Experiment No: 02

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.

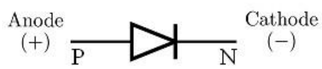


Figure 1.1: Schematic Diagram of Diode.

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.

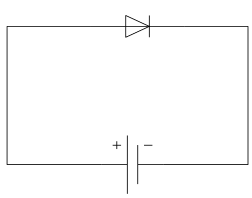


Figure 1.3: Forward Bias connection.

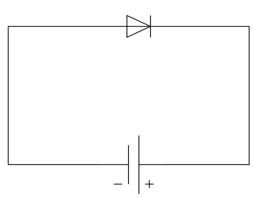


Figure 1.4: Reverse Bias connection.

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:

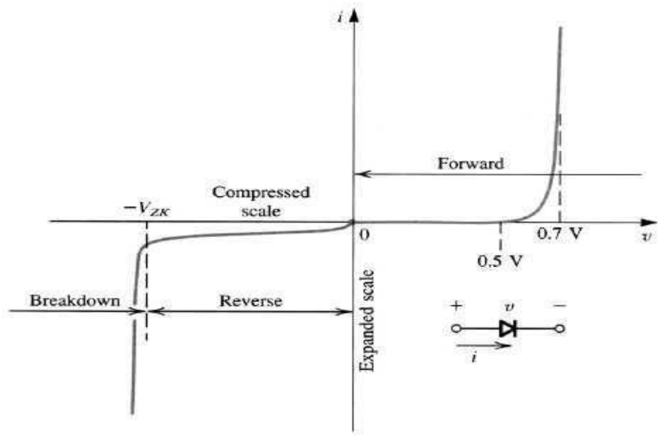


Figure 1.5: I - V Characteristics of Diode.

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:

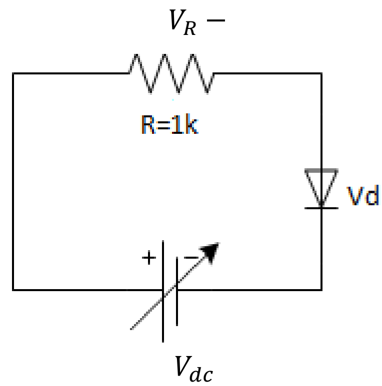


Figure 1.6: Diode forward biased configuration

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: 03

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) -

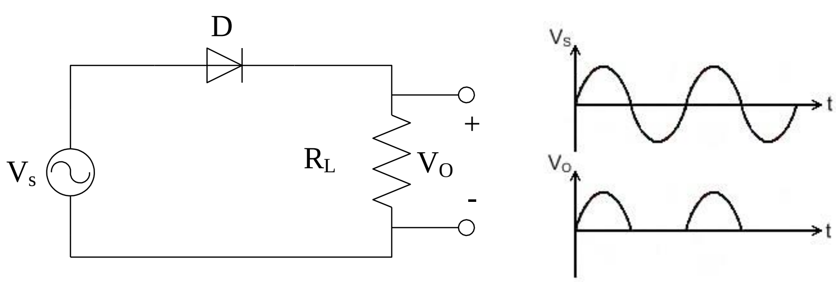


Figure 2.1: Half Wave Rectifier.

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) -

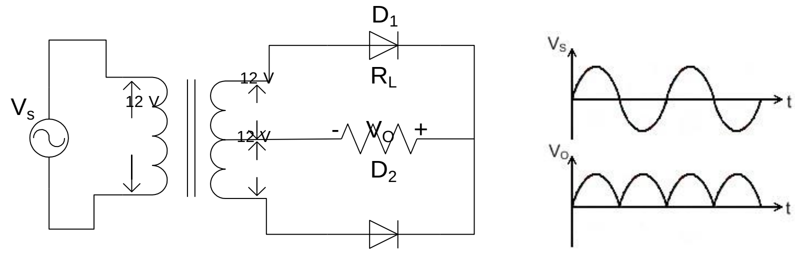


Figure 2.2: Full Wave Rectifier Using Center Tapped Transformer.

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) -

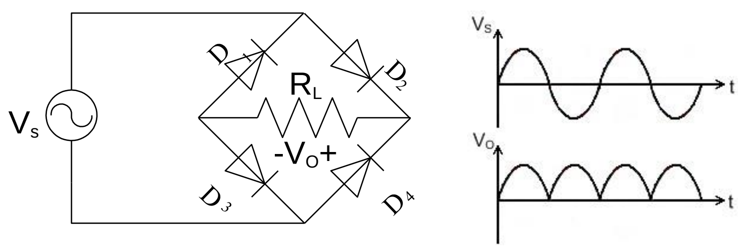


Figure 2.3: Full Wave Bridge Rectifier.

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:

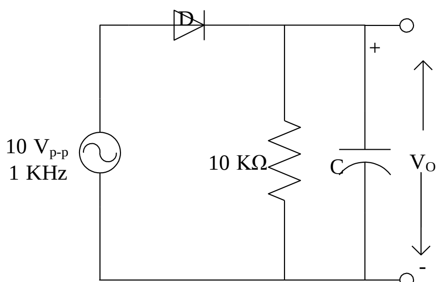


Figure 2.4: Half wave

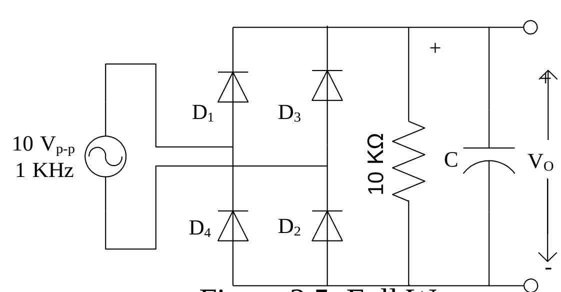


Figure 2.5: Full Wave

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 fixed at 0.22 μF, Observe the change in output 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:

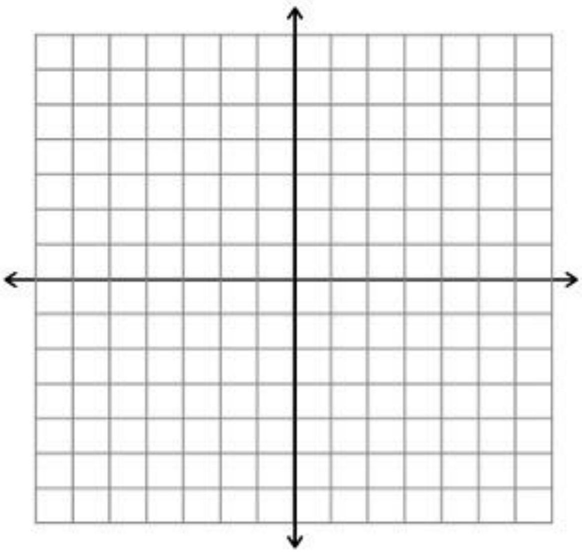
Signature of instructor:

Experiment: 2,
Performed by Group# _____

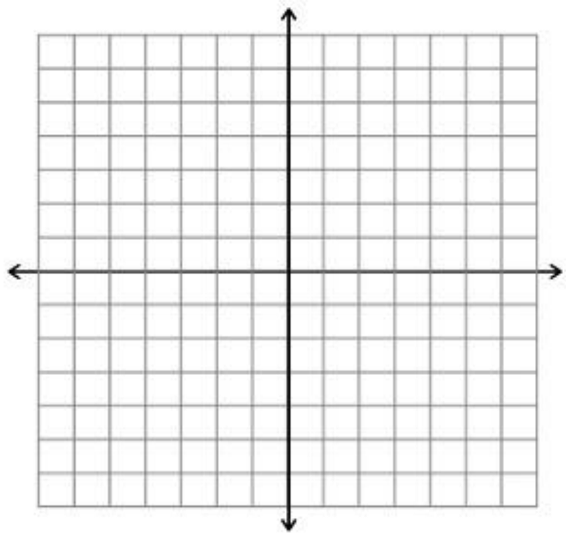
Theoretical value: R = ___ kΩ

Measured value: R = ___ kΩ

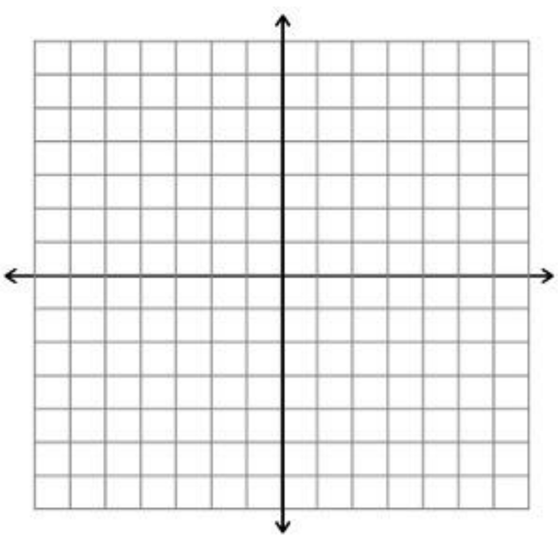
	Half Wave Rectifier (Fig 2.4)	Full wave Rectifier (Fig 2.5)
$V_o(p-p)$ (without capacitor)		
$V_o(p-p)$ (with 0.22 μF)		
$V_o(p-p)$ (with 10 μF)		



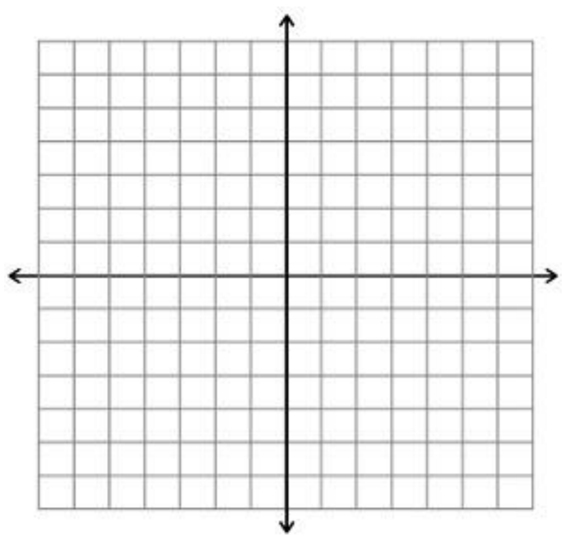
a) Input-output without capacitor (fig 2.4)



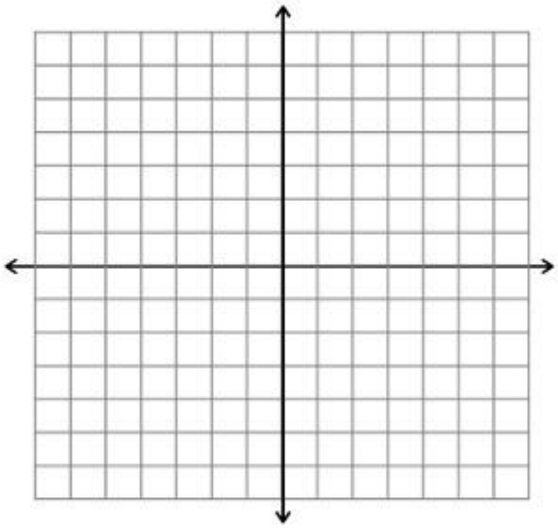
d) Input-output without capacitor (fig 2.5)



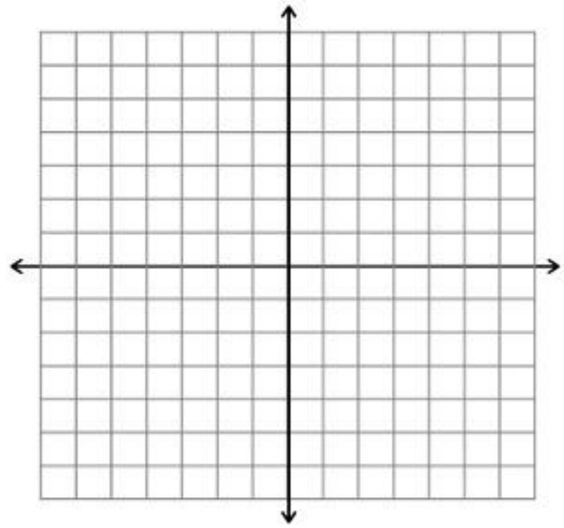
b) *Input-output with 0.22uF (fig 2.4)*



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 the effect on the output signal for 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: 04

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 4.1) -

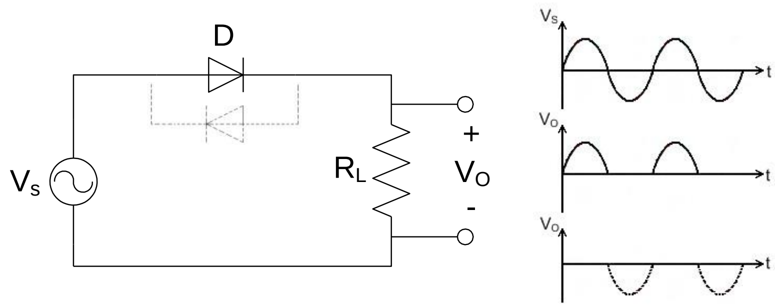


Figure 4.1: Simple Diode Clipper circuit

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.

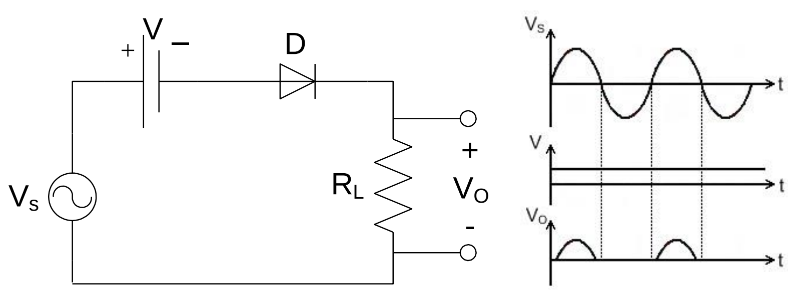


Figure 4.2: Clipper Circuit Using Bias Diode.

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.

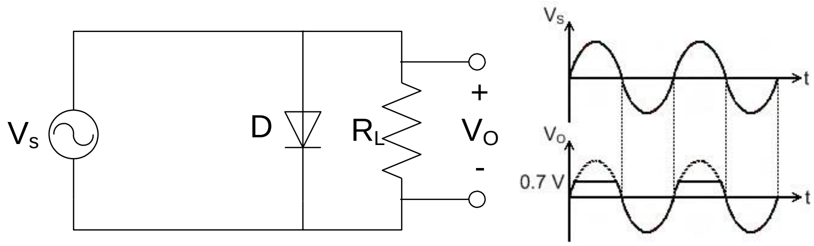


Figure 4.3: Parallel Clipper Circuit.

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.

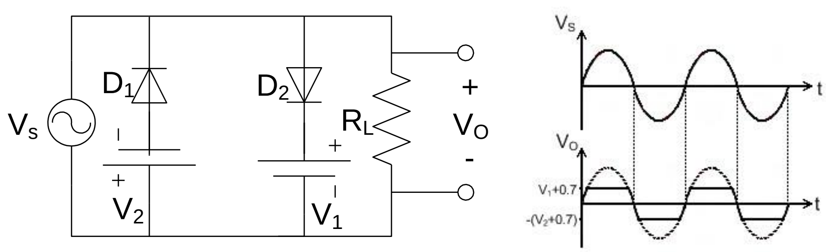
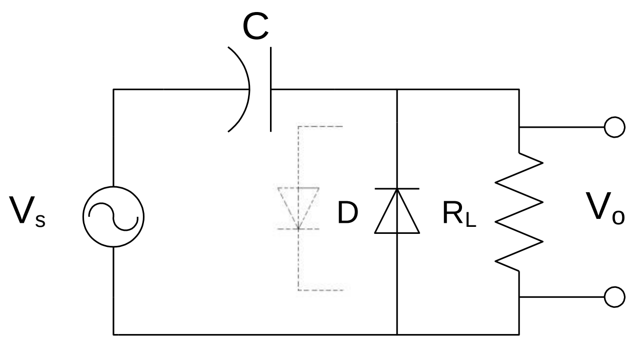


Figure 4.4: Biased Parallel Clipper Circuit.

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.



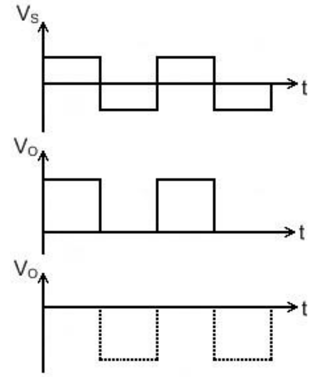


Figure 4.5: Clamper Circuit

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:

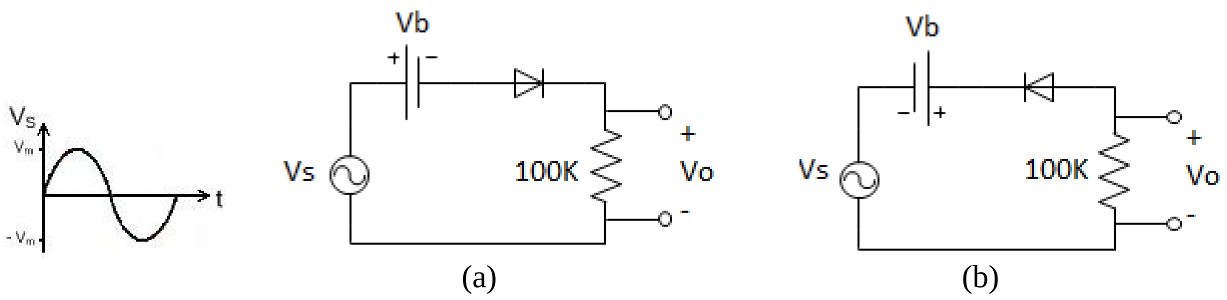


Figure 4.6: Series Clipper Circuit

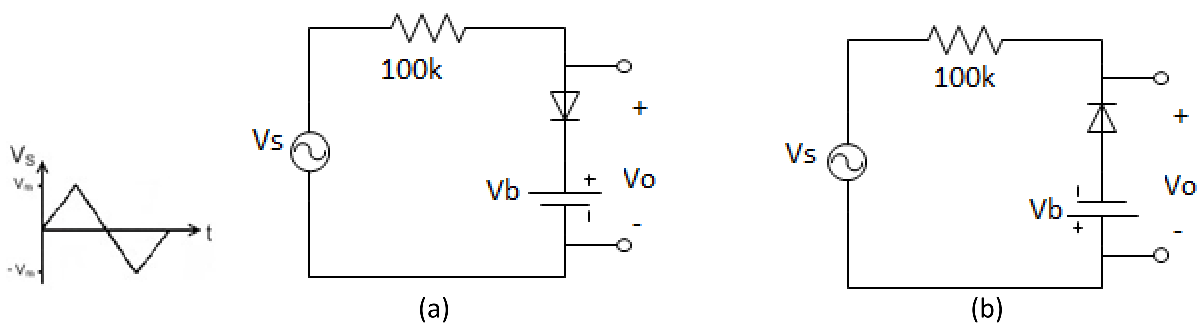


Figure 4.7: Parallel Clipper Circuits

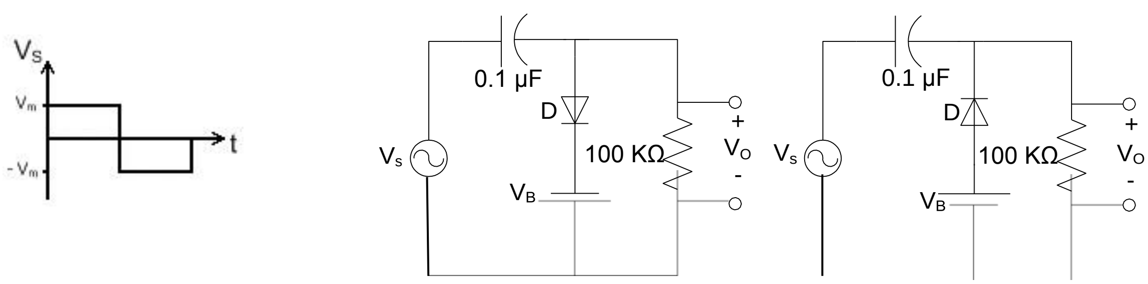


Figure 4.8: Clamper circuit

Procedure:

1. Connect the circuit as shown in the figure 4.6.
2. Using Signal generator, apply a 1kHz 10$V_{p\text{-}p}$ sinusoidal voltage source input (V_m = 5V)
3. Fix V_b to 2.5V and In the same graph paper, Draw V_s and V_o.
4. Decrease the value of V_b from 2.5V to 0V, and observe the output wave shapes
5. Increase the value of V_b from 2.5V to 5V, and observe the output wave shapes
6. Repeat step 2-4 for figure 3.7 and figure 3.8
7. Record V_{max} and V_{min} for the output wave for the clamper circuit only for V_b=2.5V.

<u>Data Collection:</u> *Signature of instructor:*

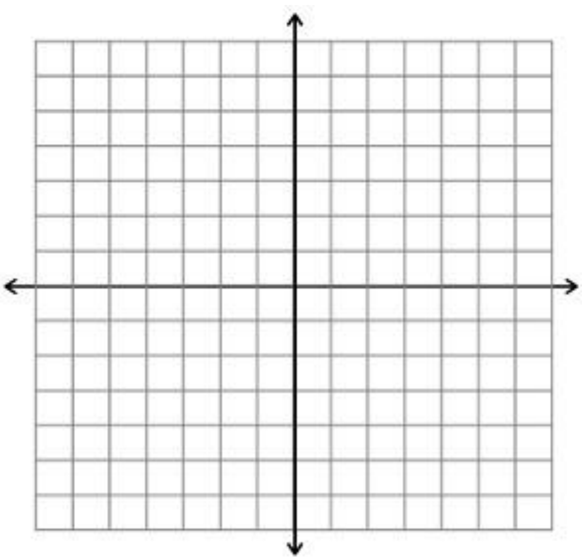
Experiment: 4,
Performed by Group# _____

Theoretical value: R = ___ kΩ

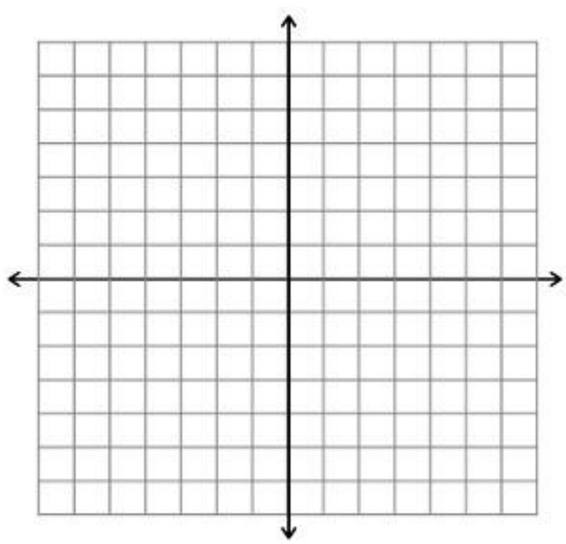
Measured value: R = ___ kΩ

Vs = _____ V(p-p).

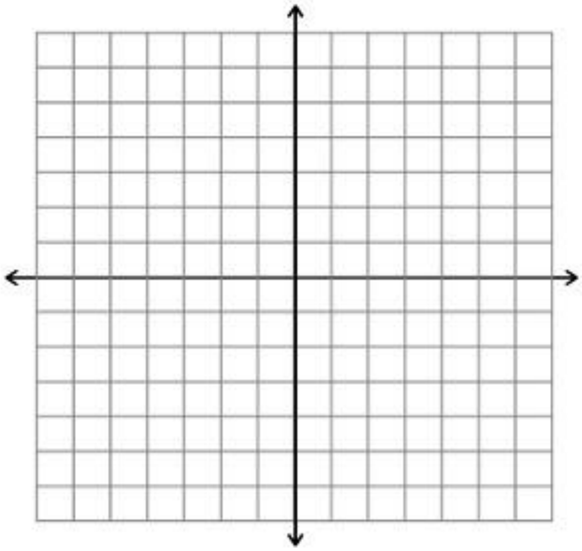
V_b (V)	Vo (p-p)					
	Fig 3.6		Fig 3.7		Fig 3.8	
	(a)	(b)	(a)	(b)	(a)	(b)
0						
1						
2						
2.5					V_{max}= V_{min}=	V_{max}= V_{min}=
3						
4						
5						



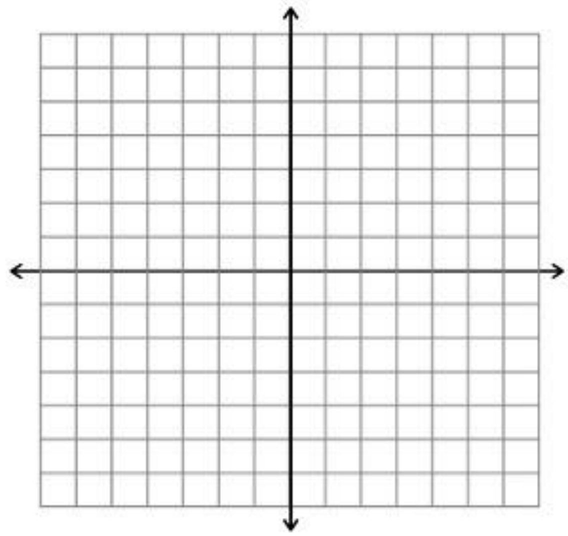
Input-output Fig 4.6 (a)



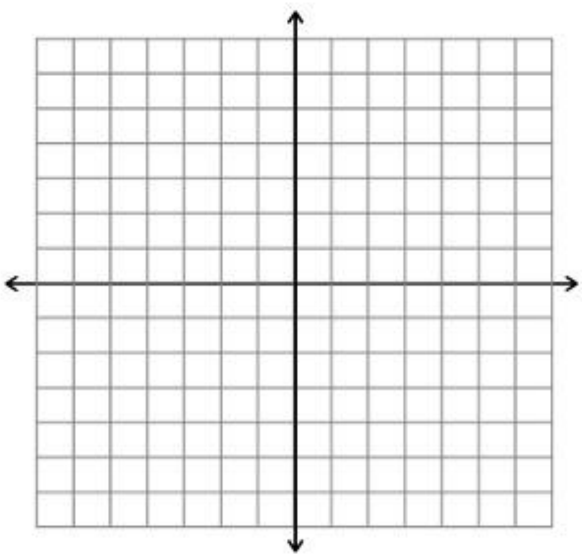
Input-output Fig 4.6 (b)



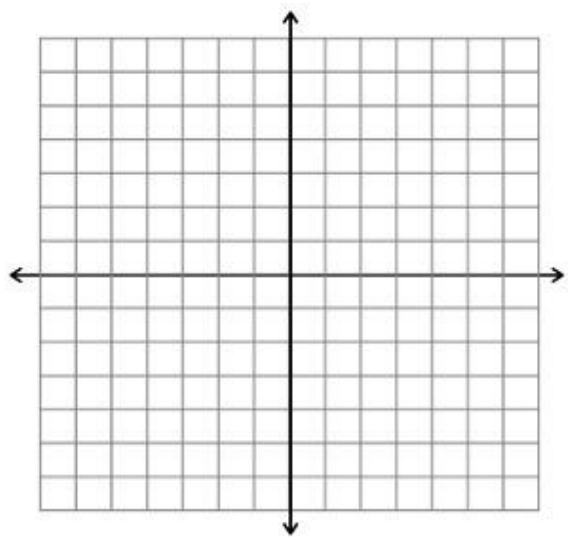
Input-output Fig 4.7 (a)



Input-output Fig 4.7 (b)



Input-output Fig 4.8 (a)



Input-output Fig 4.8 (b)

Report:

1. Using values from your data table, for all the circuit diagrams plot the input-output waveforms observed on the oscilloscope for $\boldsymbol{V_b}$=2.5V.
2. For Fig 4.6(a &b), Fig4.7 (a & b) and Fig 4.8 (a & b) what change did you observe in the output voltage, In procedure-4? *Explain the reason behind such a change.*
3. For Fig 4.6(a &b), Fig4.7 (a & b) and Fig 4.8 (a & b) what change did you observe in the output voltage, In procedure-5? *Explain the reason behind such a change.*

Experiment No: 05

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.

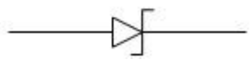


Figure 3.1 : Symbol of Zener Diode.

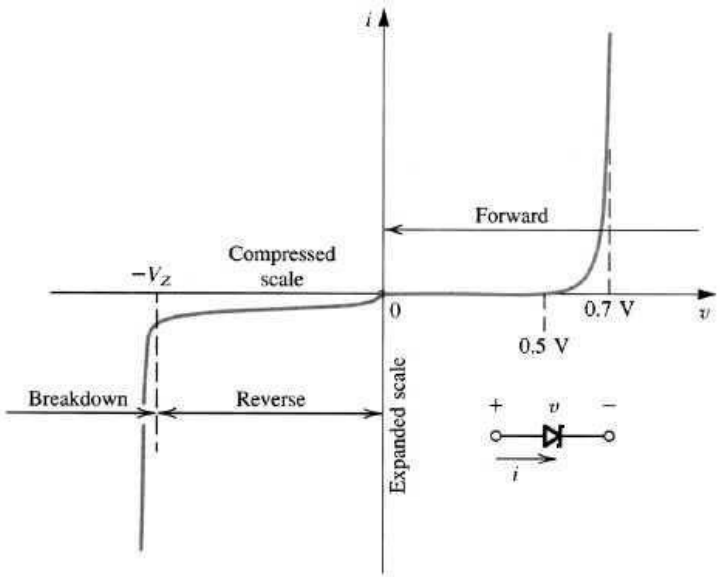


Figure 3.2 : I - V Characteristics of Zener Diode.

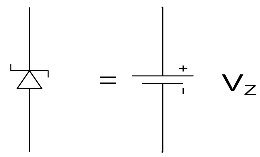
The Zener diode may have a breakdown voltage from about 2 to 200 volts. These diodes can operate in any of three regions – forward, leakage and breakdown. Figure 4.2 shows the I-V characteristics curve of Zener diode.

- 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.

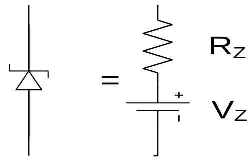
- In the breakdown it has a sharp knee, followed by an almost vertical increase in current without changing the voltage.
- The voltage is almost constant, approximately equal to V_z over most of the breakdown region.

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:

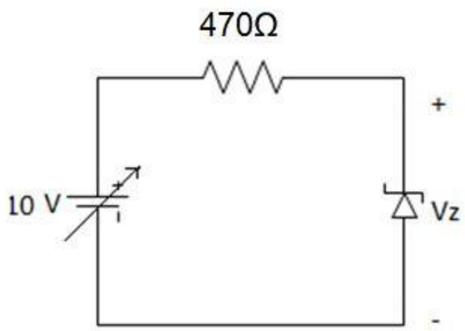


Figure 3.3: Reverse Biased Zener Characteristics

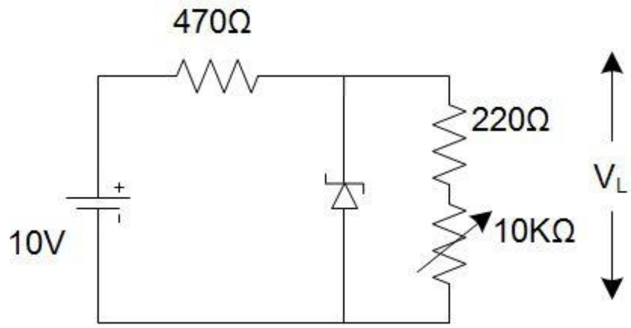


Figure 3.4: Load Regulation

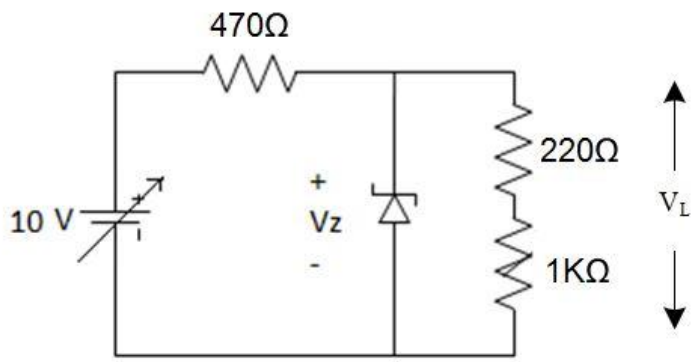


Figure 3.5: Line Regulation

Procedure:

1. Connect the circuit as shown in the figure 3.3
2. Vary the supply voltage from zero volt, complete the Table 3.1.
3. Connect the circuit as shown in the figure 3.4
4. Keep the POT at maximum position and power up the circuit.
5. Gradually decrease the POT resistance and complete the Table 3.2.
6. Replace the POT with 1KΩ resistance, vary the supply voltage and take reading for Table 3.3.

Data Collection:

Signature of instructor:

Experiment: 3,
Performed by Group# _____

Theoretical	Practical
470Ω	
220Ω	
1KΩ	

Table 3.1: Data for I - V characteristics.

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

Table 3.2: Data for Load Regulation

POT R (kΩ)	V_{220} (mV)	V_L (volts)	I_L (Amp)= $V_{220}/220$
1 kΩ			
2 kΩ			
3 kΩ			
4 kΩ			
5 kΩ			
6 kΩ			
7 kΩ			
8 kΩ			
9 kΩ			
10 kΩ			

Table 3.3: Data for Line Regulation.

V (volts)	V_L (volts)
1 V	
3 V	
5 V	
6 V	
7 V	
8 V	
9 V	
10 V	
11 V	
12 V	

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 Load regulation from the graph.
3. Plot V_L vs V for the data table 4.3. Find the line regulation from graph.

Experiment No: 06

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.

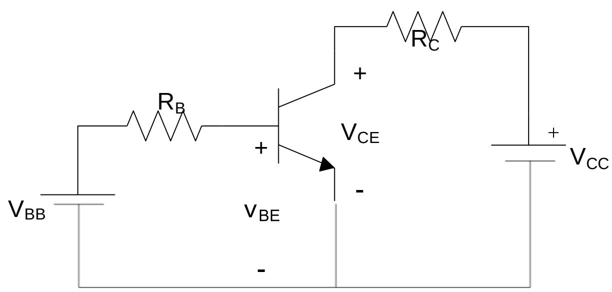


Figure 5.1: Biasing of an NPN transistor.

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.

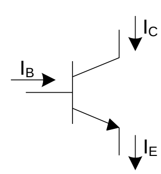


Figure 5.2 : Different current in transistor.

Here, $I_e = I_c + I_b$ and current gain, $B = I_c / I_b$

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

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

<u>Input Characteristics Curve:</u> 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.

<u>Output Characteristics Curve:</u> 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.

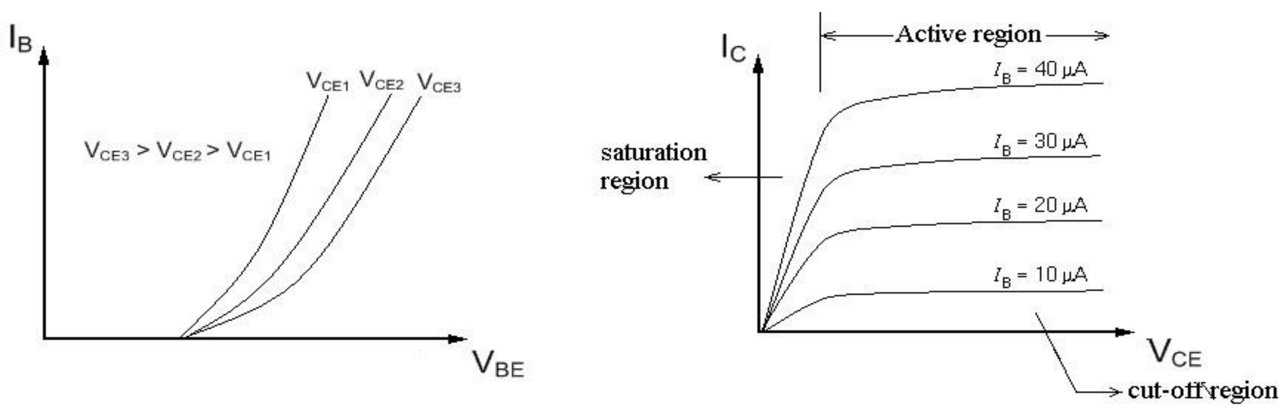
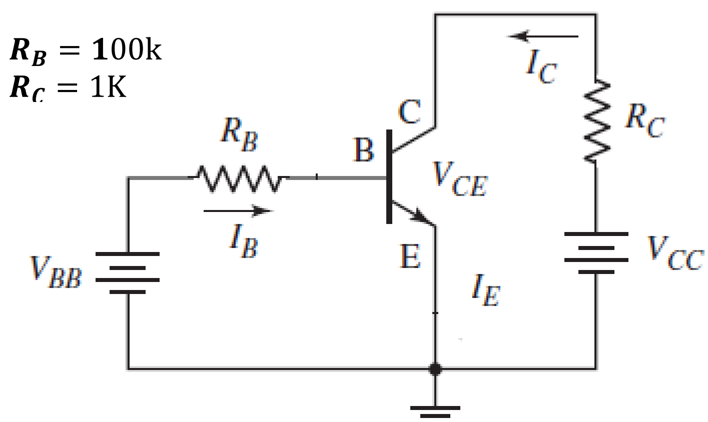


Figure 5.3 : (a) Input Characteristic, (b) Output Characteristic of NPN transistor.

Equipment & Components:

Serial	Component Details	Specification	Quantity
1	Transistor	BC 548	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:



Procedure:

Data Collection: *Signature of instructor:*

Experiment: 6,
Performed by Group# _____

- R_B = ___________________
- R_C = ___________________

Input Characteristics:

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

Table 1: Input Characteristics of BJT

- When V_{CE} = 2V → V_{CC} = ___________________
- When V_{CE} = 5V → V_{CC} = ___________________

$\mathbf{V_{CE}}$ = 2 V				$\mathbf{V_{CE}}$ = 5V			
$\mathbf{V_{BB}}$ (Volts)	$\mathbf{V_{BE}}$ (Volts)	$\mathbf{V_{RB}}$ (Volts)	$\mathbf{I_B} = \frac{V_{RB}}{R_B}$ (μA)	$\mathbf{V_{BB}}$ (Volts)	$\mathbf{V_{BE}}$ (Volts)	$\mathbf{V_{RB}}$ (Volts)	$\mathbf{I_B} = \frac{V_{RB}}{R_B}$ (μA)
0.1				0.1			
0.2				0.2			
0.3				0.3			
0.4				0.4			
0.5				0.5			
0.6				0.6			
0.7				0.7			
0.8				0.8			
0.9				0.9			
1.0				1.0			
1.2				1.2			
1.4				1.4			
1.6				1.6			
1.8				1.8			
2.0				2.0			
3.0				3.0			
4.0				4.0			
5.0				5.0			

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 $\mathbf{I_B}$ = 50µA [V_{RB} = 5V]

<u>Table 2: Output Characteristics of BJT</u>

- When V_{RB} = 2V → V_{BB} = ____________________
- When V_{RB} = 5V → V_{BB} = ____________________

	$\mathbf{I_B}$ = 20μA				$\mathbf{I_B}$ = 50μA		
$\mathbf{V_{CC}}$	$\mathbf{V_{CE}}$ **(Volts)**	$\mathbf{V_{RC}}$ **(Volts)**	$\mathbf{I_C} = \frac{V_{RC}}{RC}$ **(Amp)**	$\mathbf{V_{CC}}$	$\mathbf{V_{CE}}$ **(Volts)**	$\mathbf{V_{RC}}$ **(Volts)**	$\mathbf{I_C} = \frac{V_{RC}}{RC}$ **(Amp)**
0.1				0.1			
0.2				0.2			
0.3				0.3			
0.4				0.4			
0.5				0.5			
0.6				0.6			
0.7				0.7			
0.8				0.8			
0.9				0.9			
1.0				1.0			
1.2				1.2			
1.5				1.5			
2.0				2.0			
2.5				2.5			
3.0				3.0			
5.0				5.0			
10.0				10.0			
15.0				15.0			
20.0				20.0			
				23.0			
				26.0			
				30.0			

<u>Report:</u>

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}= 15V, draw the load line and write the coordinates of the Q-point.

Experiment No: 07

Name of the Experiment: The BJT Biasing Circuits.

Objective:

Study of the BJT Biasing Circuits.

Theory:

Biasing a BJT circuit means to provide appropriate direct potentials and currents, using external sources, to establish an operating point or Q-point in the active region. Once the Q-point is established, the time varying excursions of input signal should cause an output signal of same waveform. If the output signal is not a faithful reproduction of the input signal, for example, if it is clipped on one side, the operating point is unsatisfactory and should be relocated on the collector characteristics. Therefore, the main objective of biasing a BJT circuit is to choose the proper Q-point for faithful reproduction of the input signal. There are different types of biasing circuit. However, in the laboratory, we will study only the fixed bias and self-bias circuit. In the fixed bias circuit, shown if figure 6.1, the base current IB is determined by the base resistance RB and it remains constant. The main drawback of this circuit is the instability of Q-point with the variation of β of the transistor. In the laboratory, we will test the stability using two transistors with different β. In the self-bias circuit shown if figure 6.2, this problem is overcome by using the self-biasing resistor R_E to the emitter terminal.

Equipments and Components:

Serial no.	Component Details	Specification	Quantity
1.	Transistor	C828	1 piece
2.	Resistor	470Ω, 2.2KΩ, 3.3KΩ, 4.7KΩ, 10KΩ, 470KΩ	1 piece each
3.	POT	100KΩ	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:

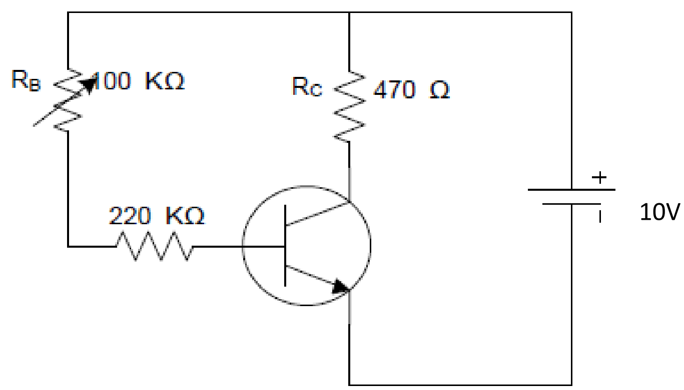


Figure 7.1: Experimental Circuit 1.

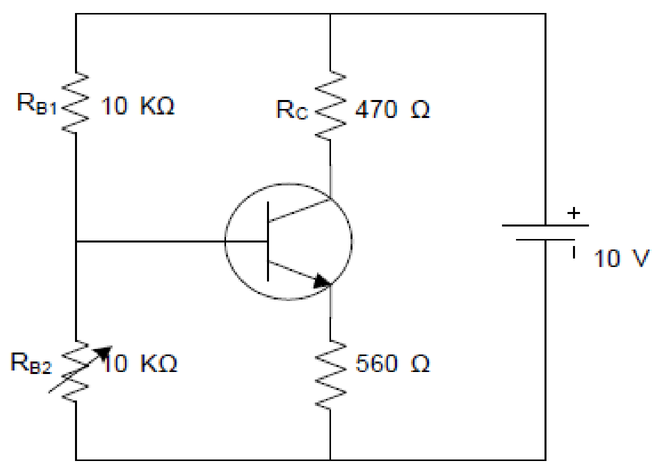


Figure 7.2: Experimental Circuit 2.

Procedure:

1. Arrange the circuit shown in figure - 6.1 by C828. Record R_C and set R_B to maximum value.
2. Decrease POT R_B gradually so that $V_{CE} = V_{CC} / 2$.
3. Measure voltage across R_C and V_{CE}.
4. Record the Q-point (V_{CE}, I_C).
5. Replace the C828 transistor by BD135 and repeat step 3 and 4.
6. Arrange the circuit shown in figure - 6.2 by C828. Record R_C and set R_B to minimum value.
7. Increase POT R_{B2} gradually so that VCE = VCC / 2.
8. Measure voltage across R_C and V_{CE}.
9. Record the Q-point (V_{CE}, I_C).
10. Replace the C828 transistor by BD135 and repeat step 8 and 9.

Data Sheet:

Table 7.1 : Data for Fixed Bias Circuit.

Transistor	R_C (Ω)	V_C (volt)	$I_C = V_C / R_C$ (Amp)	V_{CE} (volt)	Q-point
C828					
BD135					

Table 7.2 : Data for Self Bias Circuit.

Transistor	R_C (Ω)	V_C (volt)	$I_C = V_C / R_C$ (Amp)	V_{CE} (volt)	Q-point
C828					
BD135					

Report:

1. Which circuit shows better stability? Explain in the context of the results obtained in the laboratory.
2. Draw the DC load line for both the circuits and show the Q-point.

Experiment 08:

Name of the Experiment: Study of Switching Characteristics

Introduction:

The most common transistor types are the Metal Oxide Semiconductor Field Effect Transistors (MOSFETs) and the Bipolar Junction Transistors (BJT). BJTs based circuits dominated the electronics market in the 1960's and 1970's. Nowadays most electronic circuits, particularly integrated circuits (ICs), are made of MOSFETs. The BJTs are mainly used for specific applications like analog circuits (e.g. amplifiers), high-speed circuits or power electronics.

There are two main differences between BJTs and FETs. The first is that FETs are charge- controlled devices while BJTs are current or voltage controlled devices. The second difference is that the input impedance of the FETs is very high while that of BJT is relatively low.

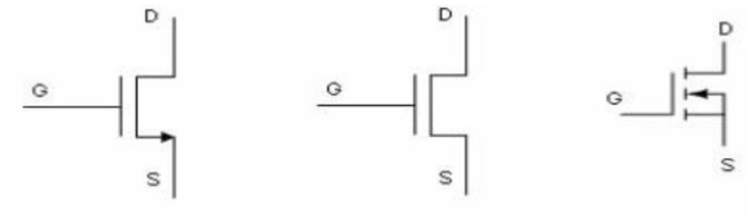
As for the FET transistors, there are two main types: the junction field-effect transistor (JFET) and the metal oxide semiconductor field effect transistor (MOSFET). The power dissipation of a JFET is high in comparison to MOSFETs. Therefore, JFETs are less important if it comes to the realization of ICs, where transistors are densely packed. The power dissipation of a JFET based circuit would be simply too high. The combination of n- type and p-type MOSFETs allow for the realization of the Complementary Metal Oxide Semiconductor (CMOS) technology, which is nowadays the most important technology in electronics. All microprocessors and memory products are based on CMOS technology. The very low power dissipation of CMOS circuits allows for the integration of millions of transistors on a single chip. In this experiment, we will concentrate on the MOSFET transistor. We will investigate its characteristics and study its behavior when used as a switch.

Theory:

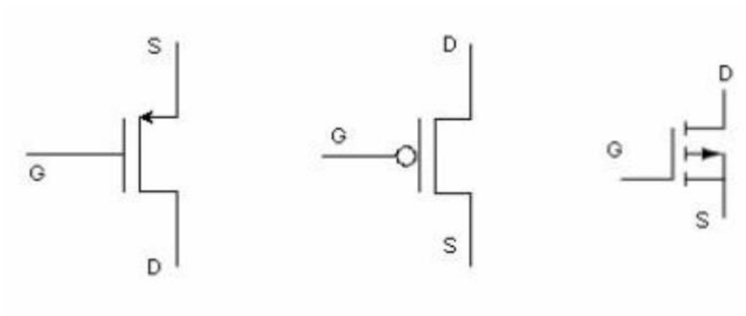
MOSFETs Structure and Physical Operation

The MOSFETs are the most widely used FETs. Strictly speaking, MOSFET devices belong to the group of Insulated Gate Field Effect Transistor (IGFETs). As the name implies, the gate is insulated from the channel by an insulator. In most of the cases, the insulator is formed by a silicon dioxide (SiO2), which leads to the term MOSFET. MOSET like all other IGFETs has three terminals, which are called Gate (G), Source (S), and Drain (D). In certain cases, the transistors have a fourth terminal, which is called the bulk or the body terminal. In PMOS, the body terminal is held at the most positive voltage in the circuit and in NMOS, it is held at the most negative voltage in the circuit.

There are four types of MOSFETs: enhancement n-type MOSFET, enhancement p-type MOSFET, depletion n-type MOSFET, and depletion p-type MOSFET. The type depends whether the channel between the drain and source is an induced channel or the channel is physically implemented and whether the current owing in the channel is an electron current or a hole current.



Symbols for Enhancement NMOS Transistor



Symbols for Enhancement PMOS Transistor

If we put the drain and source on ground potential and apply a positive voltage to the gate, the free holes (positive charges) are repelled from the region of the substrate under the gate (channel region) due to the positive voltage applied to the gate. The holes are pushed away downwards into the substrate leaving behind a depletion region. At the same time, the positive gate voltage attracts electrons into the channel region.

When the concentration of electrons near the surface of the substrate under the gate is higher than the concentration of holes, an n region is created, connecting the source and the drain regions. The induced n-region thus forms the channel for current flow from drain to source. The channel is only a few nanometers wide. Nevertheless, the entire current transport occurs in this thin channel between drain and source.

A common application of MOSFETs is switches in analog and digital circuits. Switches in analog circuits can be used for example in data acquisition systems, where they serve as analog multiplexors, which allow the selection of one of several data inputs. A simple example of a switching circuit based on an n-type enhancement transistor and a resistor is shown below.

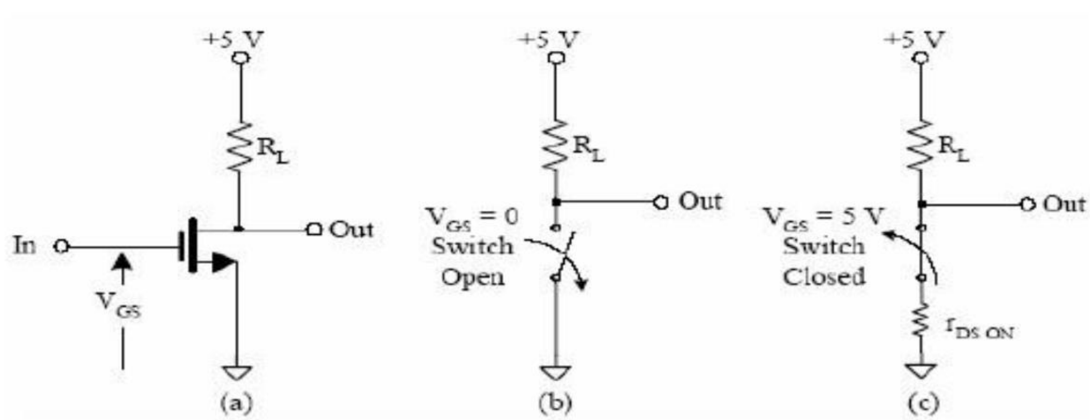


Fig: NMOS transistor switch

The voltage applied to the gate controls the conductance of the channel. A zero or low value of V_{GS}, the conductance is very low so that is the transistor acts like an open circuit and no current flows through the load resistor R_L. When V_{GS} exceeds the threshold, the channel conductance becomes higher and the transistor acts like a closed switch. The channel resistance is not getting zero but the resistance is getting small so that the output voltage V_{out} is getting small. Fig.(a) below shows an NMOS switching FET and its models for V_{in} = 0 (Fig. (b)) and V_{in} = +5V (Fig. (c)). In each case, the FET is modeled as a mechanical switch.

As for PMOS, a negative value of V_{GS} has to be applied to turn the transistor on. The operation can be described using the curves shown in figure below. When the input voltage, V_{GS}, of the transistor shown is zero, the MOSFET conducts virtually no current, and the output voltage, V_{out}, is equal to V_{DD}. When V_{GS} is equal to 5V , the MOSFET Q-point moves from point A to point B along the load line, with V_{DS} = 0.5V . Thus, the circuit acts as an inverter. The inverter forms the basis of all MOS logic gates.

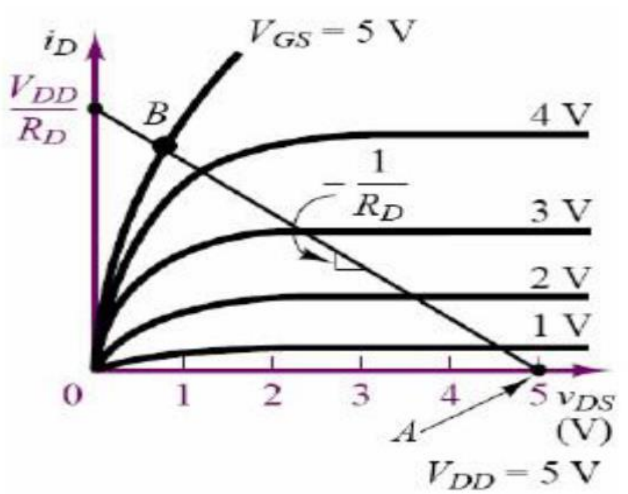
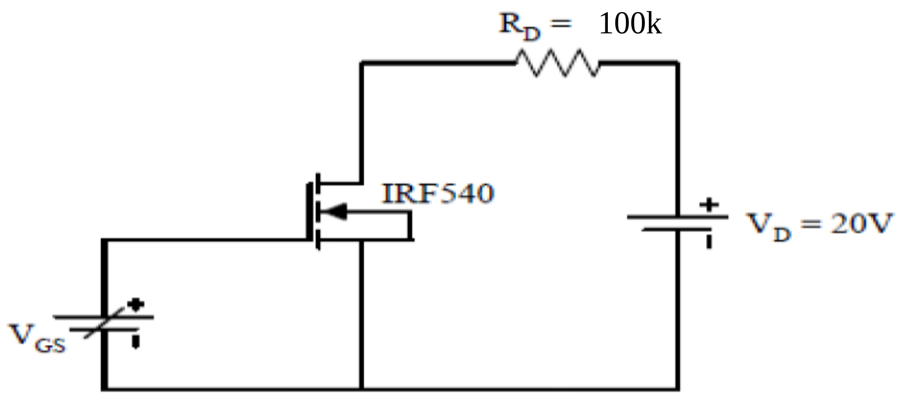


Fig: MOSFET switching characteristics

Equipment and Component:

Serial no.	Component Details	Specification	Quantity
1.	MOSFET	IRF540	1 piece each
2.	Resistor	100kΩ	1 piece each
3.	POT		1 unit
4.	Trainer Board		1 unit
5.	DC Power Supply		2 unit
6.	Digital Multimeter		1 unit
7.	Chords and wire		as required

Experimental Setup:



Procedure:

1. Set V_{GS} to zero and record the V_{DS}, V_L and I_D.
2. Increase the gate voltage V_{GS} gradually and record the readings.
3. Take reading until I_D = 20mA (or the saturation current of the MOSFET).
4. Note the condition of V_{DS} and I_D of steps 1 and 3.
5. Repeat the experiment for V_{DD} = 15 Volts.

V_{DD} = 15V				V_{DD} = 20V			
V_{GS}	V_{DS}	V_L	I_D	V_{GS}	V_{DS}	V_L	I_D