NORTH SOUTH UNIVERSITY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

EEE111L/ETE111L **Updated By: Maria Moosa**

Experiment No: 1

Name of the Experiment: I-V Characteristics of diode.

Objective:

Study the I-V characteristic of diode.

Theory:

A diode is a bi-polar device that behaves as the short circuit when it is in forward bias and as an open circuit when it is in reverse bias condition.

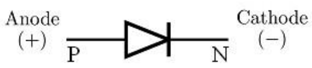


Figure 1.1: Schematic Diagram of Diode.

Figure 1.2: P - N Junction Diode.

There are two types of biasing condition for a diode:

1. When the diode is connected across a voltage source with positive polarity of source connected to P side of diode and negative polarity to N side, then the diode is in forward bias condition.

2. When the diode is connected across a voltage source with positive polarity of source connected to N side of diode and negative polarity to P side, then the diode is in reverse bias condition.

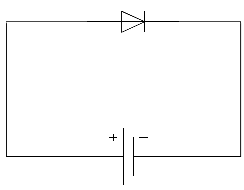


Figure 1.3: Forward Bias connection.

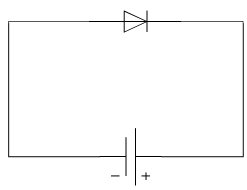


Figure 1.4: Reverse Bias connection.

If the input voltage is varied and the current through the diode corresponding to each voltage are taken, the plot of diode current (I_d) VS diode voltage (V_D) will be follows:

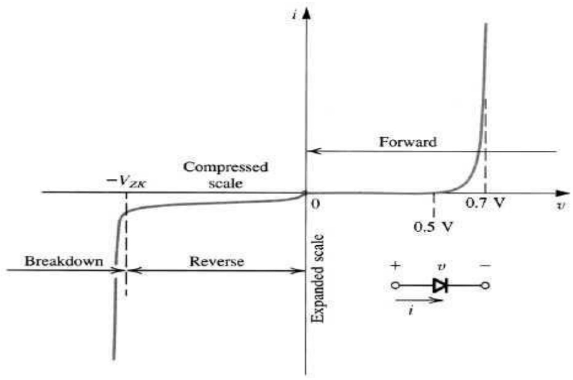


Figure 1.5: I - V Characteristics of Diode.

At the reverse bias condition the amount of current flows through the diode is very small (at microampere range). But if the voltage continuously increases in reverse direction, at a certain value the diode will break down and huge amount of current will flow in reverse direction. This is called breakdown of diode. In laboratory the breakdown will not tested because it will damages the diode permanently.

From the characteristics curve it can be seen that, a particular forward bias voltage (V_T) is required to reach the region of upward swing. This voltage, V_T is called the cut-in voltage or threshold voltage of diode. For Si diode the typical value of threshold voltage is 0.7 volt and for Ge diode is 0.3 volt.

Equipment and Components:

Serial no.	Component Details	Specification	Quantity
1.	p-n junction diode	1N4007	1 piece
2.	Resistor	1KΩ	1 piece
3.	DC power supply		1 unit
4.	Digital Multimeter		1 unit
5.	Chords and wire		as required

Experimental Setup:

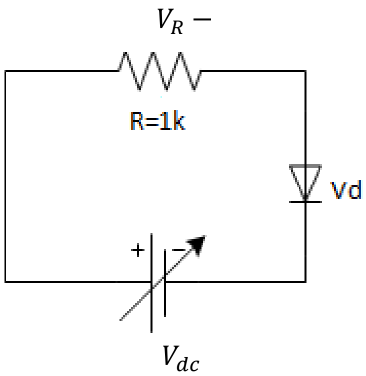


Figure a.6: Diode forward biased configuration

Procedure:

1. Measure the resistance accurately using DMM.
2. Construct the circuit as shown in Figure 1.6.
3. Vary input voltage V_{dc} with values given in table.
4. Measure V_{dc} , V_d and V_R for each increment of V_{dc} and record data on data table.
5. Obtain maximum value of V_d without exceeding 25V for V_{dc}
6. Calculate the values of I_d using the formula, $I_d = V_R / R$.

Data Collection:

Signature of instructor:

Experiment: 1
Performed by Group#

Theoretical value: R = ___ kΩ

Measured value: R = ___ kΩ

V_{dc} (volt)	V_d (volt)	V_R (volt)	$I_d = V_R / R$ (mA)
0.1			
0.3			
0.5			
0.7			
0.9			
1			

2			
3			
4			
6			
8			
10			
12			
14			
16			
18			
20			

Report:

1. Taking readings from the data table, draw I_d VS V_d curve of diode in a graph paper with proper scale [x-axis: 0.2 V per unit, y-axis: any suitable range].
2. What is dynamic and static resistance of a diode?
3. From the graph, find Vd for corresponding values of I_d = 5 mA and I_d = 10 mA and calculate the static resistance.
4. Considering V_{dc} = 2 volt, find the load line (Showing all calculations)
5. Draw the load line in the I_d VS V_d curve of diode and find Q-point.

Experiment No: 02

Name of the Experiment: Diode Rectifier circuits.

Objective:

Study of different diode rectifier circuits.

Theory:

A rectifier converts an AC signal into a DC signal. From the characteristic curve of a diode we observe that if allows the current to flow when it is in the forward bias only. In the reverse bias it remains open. So, when an alternating voltage (signal) is applied across a diode it allows only the half cycle (positive half cycle depending on the orientation of diode in the circuit) during its forward bias condition, other half cycle will be clipped off. In the output the load will get DC signal.

Diode rectifier can be categorized in two major types. They are -

1. Half-wave rectifier.
2. Full-wave rectifier.

Half - Wave Rectifier: Half-wave rectifier can be built by using a single diode. The circuit diagram and the wave shapes of the input and output voltage of half wave rectifier are shown below (figure 2.1) -

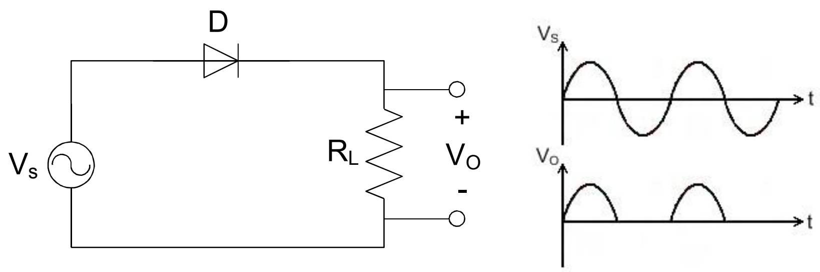


Figure 2.1: Half Wave Rectifier.

The major disadvantages of half wave rectifier are -

- In this circuit the load receives approximately half of input power.
- Average DC voltage is low.
- Due to the presence of ripple output voltage is not smooth one.

Full Wave Rectifier: in the full-wave rectifier both the half cycle is present in the output. Two circuits are used as full-wave rectifier are shown below -

a) Full-wave rectifier using center-tapped transformer.
b) Full-wave bridge rectifier.

Full-wave rectifier using center-tapped transformer: two diodes will be connected to the ends of the transformer and the load will be between the diode and center tap. The circuit diagram and the wave shapes are shown in below (figure 2.2) -

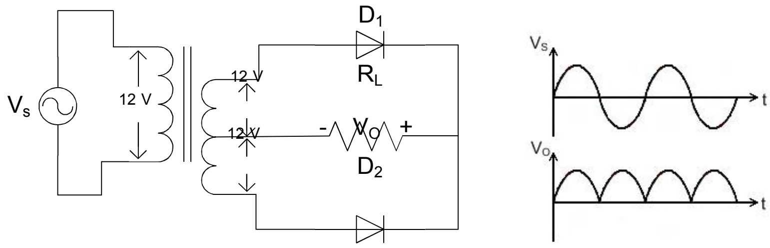


Figure 2.2: Full Wave Rectifier Using Center Tapped Transformer.

Full-wave rectifier using center-tapped transformer circuit has some advantages over full-wave rectifier. Those are -

- Wastage of power is less.
- Average DC output increase significantly.
- Wave shape becomes smoother.

The disadvantages of full-wave rectifier using center-tapped transformer are -

- Requires more space and becomes bulky because of the transformer.
- Not cost effective (for using transformer).

Full-wave bridge rectifier: a bridge rectifier overcomes all the disadvantages of described above. Here four diodes will be connected as bridge connection. The circuit diagram and the wave shapes are shown in bellow (figure 2.3) -

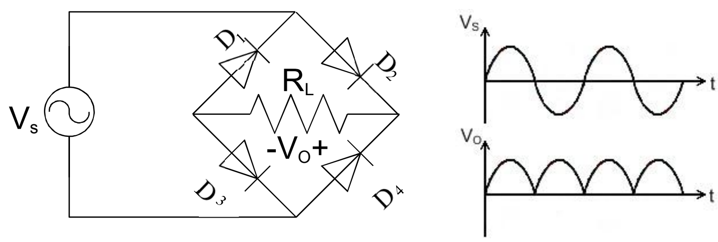


Figure 2.3: Full Wave Bridge Rectifier.

This rectifier however cannot produce a smooth DC voltage. It produces some ripple in the output. This ripple can be reducing by using filter capacitor across the load.

Equipment and Components:

Serial no.	Component Details	Specification	Quantity
1.	p-n junction diode	1N4007	4 piece
2.	Resistor	10KΩ	1 piece
3.	Capacitor	0.22µF, 10µF	1 piece each
4.	Signal generator		1 unit
5.	Trainer Board		1 unit
6.	Oscilloscope		1 unit
7.	Digital Multimeter		1 unit
8.	Chords and wire		as required

Experimental Setup:

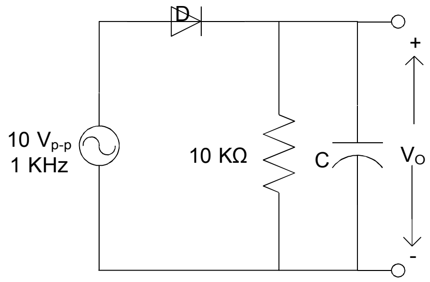


Figure 2.4: Half wave

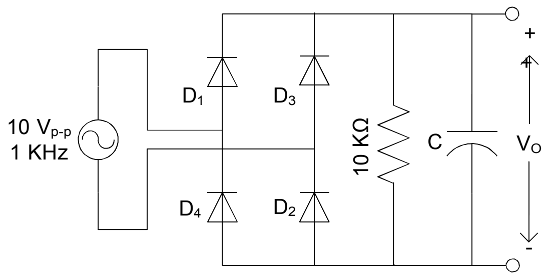


Figure 2.5: Full Wave

Procedure:

1. First, connect the circuit in breadboard as shown in figure 2.4 without any capacitor.
2. Apply 1 KHz 10V (p-p) sinusoidal input signal from signal generator.
3. Connect channel 1 of oscilloscope to the input side, and channel 2 of oscilloscope to output side. Observe the wave shapes and p-p values inputs and outputs and draw them in the graph paper with proper p-p values.
4. Connect the 0.22µF capacitor and repeat step 3. [decrease the Volts/DIV for proper wave-shape]
5. Now keeping capacitor fixes at 0.22 µF, Observe the change in wave shape by 1st varying the frequency lower than 1 Khz and then higher than 1 khz.
6. Connect the 10µF capacitor and repeat step 3 and step 5. [decrease the Volts/DIV for proper wave-shape]
7. Repeat steps 1-6 for Figure 2.5 .

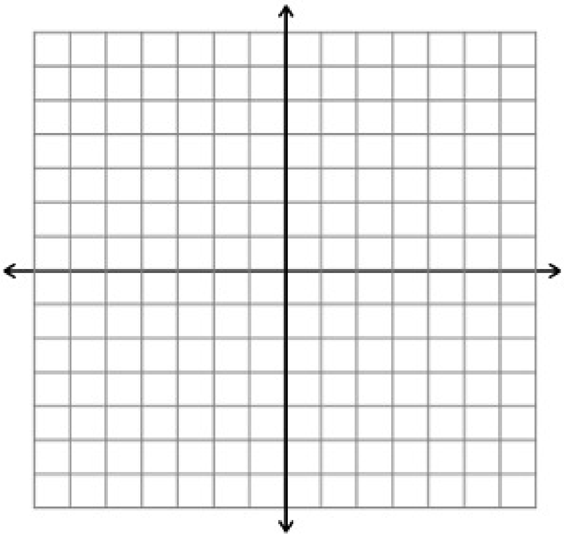
Data Collection: *Signature of instructor:*

Experiment: 2,
Performed by Group# ______

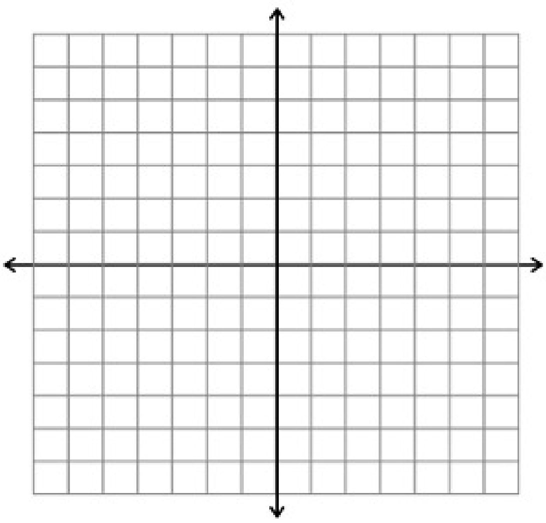
Theoretical value: R = ___ kΩ

Measured value: R = ___ kΩ

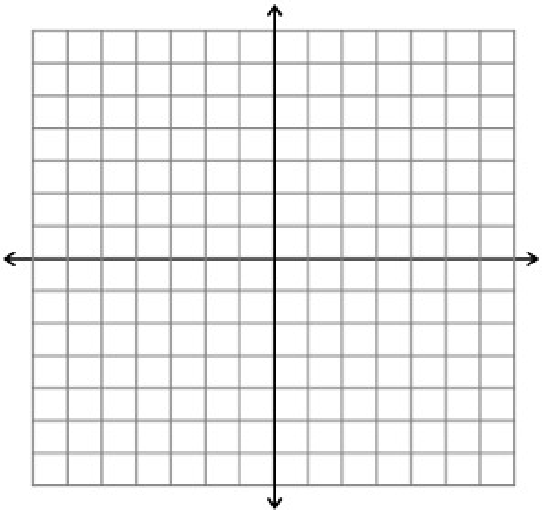
	Half Wave Rectifier (Fig 2.4)	Full wave Rectifier (Fig 2.5)
$V_o(p-p)$ (without capacitor)		
$V_o(p-p)$ (with 0.22 µF)		
$V_o(p-p)$ (with 10 µF)		



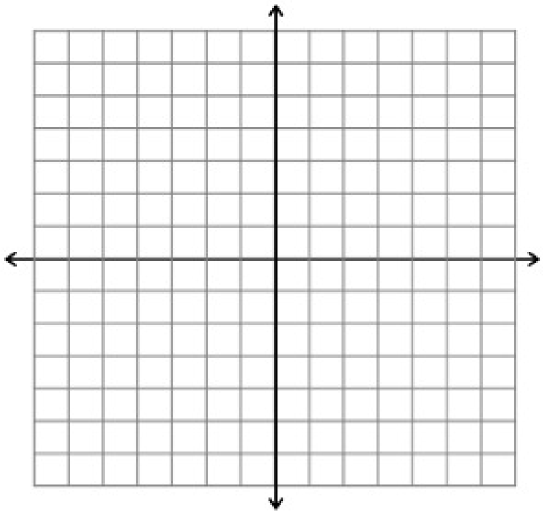
a) Input-output without capacitor (fig 2.4)



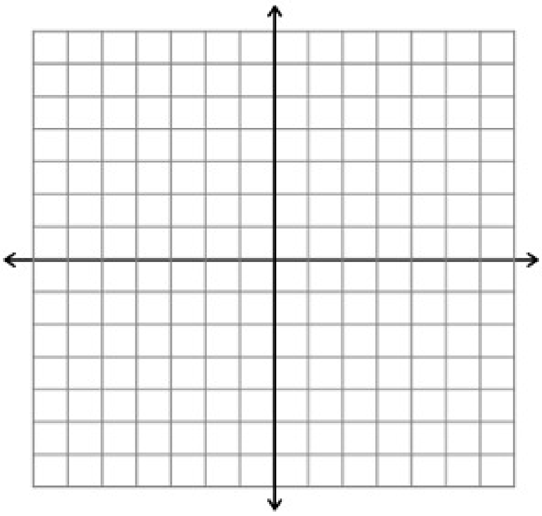
d) Input-output without capacitor (fig 2.5)



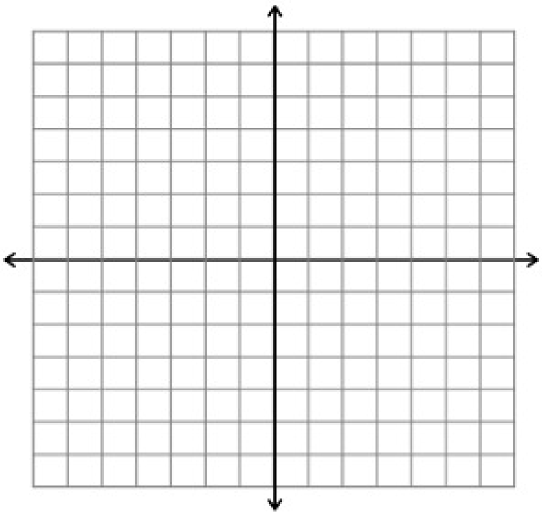
b) *Input-output with 0.22uF (fig 2.4)*



e) *Input-output with 0.22uF (fig 2.5)*



c) *Input-output with 10uF (fig 2.4)*



f) *Input-output with 10uF (fig 2.5)*

Report:

1. For Fig 2.4 and Fig 2.5, draw the input-output wave-shape without capacitor, with 0.22μF capacitor and 10μF capacitor.
2. Compare the change in the wave-shape and peak to peak values for no capacitor at the output to 0.22 μF to 10 μF.
3. Explain what is the effect of changing the frequency of the input signal.
4. Between half wave and full wave which circuit produces smoother output? Briefly explain in context with your data collection.

Experiment No: 03

Name of the Experiment: Clipper and Clamper circuits.

Objective:

Study of Clipper and Clamper circuits.

Theory:

Clipper: Clippers remove signal voltage above and below a specified level. In the experiment no. 2, half wave rectifier can also be called as a clipper circuit. Because it clipped off the negative half cycle of the input signal.

A diode connected in series with the load can clipped off any half cycle of input depending on the orientation of the diode. (Figure 3.1) -

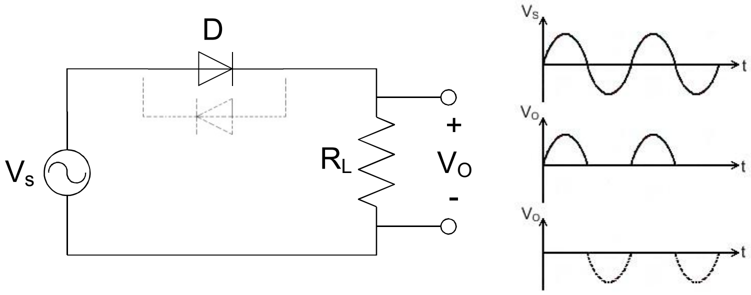


Figure 3.1: Simple Diode Clipper circuit

It is also possible to clip off a certain part of the input signal bellow a specified signal level by using a voltage source in reverse bias condition with the diode. If a battery of V volts is added to it, then for V_s above (V+0.7) volts the diode becomes forward bias and turns ON. The load receives above this voltage Level.

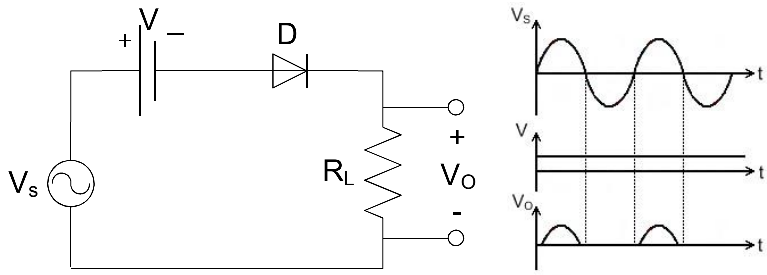


Figure 3.2: Clipper Circuit Using Bias Diode.

A diode connected in parallel with the load can clip off the input signal above 0.7 volts of one half cycle depending on the connection of the diode. Using two diodes in parallel in opposite direction both the half cycle can be limited to 0.7 volts.

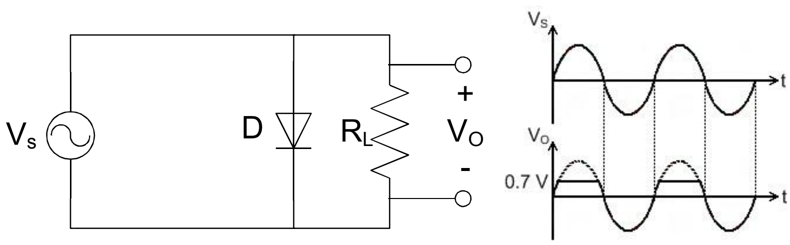


Figure 3.3: Parallel Clipper Circuit.

Using a biased diode it is possible to limit the output voltage to a specified level depending on the attached battery voltage. Either the half cycles or both of them can be clipped off above a specified level.

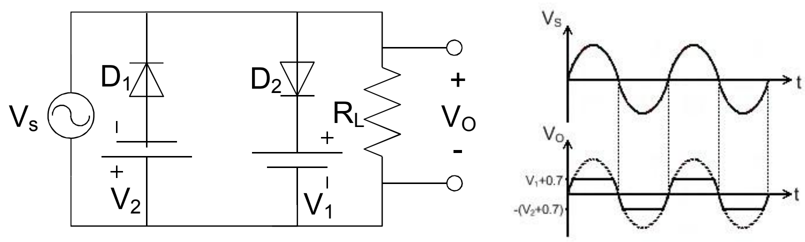


Figure 3.4: Biased Parallel Clipper Circuit.

In practical case for both the series and parallel clippers voltage source is not added. Required voltage levels are maintained by adding more semiconductor diode.

Clamper: A DC clamper circuit adds a DC voltage to the input signal. For instance, if the incoming signal varies from -10 volts to +10 volts, a positive DC clamper will produce an output that ideally swing from 0 volts to 20 volts and a negative clamper would produce an output between 0 volts to -20 volts.

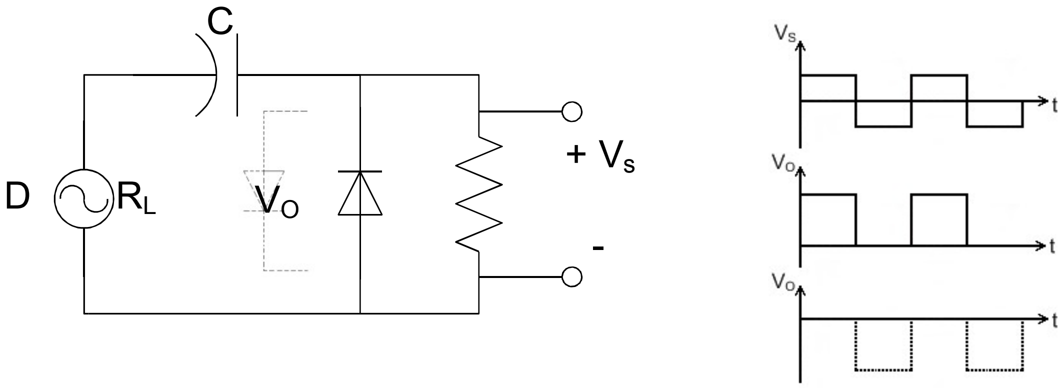


Figure 3.5: Clamper Circuit

Equipment and Components:

Serial no.	Component Details	Specification	Quantity
1.	p-n junction diode	1N4007	1 piece
2.	Resistor	100KΩ	1 piece
3.	Capacitor	0.1µF	1 piece
4.	Signal generator		1 unit
5.	Trainer Board		1 unit
6.	DC power Supply		1 unit
7.	Oscilloscope		1 unit
8.	Digital Multimeter		1 unit
9.	Chords and wire		as required

Experimental Setup:

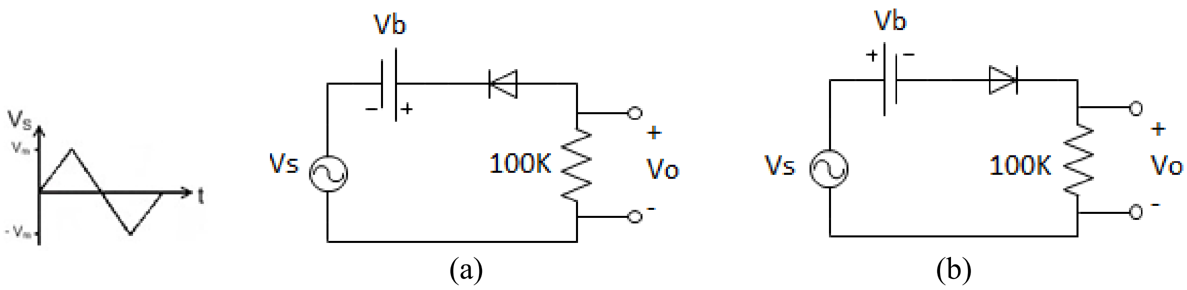


Figure 3.6: Series Clipper Circuit

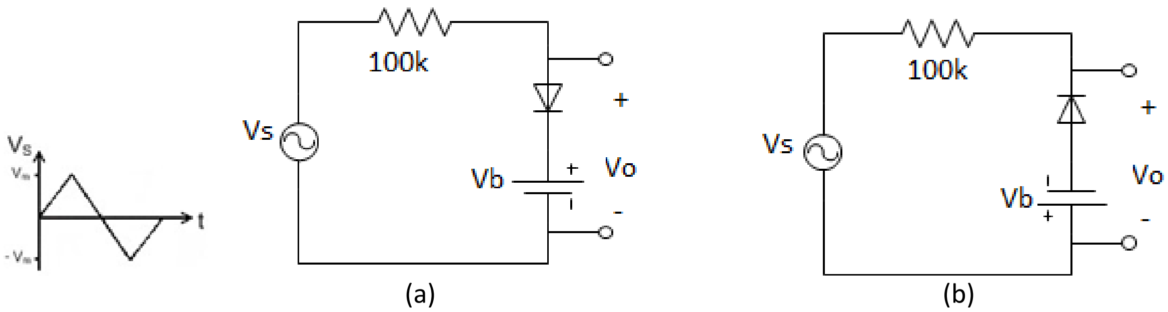


Figure 3.7: Parallel Clipper Circuits

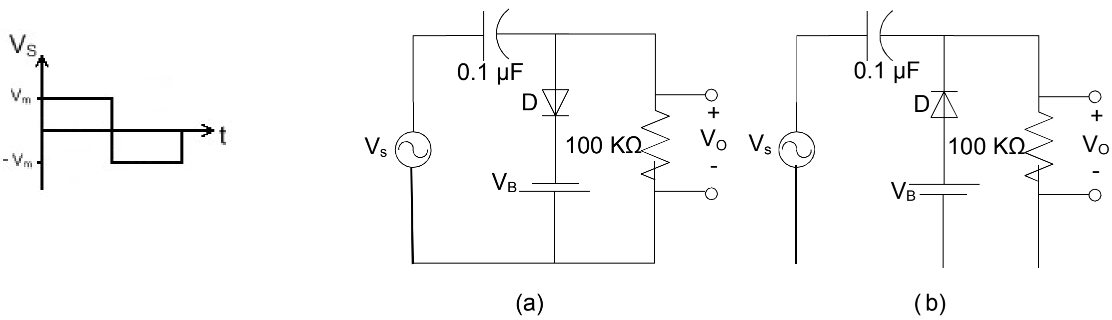


Figure 3.8: Clamper Circuits

Procedure:

1. Connect the circuit as shown in the figure 3.6.
2. Using Signal generator, apply a 1Khz 10V(p-p) sinusoidal voltage source input ($V_m = 5v$).
3. Fix Vb to 2.5V and In the same graph paper, Draw Vs and Vo.
4. Decrease the value of Vb from 2.5V to 0V, and observe the output wave shapes
5. Increase the value of Vb from 2.5V to 5V, and observe the output wave shapes
6. Repeat step 2-4 for figure 3.7 and figure 3.8

Data Collection:

Signature of instructor:

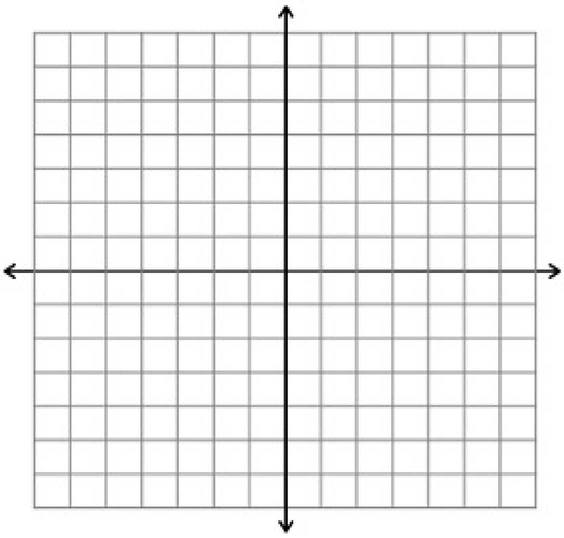
Experiment: 3,
Performed by Group# _____

Theoretical value: R = ___ kΩ

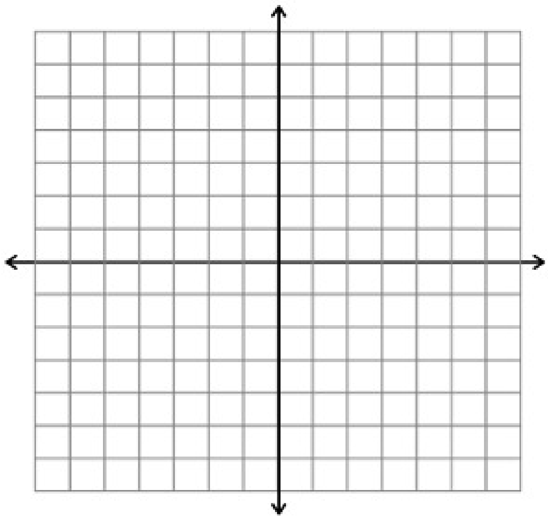
Measured value: R = ___ kΩ

Vs = _____ V(p-p).

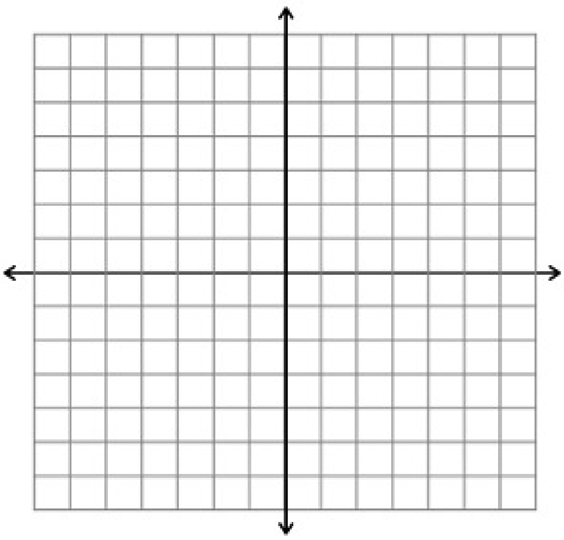
V_b (V)	Vo (p-p)					
	Fig 3.6		Fig 3.7		Fig 3.8	
	(a)	(b)	(a)	(b)	(a)	(b)
0						
1						
2						
2.5						
3						
4						
5						



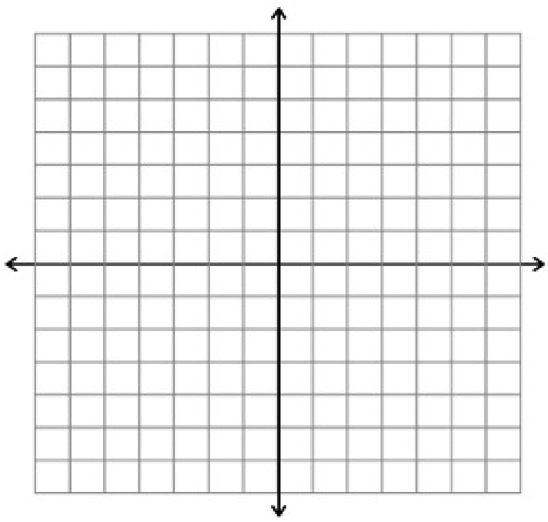
Input-output Fig 3.6 (a)



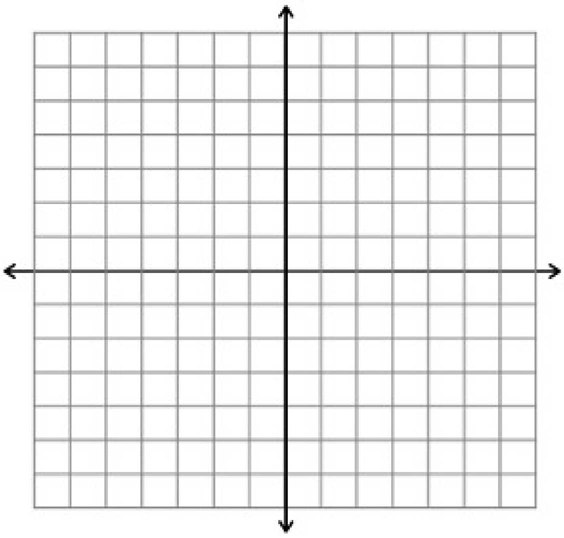
Input-output Fig 3.6 (b)



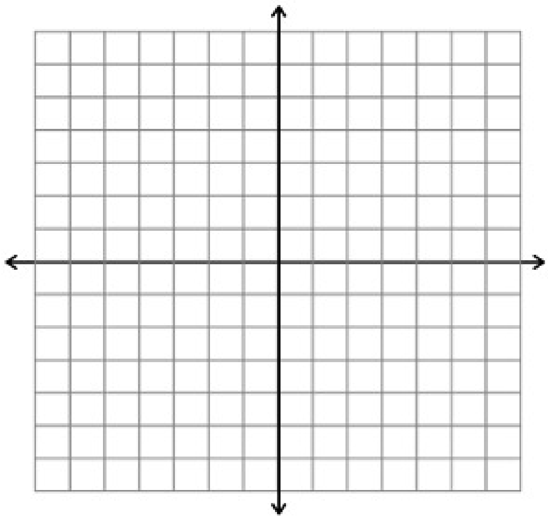
Input-output Fig 3.7 (a)



Input-output Fig 3.7 (b)



Input-output Fig 3.8 (a)



Input-output Fig 3.8 (b)

Report:

1. Sketch all the waveforms observed on the oscilloscope for $\boldsymbol{V_b}$=2.5V.
2. In procedure-4, explain the change in the p-p values and output wave form for Fig 3.6(a &b), Fig3.7 (a & b) and Fig 3.8 (a & b)
3. In procedure-5, explain the change in the p-p values and output wave form for Fig 3.6(a &b), Fig3.7 (a & b) and Fig 3.8 (a & b).

Experiment No: 04

Name of the Experiment: Zener Diode applications.

Objective:

Study of the Zener Diode applications.

Theory :

The diodes we have studied before do not operate in the breakdown region because this may damage them. A Zener diode is different; it is a silicon diode that the manufacturer has optimized for operation in the breakdown region. It is used to build voltage regulator circuits that ~~circuits that~~ hold the load voltage almost constant despite large change in line voltage and load resistance. The symbol of Zener diode shows in figure 4.1.

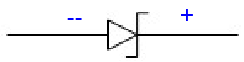


Figure 4.1 : Symbol of Zener Diode.

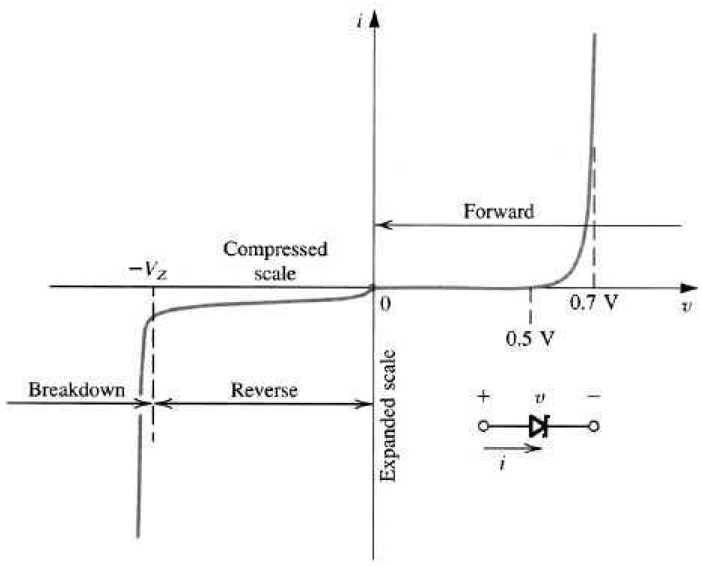


Figure 4.2 : I - V Characteristics of Zener Diode.

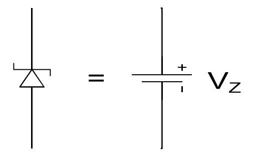
The Zener diode may have a breakdown voltage from about 2 to 200 volts. These diodes can operate in any of three regions – forward, leakage and breakdown. Figure 4.2 shows the I-V characteristics curve of Zener diode.

- In the forward region it works as an ordinary diode.
- In the leakage region (between zero and breakdown) it has only a small reverse saturation current.

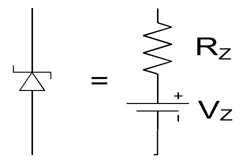
- In the breakdown it has a sharp knee, followed by an almost vertical increase in current without changing the voltage.
- The voltage is almost constant, approximately equal to V_z over most of the breakdown region.

Equivalent circuits of Zener Diode : Two approximation are used for Zener Diode equivalent circuit.

First Approximation : As the voltage remains constant across the Zener diode though the current changes through it, it is considered as a constant voltage source according to the first approximation.



Second Approximation : A Zener resistance is in series with the ideal voltage source is approximated.



Equipment and Components:

Serial no.	Component Details	Specification	Quantity
1.	Zener diode	5 volts	1 piece
2.	Resistor	220Ω, 470Ω, 1KΩ	1 piece each
3.	POT	10KΩ	1 unit
4.	Trainer Board		1 unit
5.	DC Power Supply		1 unit
6.	Digital Multimeter		1 unit
7.	Chords and wire		as required

Experimental Setup:

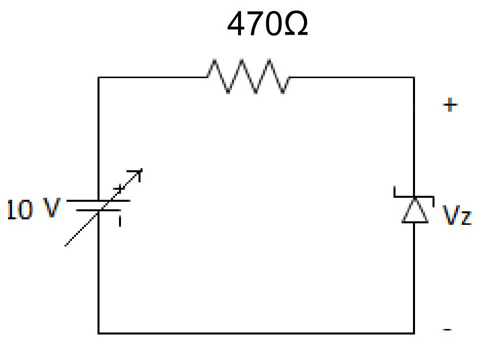


Figure 4.3: Reverse Biased Zener Characteristics

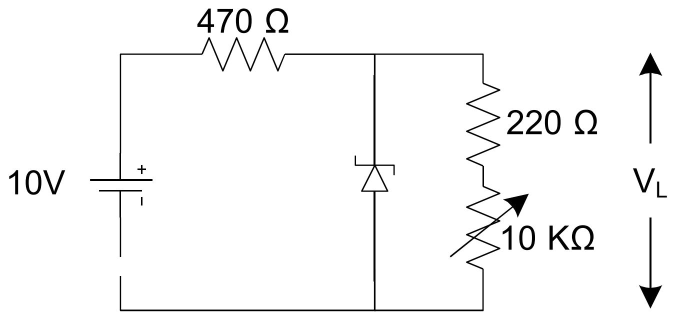


Figure 4.4: Load Regulation

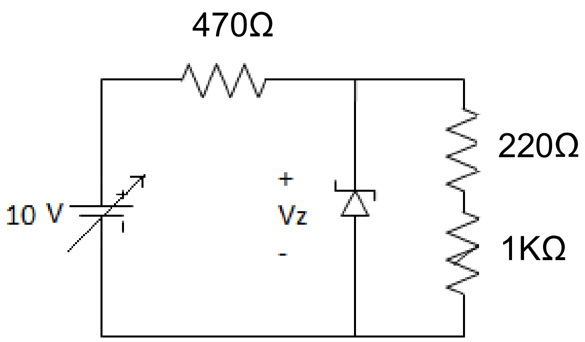


Figure 4.5: Line Regulation

Procedure:

1. Connect the circuit as shown in the figure 4.3
2. Vary the supply voltage from zero volt, complete the Table 4.1.
3. Connect the circuit as shown in the figure 4.4
4. Keep the POT at maximum position and power up the circuit.
5. Gradually decrease the POT resistance and complete the Table 4.2.
6. Replace the POT with 1KΩ resistance, vary the supply voltage and take reading for Table 4.3.

Data Collection:

Signature of instructor:

Experiment: 3,
Performed by Group# ______

Theoretical	Practical
470Ω	
220Ω	
1KΩ	

Table 4.1: Data for I - V characteristics.

V (volts)	V_R (volts)	V_Z (volts)	$I_Z = V_R / R$ (ma)
0.1			
0.3			
0.5			
0.3			
1.0			
2.0			
3.0			
4.0			
5.0			
6.0			
7.0			
8.0			
9.0			
10.0			

Table 4.2: Data for Load Regulation

POT R (kΩ)	V_{220} (mV)	V_L (volts)	I_L (Amp)= $V_{220}/220$

Table 4.3: Data for Line Regulation.

V (volts)	V_L (volts)
1.0	
3.0	
6.0	
8.0	
9.0	
10.0	
11.0	
12.0	

Report:

1. Plot I_Z VS V_Z characteristics of Zener diode. Determine the Zener breakdown voltage from the plot.
2. Plot I_L vs V_L for the data table 4.2. Scale [x-axis: 0.1V/DIV, y-axis: any suitable range]. Find the voltage regulation from the graph.
3. Plot V_L vs V for the data table 4.3. Find the line regulation from graph.

Experiment No: 05

Name of the Experiment: The Input-Output characteristics of CE (common emitter) configuration of BJT.

Objective: Study of the input-output characteristics of CE (common emitter) configuration of BJT.

Theory: Unlike the diode, which has two doped regions, a transistor has three doped regions. They are as follows –

a) Emitter, b) Base and c) Collector.

These three doped regions form two junctions: One between the emitter and base and other between the collector and the base. Because of these it can be thought as combination of two diodes, the emitter and the base form one diode and the collector and base form another diode. The emitter is heavily doped. Its job is to emit or inject free majority carrier (electron for NPN and hole for PNP) into the base. The base is lightly doped and very thin. It passes the most of the emitter-injected electron (for NPN) into the collector. The doping level of the collector is between emitter and base. Figure 5.1 shows the biased NPN transistor.

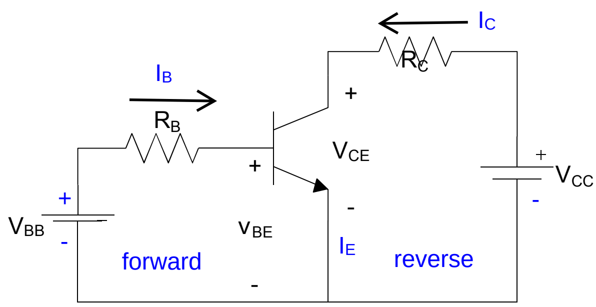


Figure 5.1 : Biasing of an NPN transistor. common emitter

If the V_{BB} is greater than the barrier potential, emitter electron will enter base region. The free electron can flow either into the base or into the collector. As base lightly doped and thin, most of the free electron will enter into the collector.
There are three different current in a transistor. They are emitter current (I_E), collector current (I_C) and the base current (I_B) are shows in figure 5.2.

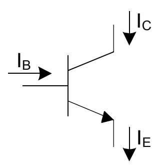


Figure 5.2 : Different current in transistor.

Here, $I_E = I_C + I_B$, and the current gain $\frac{I_C}{I_B}$ = Beta

The characteristics of a transistor is measured by two characteristics curve.

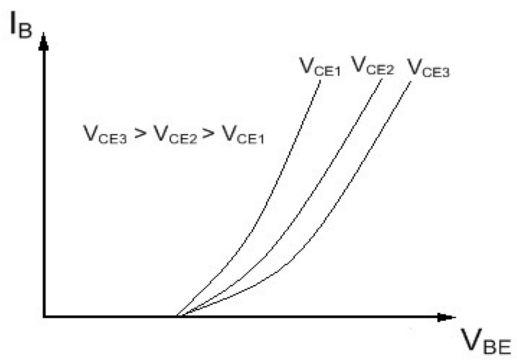
a) Input characteristics curve.
b) Output characteristics curve.

For npn common emitter transistor,

Input Characteristics Curve: Input characteristics is defined as the set of curves between input current (I_B) vs. input voltage (V_{BE}) for the constant output voltage (V_{CE}). It is the same curve that is found for a forward biased diode.

Output Characteristics Curve: Output characteristics is defined by the set of curves between output current (I_C) vs. output voltage (V_{CE}) for the constant input current (I_B). The curve has the following features –

- It has three regions namely Saturation, Active and Cutoff region.
- The rising part of the curve, where V_{CE} is between 0 and approximately 1 volt is called saturation region. In this region, the collector diode is not reversed biased.
- When the collector diode of the transistor becomes reverse biased, the graph becomes horizontal. In this region, the collector remains almost constant. This region is known as the active region. In applications where the transistor amplifies weak radio and TV signal, it will always be operation in the active region.
- When the base current is zero, but there is some collector current. This region of the transistor curve is known as the cutoff region. The small collector current is called collector cutoff current.
- For different value of base current (I_B) an individual curve can be obtained.



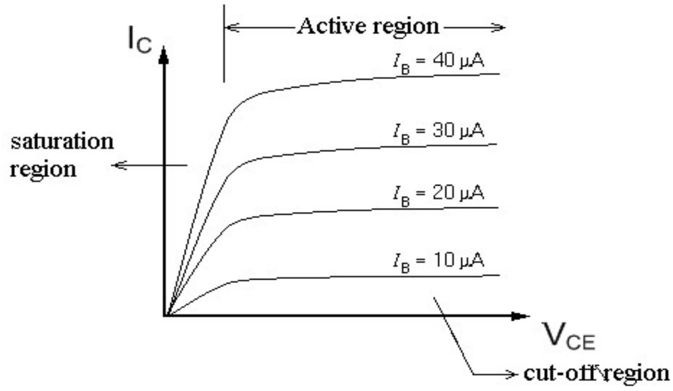


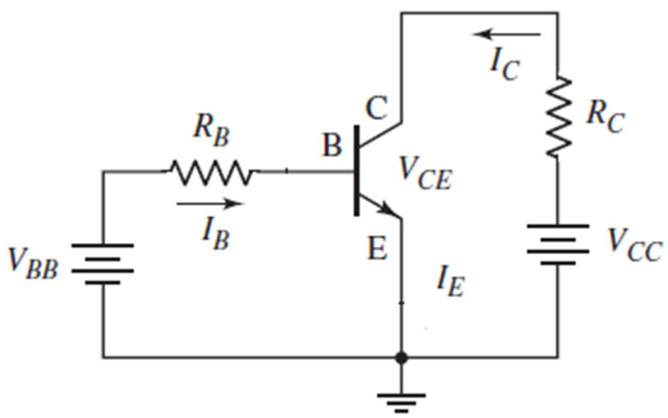
Figure 5.3 : (a) Input Characteristic, (b) Output Characteristic of NPN transistor.

Equipment And Components:

Serial	Component Details	Specification	Quantity
1	Transistor	C828	1 piece
2	Resistor	100kΩ, 1KΩ,	1 piece each
4	Trainer Board		1 unit
5	DC Power Supply		1 unit
6	Digital Multimeter		1 unit
7	Chords and wire		as required

Circuit Diagram:

$\boldsymbol{R_B}$100k
$\boldsymbol{R_C}$ = 1K



Procedure:

Input Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. By varying $\boldsymbol{V_{CC}}$, make $\mathbf{V_{CE}}$ = 1V.
3. Varying $\mathbf{V_{BB}}$ gradually, measure $\mathbf{V_{RB}}$ and base-emitter voltage $\mathbf{V_{BE}}$. Calculate $\mathbf{I_B} = \frac{V_{RB}}{R_B}$. Complete Table 1.
4. Step size is not fixed because of non-linear curve. Initially vary $\mathbf{V_{BB}}$ in steps of 0.1V. Once the current starts increasing vary $\mathbf{V_{BB}}$ in steps of 1V up to 12V.
5. Repeat above procedure (step 3) for $\mathbf{V_{CE}}$ = 5V.

Output Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. By varying $\mathbf{V_{BB}}$, make $\mathbf{V_{RB}}$ = 2V. This makes $\mathbf{I_B}$ = 20μA.
3. Varying $\mathbf{V_{CC}}$ gradually in steps, measure Collector-Emitter Voltage ($\mathbf{V_{CE}}$) and $\mathbf{V_{RC}}$. Calculate $\mathbf{I_C} = \frac{V_{RC}}{R_C}$. Fill up Table-2.
4. Repeat above procedure (step 3) for $\mathbf{I_B}$ = 30μA [V_{RB} = 3V]

Data Collection:

Signature of instructor:

Experiment: 3,
Performed by Group# _____

Table 1: Input Characteristics of BJT

V_{CE} = 1 V				V_{CE} = 5V			
V_{BB} (Volts)	V_{BE} (Volts)	V_{RB} (Volts)	$I_B = \frac{V_{RB}}{R_B}$ (μA)	V_{BB} (Volts)	V_{BE} (Volts)	V_{RB} (Volts)	$I_B = \frac{V_{RB}}{R_B}$ (μA)
0.1							
0.3							
0.5							
0.7							
1.0							
2.0							
3.0							
4.0							
5.0							
7.0							
9.0							
10.0							
12.0							
14.0							
16.0							

Table 2: Output Characteristics of BJT

	$I_B = 20\mu A$			$I_B = 30\mu A$		
V_{CC}	V_{CE} (Volts)	V_{RC} (Volts)	$I_C = \frac{V_{RC}}{RC}$ (mA)	V_{CE} (Volts)	V_{RC} (Volts)	$I_C = \frac{V_{RC}}{RC}$
1.0						
2.0						
3.0						
4.0						
5.0						
6.0						
8.0						
10.0						
12.0						
14.0						
16.0						
18.0						
20.0						
22.0						
24.0						

Report:

1. Plot $\mathbf{I_B}$ **vs.** $\boldsymbol{V_{BE}}$ for different values of $\mathbf{V_{CE}}$ **.**
2. Plot $\mathbf{I_C}$ **vs** $\boldsymbol{V_{CE}}$ for different values of $\mathbf{I_B}$**.** Show different regions of operations.
3. Find β for the each $\mathbf{I_B}$ [for active region only]
4. For V_{cc}= 12v, draw the load line and find the Q-point.