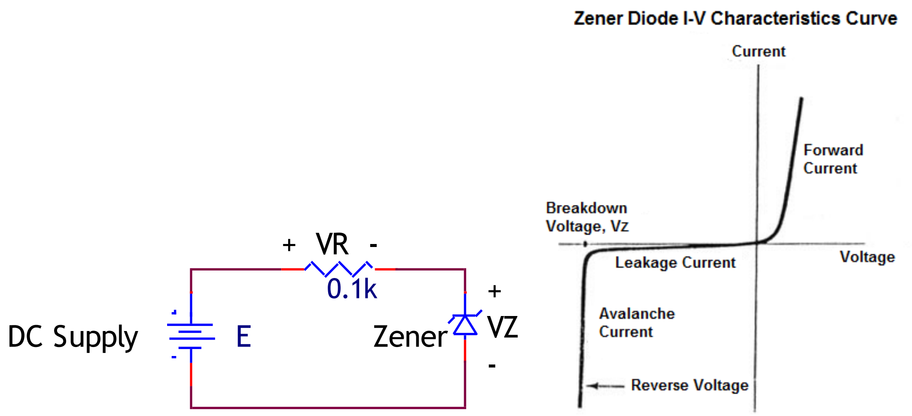


Fig. 1

Set the DC supply (E) to the values appearing in Table 4.1 and measure both V_Z and V_R. Calculate the Zener current, I_Z using the Ohm's law given in the table and complete the table.

Results:

E(V)	2.10 V	4.01 V	6.07 V	8.01 V	10.22 V	12.17 V	13.01 V	14.15 V	15.53 V
VZ	2.10 V	3.96 V	6.06 V	7.88 V	10.20 V	12.10 V	12.23 V	13.40 V	13.41 V
VR	0	0	0	0	0	0	0.06 V	0.71 V	1.56 V
IZ=VR/R	0	0	0	0	0	0	0.6 mA	7.1 mA	15.6 mA

$R_Z = V_{Z2} - V_{Z1} / I_{Z2} - I_{Z1}$

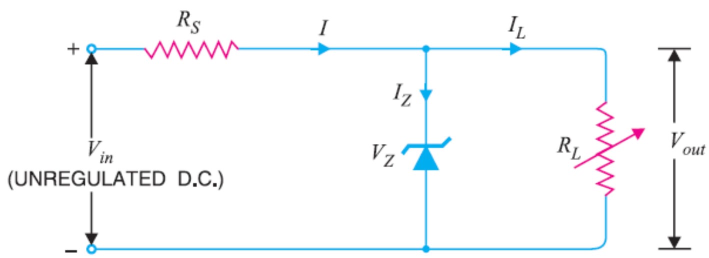
R_Z= 13.41 -12.10/0.0156 -0.0006

R_Z= **87.33Ω**

Curve on graph paper

Part B As A Regulator

Construct the circuit of *Fig. 4.2*. Record the measured value of each resistor.



Measure the value of V_L and V_R. Using the measured values, calculate the

Value for current across R, I_R, current across R_L, I_L, and current across the Zener

Diode, I_Z.

Results:

Calculated

$$\boldsymbol{RLmin = \frac{1k \times 12.33}{15 - 12.33} = 4.41\ k\Omega}$$

Measured R_{Lmin} = **4.64 kΩ**

Experiment No. 9: Characteristics of Transistors

Objectives:

1. To determine transistor type (npn, pnp), terminals and material using Digital multimeter.
2. To determine the values of the alpha and beta ratios of transistors.

Equipment:

Digital Multimeter (DMM)

DC Power Supply

Components

Resistors: 1 kΩ, 330 kΩ, 10 kΩ potentiometer, 1MΩ potentiometer

Transistors: 2N3904

Theory:

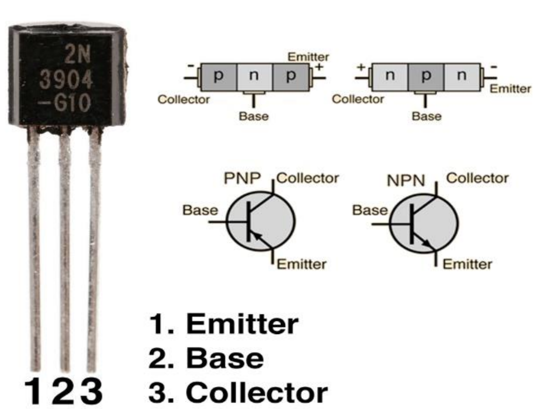
Transistor

A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material usually with at least three terminals for connection to an external circuit.

Bipolar Junction Transistor (BJT)

Bipolar Junction Transistor (**BJT**) is a Semiconductor device constructed with three doped Semiconductor Regions (Base, Collector and Emitter) separated by two p-n Junctions, Figure 1. The p-n Junction between the Base and the Emitter has a Barrier Voltage (V_0) of about 0.6 V, which is an important parameter of a **BJT**.

The relationships between the voltages and the currents associated with a BJT under various operating conditions determine its performance. These relationships are collectively kown as characteristics of the transistor.



Procedure:

Construct the circuit of *Fig.1*. Vary the 1MΩ potentiometer to set I_B = 10 µA as in Table.

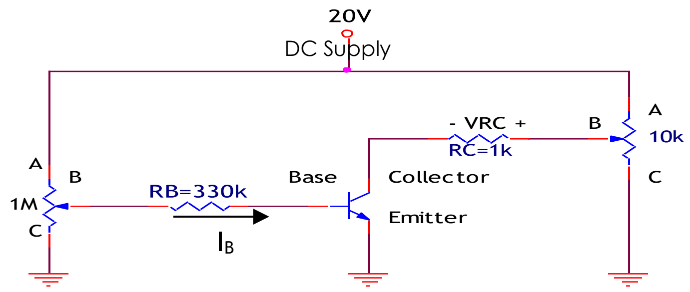


Fig. 1

1. Set the V_{CE} to 2V by varying the 10kΩ potentiometer as required by the first line of Table
2. Record the V_{RC} and V_{BE} values in Table
3. Vary the 10 kΩ potentiometer to increase V_{CE} from 2V to the values appearing in Table . (Note: I_B should be maintained at 10 µA for the range of V_{CE} levels.)
4. Record V_{RC} and V_{BE} values for each of the measured V_{CE} values. Use the mV range for V_{BE}.
5. Repeat step 2 through 5 for all values of I_B indicated in Table
6. Compute the values of I_C (from $I_C = V_{RC}/R_C$) and I_E (from $I_E = I_B+I_C$). Use measured resistor value for R_C.
7. Compute the values of **α** (from **α** = I_C/I_E) and **β** (from **β** = I_C/I_B).

Results:

V_{RB}(V)	I_B(µA)	V_{CE}(V)	V_{RC}(V)	I_C(mA)	V_{BE}(V)	I_E(mA)	α	β
0.19	9.7	1.87	0.73	0.48	0.57	0.489	1	50
0.22	10	2.10	3.98	2.8	0.71	2.81	1	280
0.45	20	4.04	8.30	5.9	0.75	6.1	1.03	295

Characteristic Curve on graph paper...

Experiment No. 10: BJT BIASING CIRCUITS FIXED BIASED CONFIGURATION

Objectives:

To determine the quiescent operating conditions of the fixed-bias BJT configuration.

Equipment:

Digital Multimeter (DMM)

DC Power Supply

Components

Resistors: 2.7 kΩ, 1 MΩ

Transistors: 2N3904, 2N4401

Theory:

Biasing of the bipolar junction transistor (BJT) is the process of applying external voltages to it. In order to use the BJT for any application like amplification, the two junctions of the transistor CB and BE should be properly biased according to the required application. Depending on whether the two junctions of the transistor are forward or reverse biased, a transistor is capable of operating in three different modes.

Cutoff Mode of BJT

The BJT is fully off in this state. In the cutoff mode both the base emitter as well as collector base junction is reverse biased. The BJT is equivalent to an open switch in this mode.

Saturation Mode of BJT

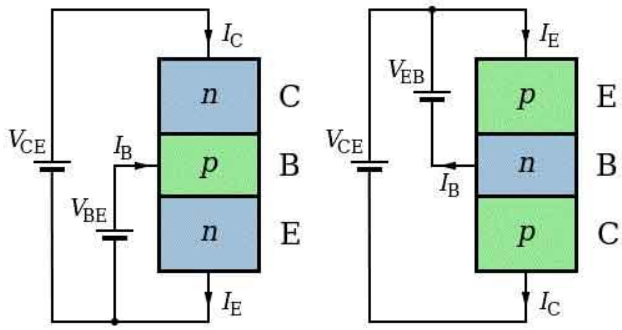
The transistor is fully on in this state. The CB as well as BE junctions are forward biased. The BJT operates like a closed switch in the saturation mode. If a BJT is in saturation mode than it should satisfy the following condition,

$$| I_B | \geq \left(\frac{| I_C |}{\beta_{DC}} \right)$$

Where, β_{DC} is common emitter current amplification factor or current gain.

Active Mode of BJT

In order to use the transistor as an amplifier, it must be operated in the active mode. The BE junction is forward biased whereas the CB junction is reverse biased. Figure below shows both n-p-n and p-n-p transistors biased in the active mode of operation.



Biasing Circuits of BJT

To make the Q point stable different biasing circuits are tried. The Q point is also called as operating bias point, is the point on the DC load line (a load line is the graph of output current vs. output voltage in any of the transistor configurations) which represents the DC current through the transistor and voltage across it when no ac signal is applied. The Q point represents the DC biasing condition. When the BJT is biased such that the Q point is halfway between cutoff and saturation than the BJT operates as a CLASS-A amplifier. The three circuits or biasing arrangements which are practically used are explained below.

Procedure:

1. Measure all resistor values (R_B and R_C) from circuit in *Fig. 1* using DMM. Record them.
2. Construct circuit as of *Fig.1* using 2N3904 transistor and set V_{CC} = 20 V.
3. Measure the voltages V_{BE} and V_{RC}. Record them.
4. Calculate the resulting base current, I_B and collector current, I_C. Using the values obtained, find β.
5. Using the values obtained in Step 4, calculate the values of V_B, V_C, V_E and V_{CE}.
6. Energize the network in *Fig. 1*, measure V_B, V_C, V_E and V_{CE}.
7. How do the measured values (Step 6) compare to the calculated values (Step 5)?
8. Simply remove the 2N3904 transistor and replace with 2N4401 transistor.
9. Then, measure the voltages V_{BE} and V_{RC}. Using the same equations, calculate the values of I_B and I_C. From the values obtained, determine the β value for 2N4401 transistor.
10. Compile all the data needed for both transistors in Table
11. Calculate the magnitude (ignore the sign) of the percent change in each quantity due to a change in transistors.

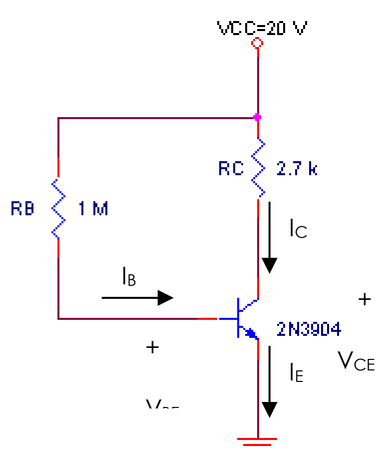


Fig. 1

Results:

Formulas

$$I_B = \frac{V_{RB}}{R_B} = \frac{V_{CC} - V_{BE}}{R_B} =$$

$$I_C = \frac{V_{RC}}{R_C} = \qquad\qquad \beta = \frac{I_C}{I_B} =$$

$$\%\Delta\beta = \frac{\left|\beta_{(4401)} - \beta_{(3904)}\right|}{\left|\beta_{(3904)}\right|} x100\% =$$

$$\%\Delta I_C = \frac{\left|I_{C(4401)} - I_{C(3904)}\right|}{\left|I_{C(3904)}\right|} x100\% =$$

$$\%\Delta V_{CE} = \frac{\left|V_{CE(4401)} - V_{CE(3904)}\right|}{\left|V_{CE(3904)}\right|} x100\% =$$

$$\%\Delta I_B = \frac{\left|I_{B(4401)} - I_{B(3904)}\right|}{\left|I_{B(3904)}\right|} x100\% =$$

Calculated: Transistor 1

I_B = 14.34 μA, I_C = 3.9 mA, β_{DC} = 271.96, V_B = 0.64 V, V_C = 6.37 V,

V_{CE} = 6.37 V

Measured:

V_{CE} = 6.39 V

Calculated: Transistor 2

I_B = 14.46 μA, I_C = 5.51 mA, β_{DC} = 380, V_B = 0.52 V, V_C = 2.81 V,

V_{CE} = 2.81 V

Measured:

V_{CE} = 2.77 V

Table

Trans. Type	**V_{CE} (V)**	**I_C (mA)**	**I_B (μA)**	**β**
2N3904	6.39	3.9	14.34	271.96
2N4401	2.77	5.51	14.46	380

%AGE ERROR:

%error β = **39.72%**

%error I_B = **0.83%**

%error I_C = **41%**

%error V_{CE} = **55.88%**

Experiment No. 11: BJT BIASING CIRCUITS Voltage-Divider-Bias Configuration

Objectives:

To determine the quiescent operating conditions of the fixed-bias BJT configuration.

Equipment:

Digital Multimeter (DMM)

DC Power Supply

Components

Resistors: 680Ω, 10 kΩ, 2.2 kΩ, 33 kΩ

Transistors: 2N3904, 2N4401

Theory:

Biasing of the bipolar junction transistor (BJT) is the process of applying external voltages to it. In order to use the BJT for any application like amplification, the two junctions of the transistor CB and BE should be properly biased according to the required application. Depending on whether the two junctions of the transistor are forward or reverse biased, a transistor is capable of operating in three different modes.

Cutoff Mode of BJT

The BJT is fully off in this state. In the cutoff mode both the base emitter as well as collector base junction is reverse biased. The BJT is equivalent to an open switch in this mode.

Saturation Mode of BJT

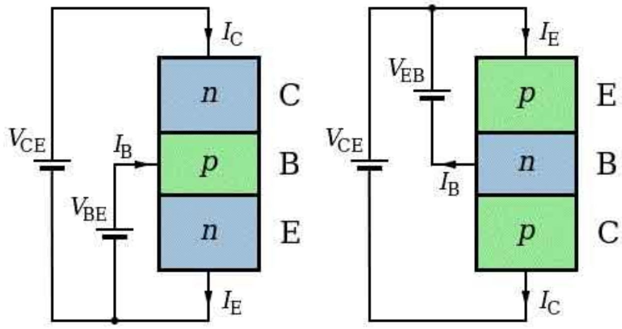
The transistor is fully on in this state. The CB as well as BE junctions are forward biased. The BJT operates like a closed switch in the saturation mode. If a BJT is in saturation mode than it should satisfy the following condition,

$$|\ I_B\ |\ \geq\ \left(\frac{|\ I_C\ |}{\beta_{DC}}\right)$$

Where, β_{DC} is common emitter current amplification factor or current gain.

Active Mode of BJT

In order to use the transistor as an amplifier, it must be operated in the active mode. The BE junction is forward biased whereas the CB junction is reverse biased. Figure below shows both n-p-n and p-n-p transistors biased in the active mode of operation.



Biasing Circuits of BJT

To make the Q point stable different biasing circuits are tried. The Q point is also called as operating bias point, is the point on the DC load line (a load line is the graph of output current vs. output voltage in any of the transistor configurations) which represents the DC current through the transistor and voltage across it when no ac signal is applied. The Q point represents the DC biasing condition. When the BJT is biased such that the Q point is halfway between cutoff and saturation than the BJT operates as a CLASS-A amplifier.

Procedure:

1. Measure all resistor values (R_1, R_2, R_B and R_C) from circuit in *Fig. 1* using DMM. Record them.
2. Using the β determined for 2N3904 transistor in Part B, calculate the theoretical values of V_B, V_E, I_E, I_C, V_C, V_{CE} and I_B for the network shown in *Fig. 1.* Record them in Table
3. Construct the network of *Fig. 1* and measure V_B, V_E, V_C and $V_{CE.}$ Record them in Table

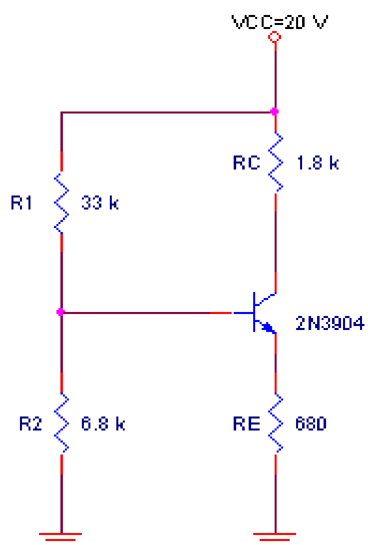


Figure 15

Results:

Formulas

$I_1 = \frac{V_{R1}}{R_1} =$ $\qquad$ $I_2 = \frac{V_{R2}}{R_2} =$ $\qquad$ $I_B = I_1 - I_2$ $\qquad$ $V_C = V_{CC} - I_C R_C$ $\qquad$ $V_{CE} = V_{CC} - I_C (R_C + R_E)$

$$I_C = \frac{V_{RC}}{R_C} = \qquad \beta = \frac{I_C}{I_B} =$$

$$\%\Delta\beta = \frac{\left|\beta_{(4401)} - \beta_{(3904)}\right|}{\left|\beta_{(3904)}\right|} x100\% =$$

$$\%\Delta I_C = \frac{\left|I_{C(4401)} - I_{C(3904)}\right|}{\left|I_{C(3904)}\right|} x100\% =$$

$$\%\Delta V_{CE} = \frac{\left|V_{CE(4401)} - V_{CE(3904)}\right|}{\left|V_{CE(3904)}\right|} x100\% =$$

$$\%\Delta I_B = \frac{\left|I_{B(4401)} - I_{B(3904)}\right|}{\left|I_{B(3904)}\right|} x100\% =$$

Calculated: Transistor 1

I_1 = 0.000359 A , I_2 = 0.000343 A, I_B = 1.6x10^{-5} A, I_C = 4.0 mA, β_{DC} = 250,

V_B = 3.35 V, V_E = 2.6 V, V_C = 6.16 V

V_{CE} = 3.56 V

Measured:

V_{CE} = 3.49 V

Calculated: Transistor 2

I_1 = 0.00035 A , I_2 = 0.00034 A, I_B = 0.1x10^{-6} A, I_C = 0.00408 A, β_{DC} = 370.90,

V_B = 3.39 V, V_E = 2.6 V, V_C = 6.16 V

V_{CE} = 3.56 V

Measured:

V_{CE} = 3.25 V

Table

Trans. Type	V_{CE} (V)	I_C (mA)	I_B (μA)	β
2N3904	3.49	4.00	0.16	250
2N4401	3.25	4.08	0.1	370.90

%AGE ERROR:

%error β = **48.36%**

%error I_B = **0.6%**

%error I_C = **1.74%**

%error V_{CE} = **7.38%**