DEPT. OF ELECTRICAL & ELECTRONICS ENGINEERING
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY, Kattankulathur – 603203.

Title of Experiment	: **4. Characteristics of semiconductor devices (a) PN junction diode, (b) Zener diode, (c)BJT**
Name of the candidate	: Arnav shukla
Register Number	: RA2111050010001
Date of Experiment	: 25-10-2021
Date of submission	: 28-10-2021

Sl. No.	Marks Split up	Maximum marks	Marks obtained
1	Pre-Lab questions		
2	Preparation of observation		
3	Execution of experiment		
4	Calculation / Evaluation of Result		
5	Post Lab questions		
Total			

Staff Signature

PRE LAB QUESTIONS

1. What are intrinsic and extrinsic semiconductors?

Intrinsic semiconductor: The pure form of the semiconductor is known as the intrinsic semiconductor.

Extrinsic semiconductors: The semiconductor where purposefully impurities are added for making it conductive is known as the extrinsic semiconductor.

2. Give examples for Trivalent and Pentavalent impurity.

Examples of pentavalent impurities are antimony, arsenic, phosphorus.
Examples of trivalent impurities are boron, aluminum, and gallium.

3. What is the need for Zener diode?

Zener diodes are used for voltage regulation, as reference elements, surge suppressors, and in switching applications and clipper circuits.

At the point when associated in corresponding with a variable voltage source so it is converse one-sided, a Zener diode conducts when the voltage comes to

4. What is voltage regulation and mention its significance?

Definition:

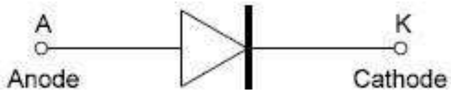
Voltage guideline is the proportion of how well a force transformer can keep up steady optional voltage given a consistent essential voltage and wide change in load current.

Significance:

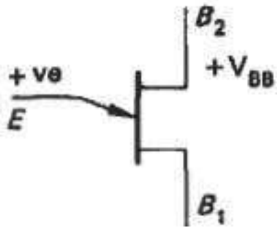
The load connected to the power system or a transformer will not be steady all the time. Change in load causes changes in current and hence the voltage drop in the transformer winding as well. It is necessary to maintain the supply voltage of the equipment supplied by the transformer. Because the supply voltage directly affects the performance of the equipment. Hence, the voltage regulation of the transformer is significant.

5. Give the different types of semiconductor devices with symbols

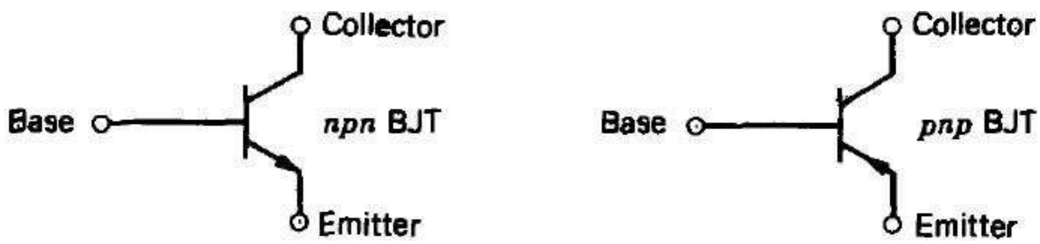
POWER DIODE:



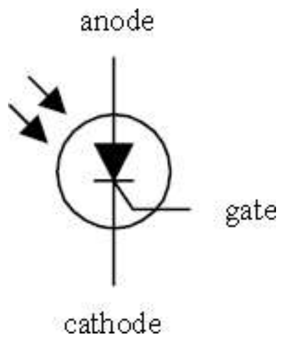
UNI JUNCTION TRANSISTOR:



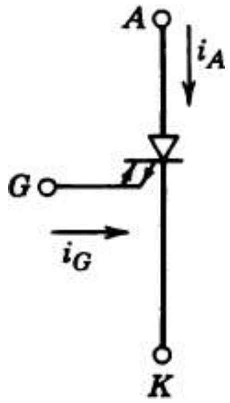
POWER BJT:



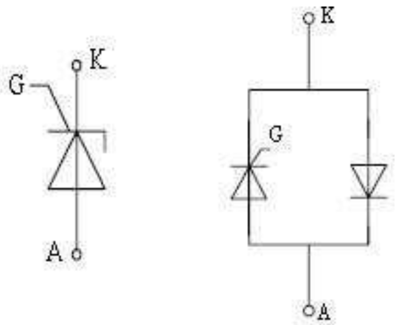
SILICON CONTROLLED RECTIFIER:



GATE TURN OFF THYRISTOR:



REVERSE CONDUCTING THYRISTOR:



Experiment No. 4 a) Date :	CHARACTERISTICS OF PN JUNCTION DIODE

Aim

To study the characteristics of PN Junction diode under forward and reverse bias conditions.

Apparatus Required

S.No.	Name	Range	Qty
1	R.P.S	(0-30)V	1
2	Ammeter	(0–30)mA	1
		(0-500)μA	1
3	Voltmeter	(0–1)V	1
		(0-10)V	1

Components Required

S.No.	Name	Range	Qty
1	Diode	IN4001	1
2	Resistor	1kΩ	1
3	Bread Board	-	1
4	connecting Wires	-	Req

Theory

A PN junction diode is a two terminal semiconducting device. It conducts only in one direction (only on forward biasing).

Forward Bias

On forward biasing, initially no current flows due to barrier potential. As the applied potential exceeds the barrier potential the charge carriers gain sufficient energy to cross the potential barrier and hence enter the other region. The holes, which are majority carriers in the P-region, become minority carriers on entering the N-regions, and electrons which are the majority carriers in the N-region, become minority carriers on entering the P-region. This injection of minority carriers results in the current flow, opposite to the direction of electron movement.

Reverse Bias

On reverse biasing, the majority charge carriers are attracted towards the terminals due to the applied potential resulting in the widening of the depletion region. Since the charge carriers are pushed towards the terminals no current flows in the device due to majority charge carriers. There will be some current in the device due to the thermally generated minority carriers. The generation of such carriers is independent of the applied potential and hence the current is constant for all increasing reverse potential. This current is referred to as Reverse Saturation Current (I_O) and it increases with temperature. When the applied reverse voltage is increased beyond the certain limit, it results in breakdown. During breakdown, the diode current increases tremendously.

Procedure

Forward Bias

1. Connect the circuit as per the diagram.
2. Vary the applied voltage V in steps of 0.1V.
3. Note down the corresponding Ammeter readings I.
4. Plot a graph between V & I

Observations

1. Find the d.c (static) resistance = V/I.
2. Find the a.c (dynamic) resistance r = δV / δI (**r = ΔV/ΔI) =** $\frac{V_2 - V_1}{I_2 - I_1}$.
3. Find the forward voltage drop [Hint: it is equal to 0.7 for Si and 0.3 for Ge]

Reverse Bias

1. Connect the circuit as per the diagram.
2. Vary the applied voltage V in steps of 1.0V.
3. Note down the corresponding Ammeter readings I.
4. Plot a graph between V & I
5. Find the dynamic resistance **r = δV / δI.**

Formula for Reverse Saturation Current (I_O):

$$I_o = \partial I / [\exp(\partial V / \eta V_T)] - 1$$

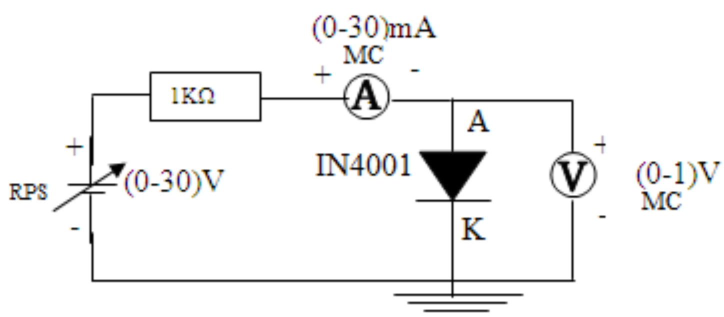
Where V_T is the voltage equivalent of Temperature = kT/q

-k is Boltzmann's constant, q is the charge of the electron and T is the temperature in degrees Kelvin.

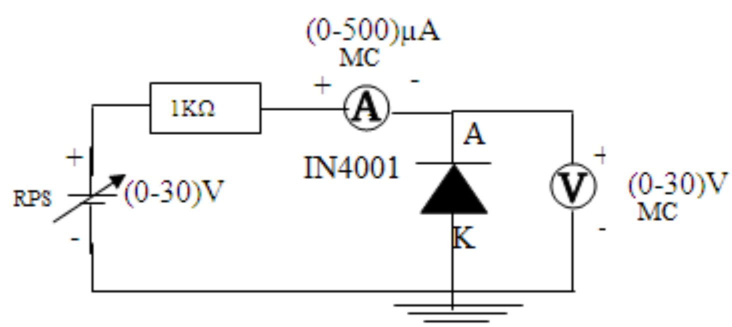
η =1 for Silicon and 2 for Germanium

Circuit Diagram

Forward Bias



Reverse Bias



Specification for 1N4001: Silicon Diode

Peak Inverse Voltage: 50V

I_{dc} = 1A.

Maximum forward voltage drop at 1 Amp is 1.1 volts

Maximum reverse current at 50 volts is 5µA

Tabular Column

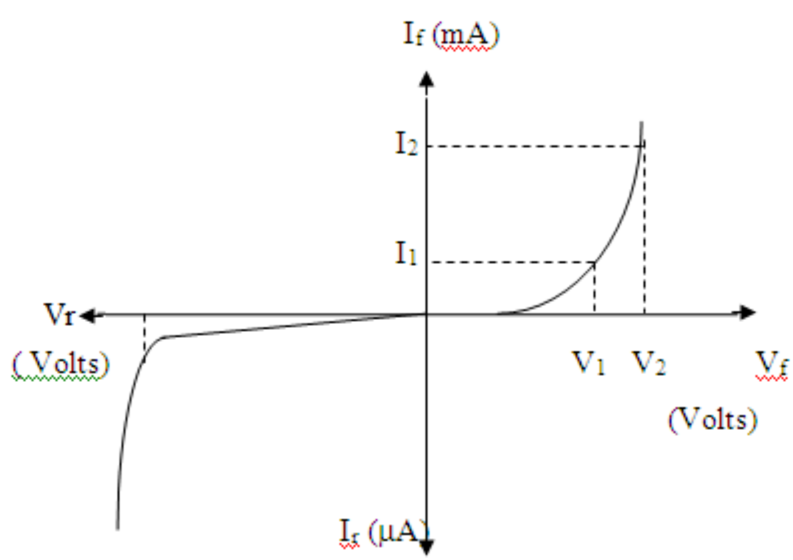
Forward Bias

S.no	Voltage (in Volts)	Current (in mA)
1	0	0
2	0.1	0.54 p
3	0.2	29.8 p
4	0.3	1.63 n
5	0.4	88.55 n
6	0.5	4.12µ
7	0.6	44.56µ
8	0.7	119.83µ
9	0.8	206.2µ
10	0.9	297.1µ
11	1	390µ

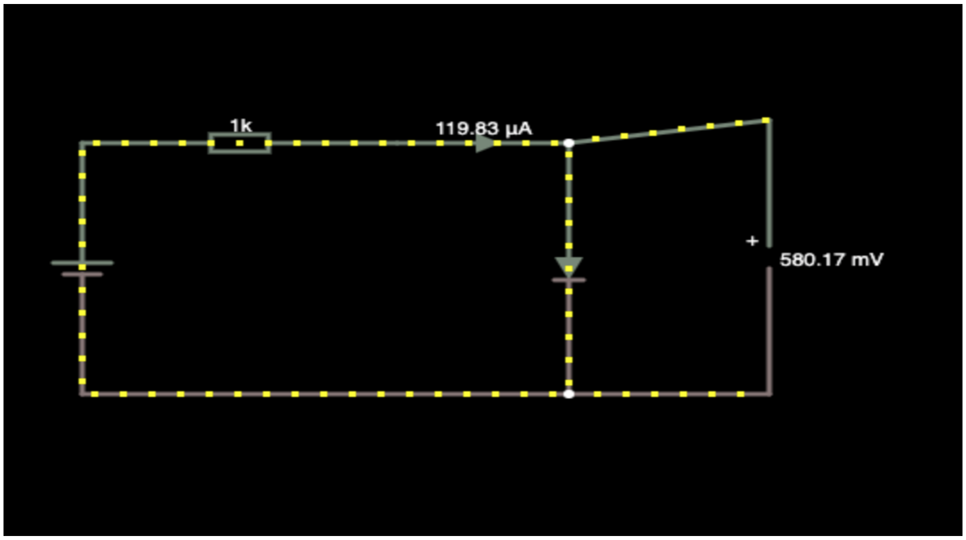
Reverse Bias

S.no	Voltage (in Volts)	Current (in mA)
1	1	0
2	2	0
3	3	0
4	4	0
5	5	0
6	6	0
7	7	0
8	8	0
9	9	0
10	10	0
11	11	0
12	12	0
13	13	0

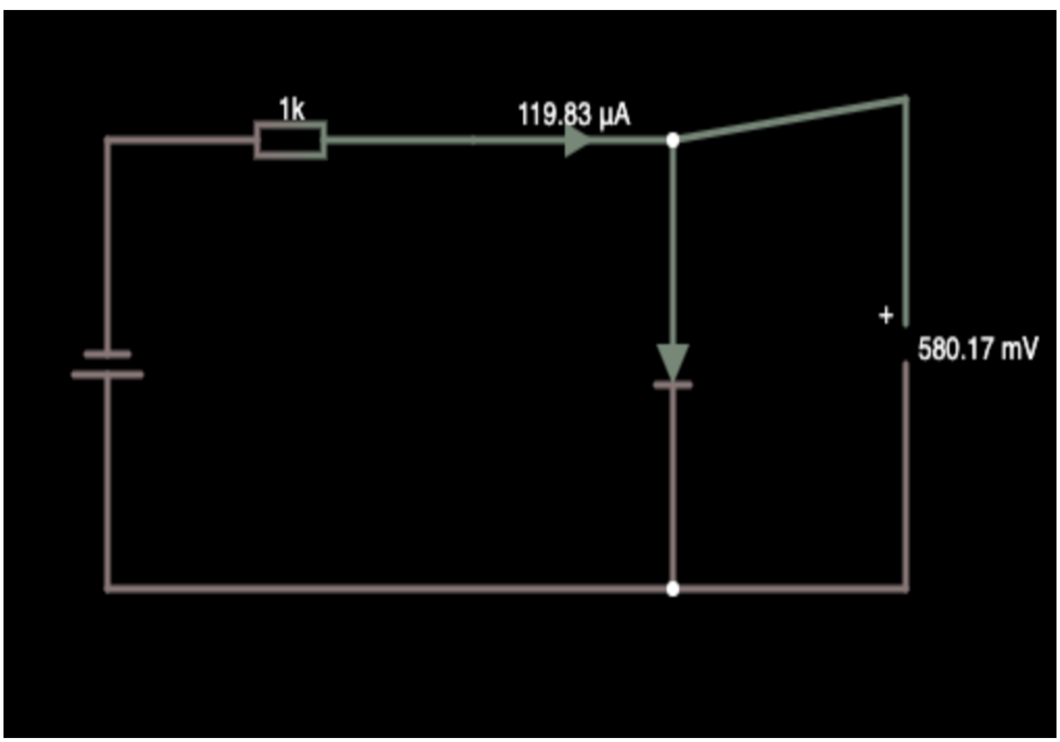
Model Graph



Simulation output

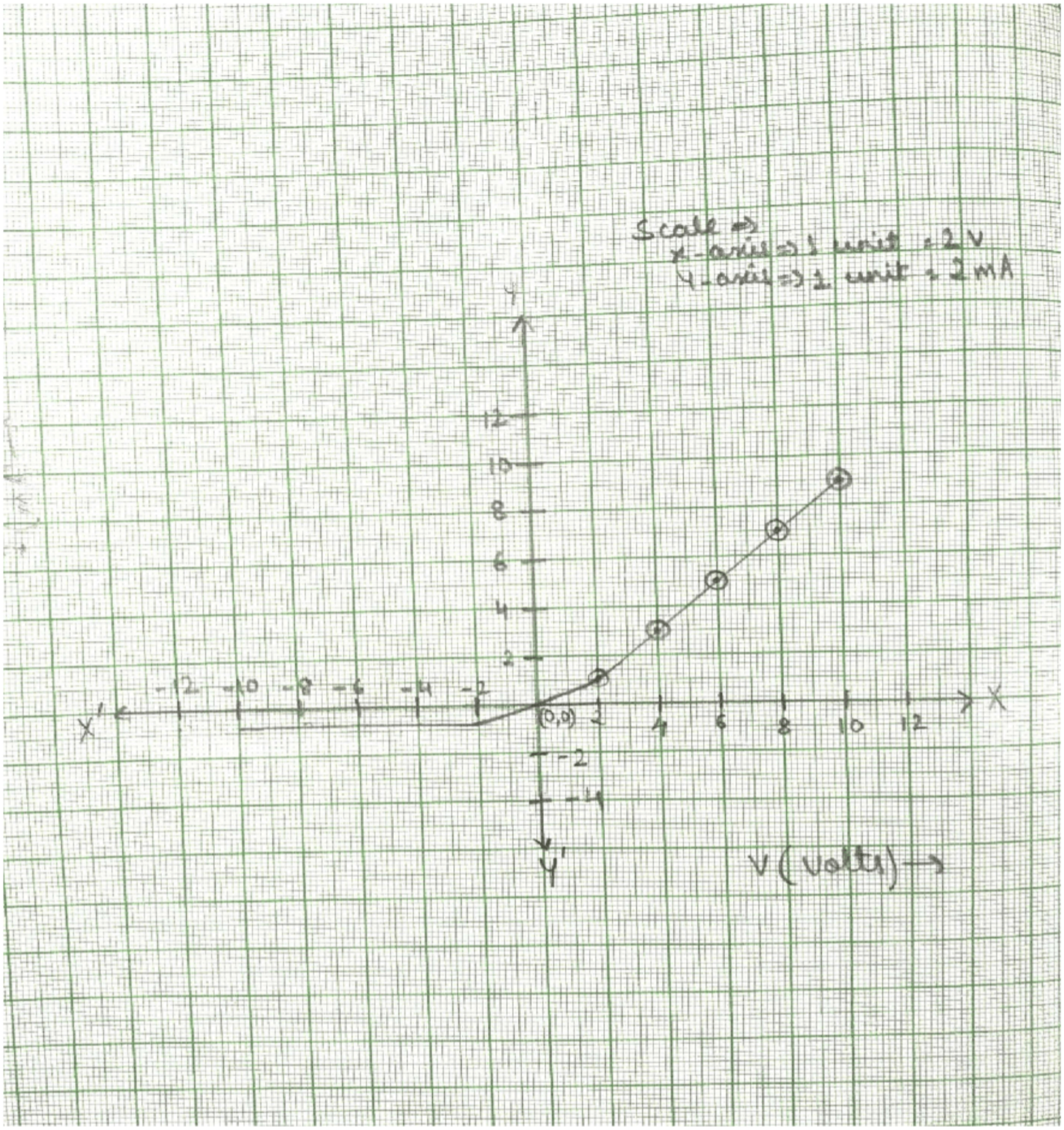


Forward Bias



Reversed bias

GRAPH:



Result

From the experiment we can conclude that under reverse biasing of diode the resistance infinite and no current flows through it but when very large voltage is applied the current overcomes the potential barrier and the values become infinite in case of forward biased diode it was noticed that current passed through it and there was exponential increase in current as voltage was increased.

Experiment No. 4 b) Date :	CHARACTERISTICS OF ZENER DIODE

Aim

To find the forward and reverse bias characteristics of a given Zener diode.

Apparatus Required

S.No.	Name	Range	Qty
1	R.P.S	(0-30)V	1s
2	Ammeter	(0–30)mA	2
3	Voltmeter	(0–10)V	1
		(0–1)V	1

Components Required

S.No.	Name	Range	Qty
1	Zener diode	FZ5.1	1
2	Resistor	1KΩ	1
3	Bread Board	-	1
4	Wires	-	Req

Theory

A properly doped crystal diode, which has a sharp breakdown voltage, is known as Zener diode.

Forward Bias

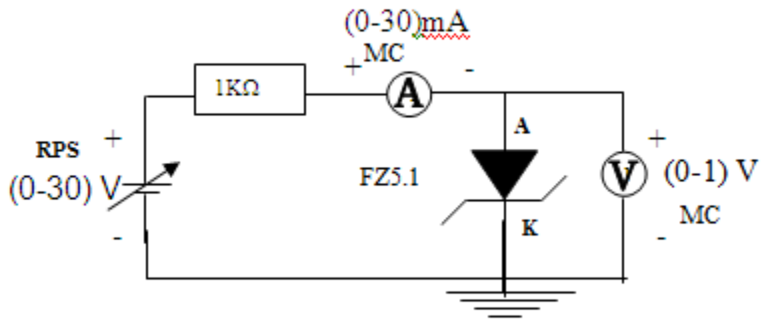
On forward biasing, initially no current flows due to barrier potential. As the applied potential increases, it exceeds the barrier potential at one value and the charge carriers gain sufficient energy to cross the potential barrier and enter the other region. the holes ,which are majority carriers in p-region, become minority carriers on entering the N-regions and electrons, which are the majority carriers in the N-regions become minority carriers on entering the P-region. This injection of minority carriers results current, opposite to the direction of electron movement.

Reverse Bias

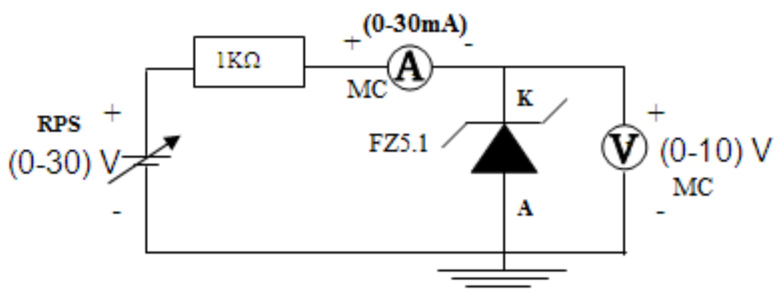
When the reverse bias is applied, due to majority carriers small amount of current (ie) reverse saturation current flows across the junction. As the reverse bias is increased to breakdown voltage, sudden rise in current takes place due to Zener effect.

Circuit Diagram

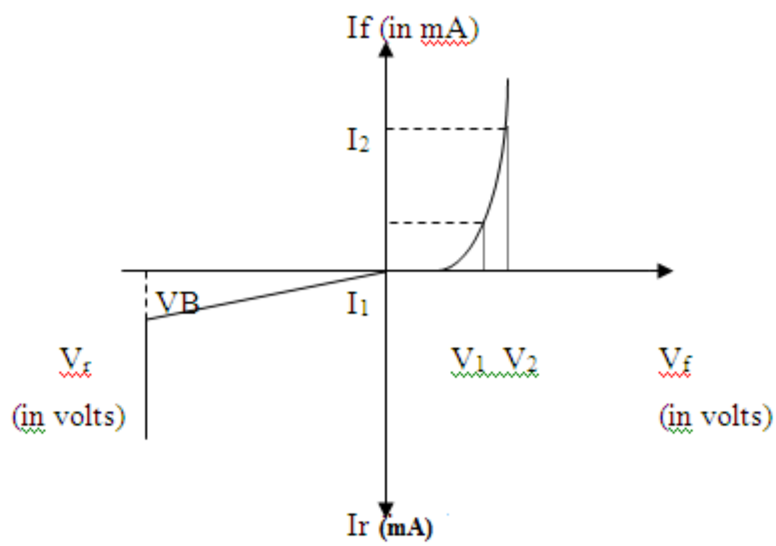
Forward Bias



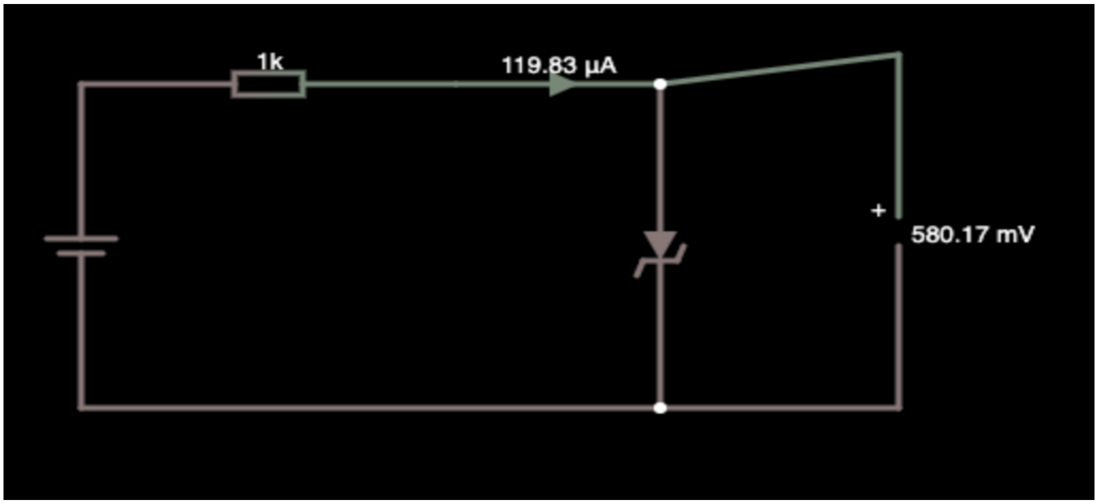
Reverse Bias



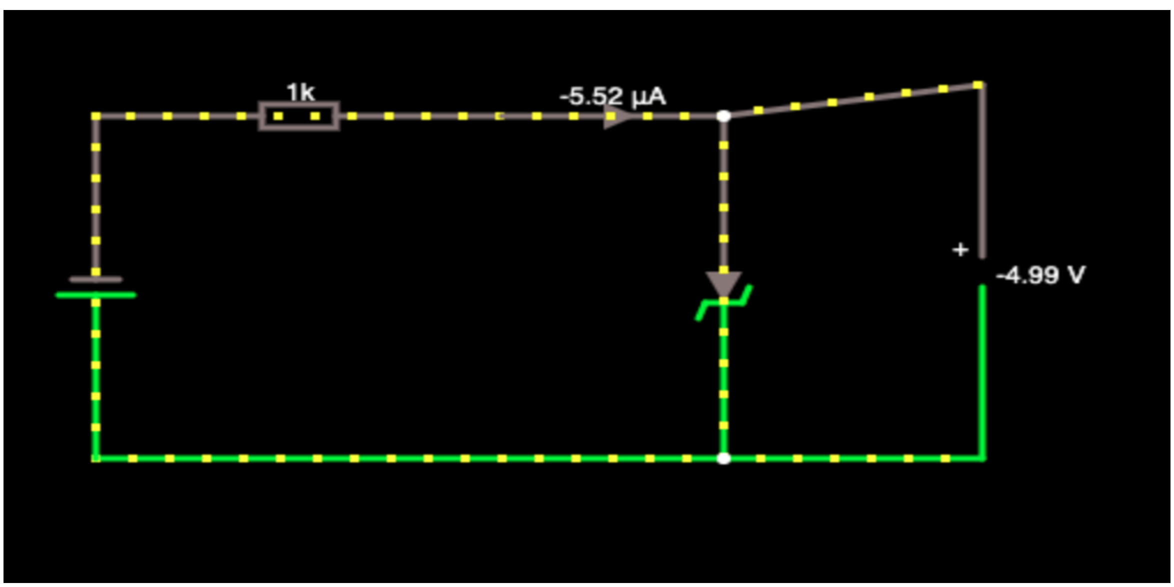
Zener Diode



Simulation Outputs



Forward bias



Reverse bias

Tabular Column

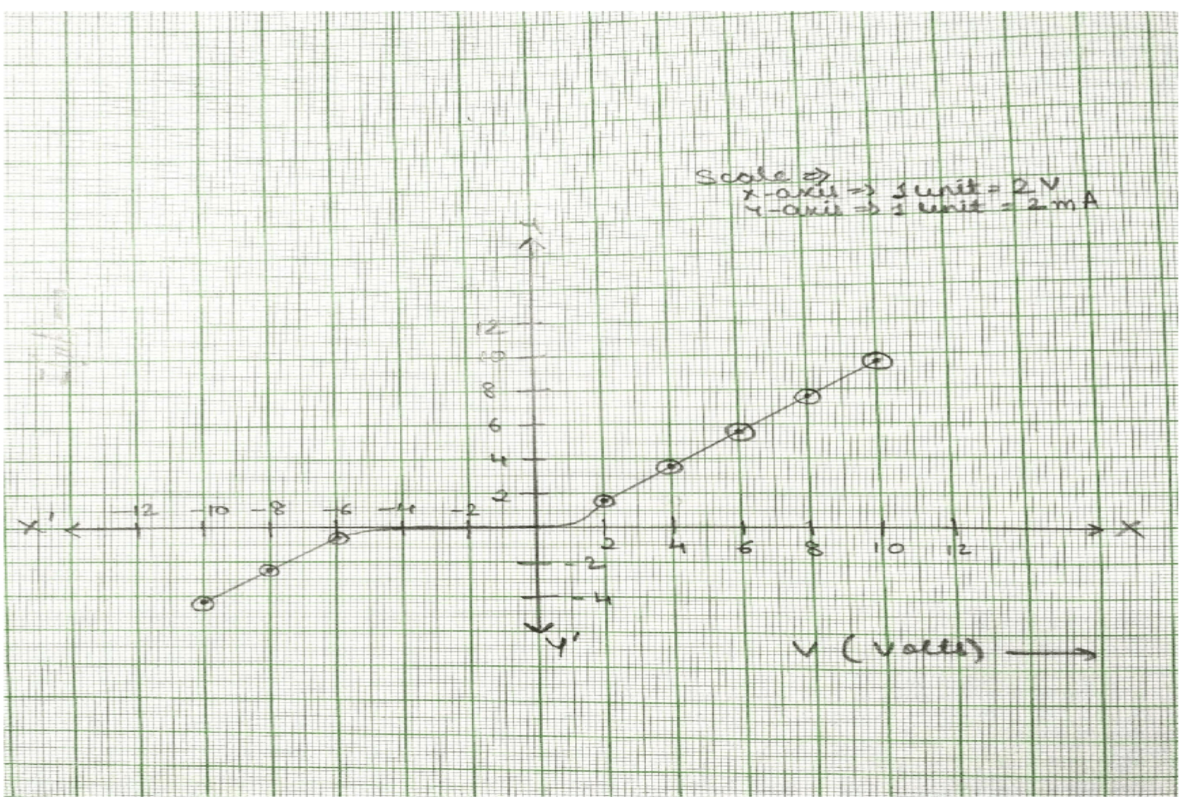
Forward Bias

S.no	Voltage (in Volts)	Current (in mA)
1	0	0
2	0.01	751.7 n
3	0.1	13.5µ
4	0.2	46.29µ
5	0.3	99.38µ
6	0.4	166.57µ
7	0.5	242.4µ
8	0.6	323.65µ
9	0.7	408.49µ
10	0.8	495.83µ

Reverse Bias

S.no	Voltage (in Volts)	Current (in mA)
1	-1	− 5µ
2	-2	− 5µ
3	-3	− 5µ
4	-4	− 5µ
5	-4.99	-5.52 µ
6	-5.45	-546 µ
7	-5.52	-1.48 mA
8	-5.55	-2.45 mA

GRAPH:



Result

In the event of forward one-sided Zener diode it is seen that there is continuous in increment in current as voltage is expanded .if there should be an occurrence of converse one-sided Zener diode at beginning there is augmentation in estimation of current however after some tie the estimation of current remaining parts unaltered for an extensive stretch of qualities then when the estimation of voltage is additionally expanded then it is seen that there is an outstanding ascent in current as well.

Zener Effect

Normally, PN junction of Zener Diode is heavily doped. Due to heavy doping the depletion layer will be narrow. When the reverse bias is increased the potential across the depletion layer is more. This exerts a force on the electrons in the outermost shell. Because of this force the electrons are pulled away from the parent nuclei and become free electrons. This ionization, which occurs due to electrostatic force of attraction, is known as Zener effect. It results in large number of free carriers, which in turn increases the reverse saturation current

Procedure

Forward Bias

1. Connect the circuit as per the circuit diagram.
2. Vary the power supply in such a way that the readings are taken in steps of 0.1V in the voltmeter till the needle of power supply shows 30V.
3. Note down the corresponding ammeter readings.
4. Plot the graph :V (vs) I.
5. Find the dynamic resistance **r = δV / δI.**

Reverse Bias

1. Connect the circuit as per the diagram.
2. Vary the power supply in such a way that the readings are taken in steps of 0.1V in the voltmeter till the needle of power supply shows 30V.
3. Note down the corresponding Ammeter readings I.
4. Plot a graph between V & I
5. Find the dynamic resistance **r = δV / δI.**
6. Find the reverse voltage Vr at I_z=20 mA.

Experiment No. 4 c) Date :	CHARACTERISTICS OF BJT (CE CONFIGURATION)

Aim

To plot the transistor (BJT) characteristics of CE configuration.

Apparatus Required

S.No.	Name	Range	Qty
1	R.P.S	(0-30)V	2
2	Ammeter	(0–30) mA MC	1
		(0–250) μA MC	1
3	Voltmeter	(0–30)V MC	1
		(0–1)V MC	1

Components Required

S.No.	Name	Range	Qty
1	Transistor	BC 107	1
2	Resistor	10 KΩ	1
	Resistor	1 KΩ	1
3	Bread Board		1
4	Wires		

Theory

A BJT is a three terminal two – junction semiconductor device in which the conduction is due to both the charge carrier. Hence it is a bipolar device. BJT is classified into two types – NPN & PNP. A NPN transistor consists of two N types in between which a layer of P is sandwiched. The transistor consists of three terminal emitter, collector and base. The emitter layer is the source of the charge carriers and it is heavily doped with a moderate cross sectional area. The collector collects the charge carries and hence moderate doping and large cross sectional area. The base region acts a path for the movement of the charge carriers. In order to reduce the recombination of holes and electrons the base region is lightly doped and is of hollow cross sectional area. Normally the transistor operates with the EB junction forward biased.

Procedure

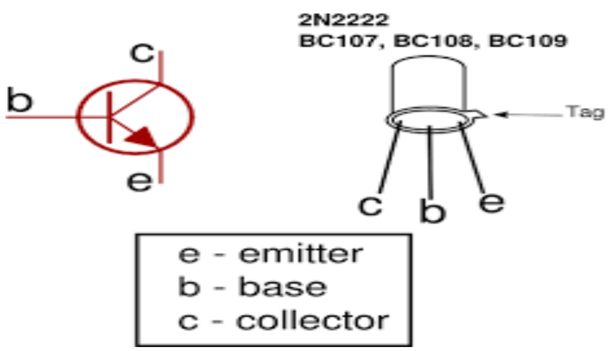
Input Characteristics

1. Connect the circuit as per the circuit diagram.
2. Set V_{CE}, vary V_{BE} in regular interval of steps and note down the corresponding I_B reading. Repeat the above procedure for different values of V_{CE}.
3. Plot the graph: V_{BE} Vs I_B for a constant V_{CE}.

Output Characteristics

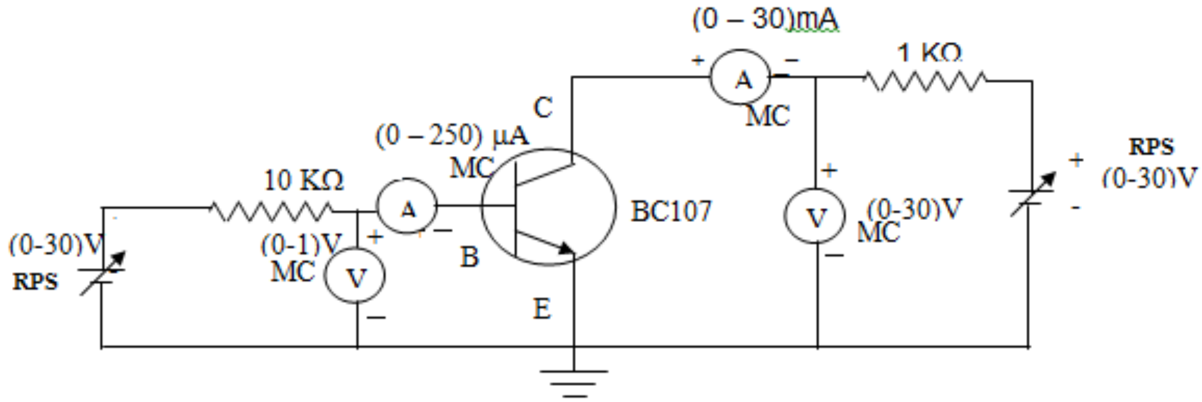
1. Connect the circuit as per the circuit diagram.
2. Set I_B, Vary V_{CE} in regular interval of steps and note down the corresponding I_C reading. Repeat the above procedure for different values of I_B.
3. Plot the graph: V_{CE} Vs I_C for a constant I_B.

Pin Diagram



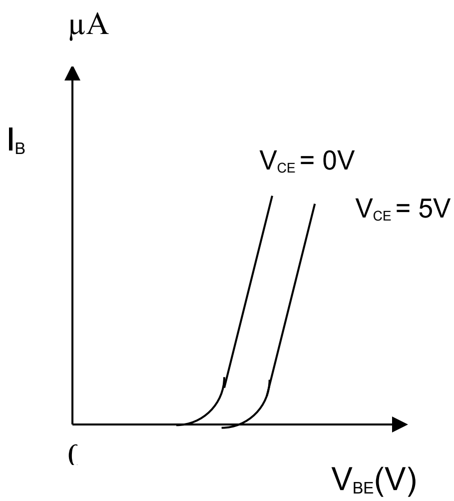
Specification: BC107/50V/0.1A,0.3W,300 MH

Circuit Diagram

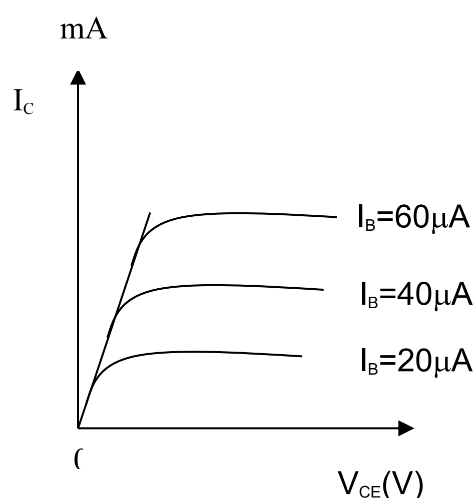


Model Graph

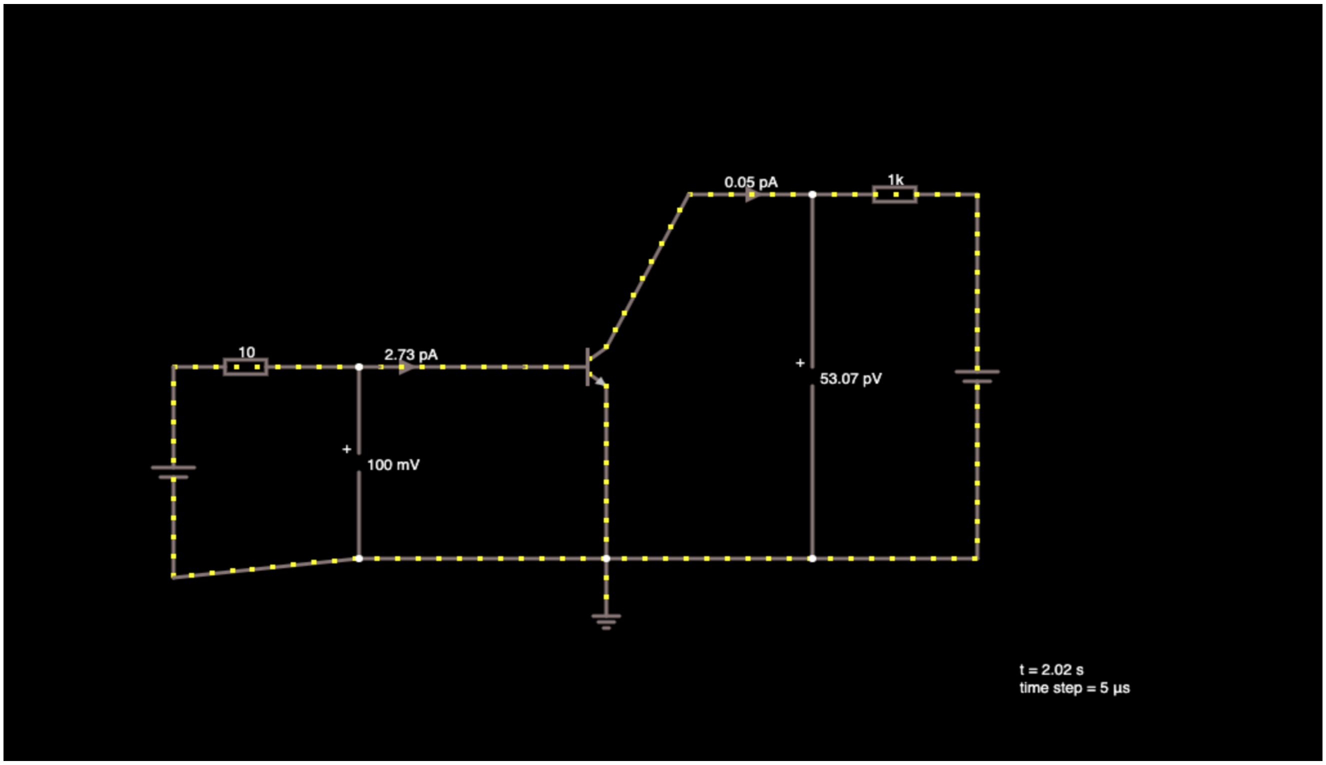
Input Characteristics

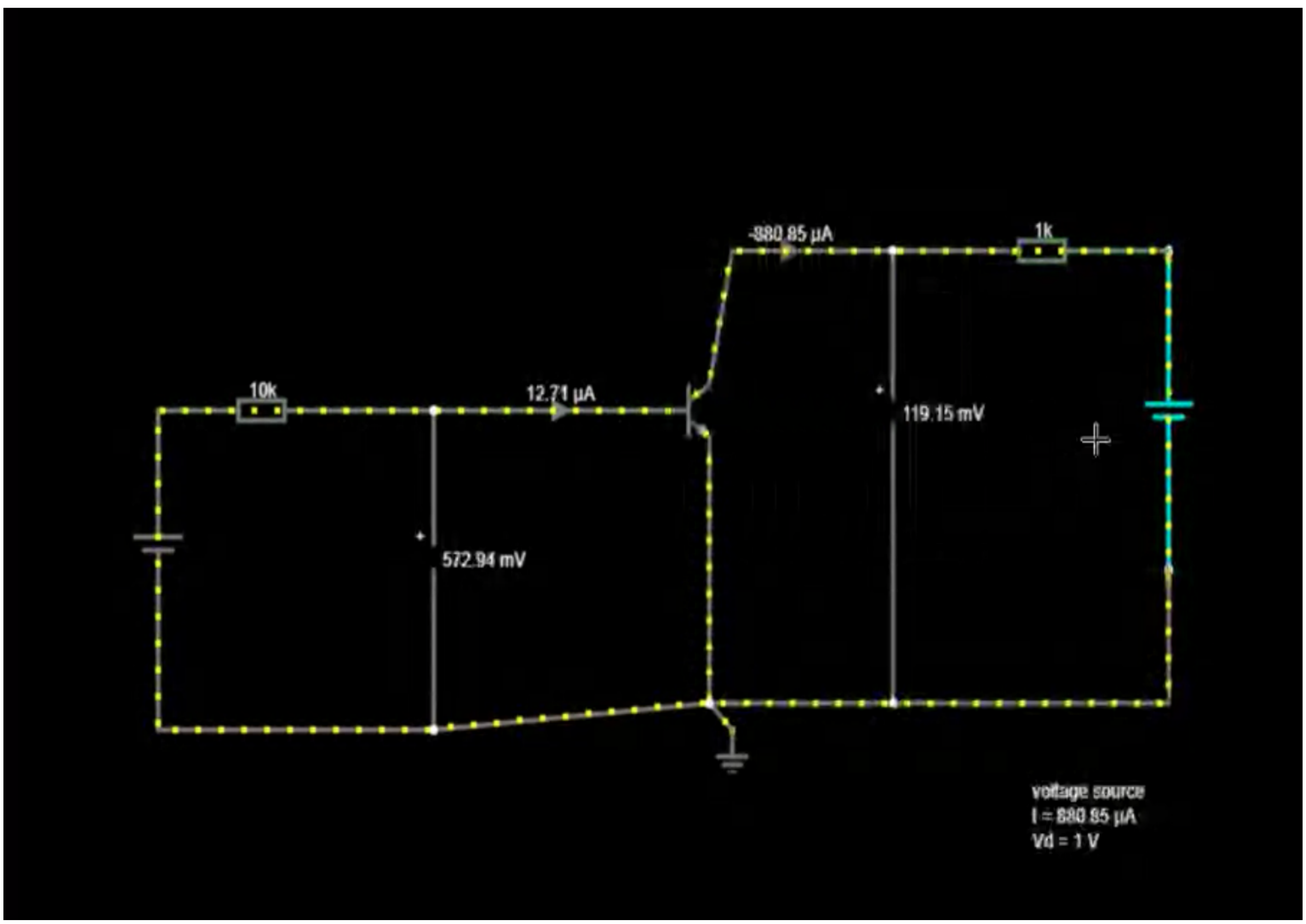


Output Characteristics



Simulation output





Tabular Column

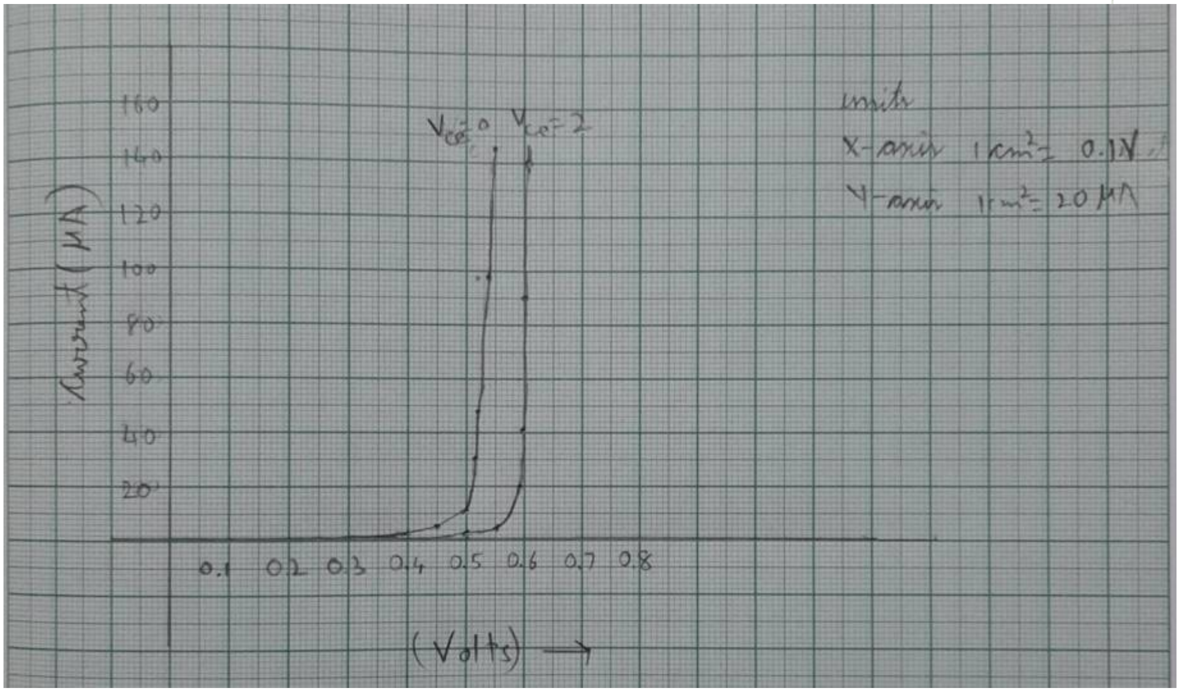
Input Characteristics

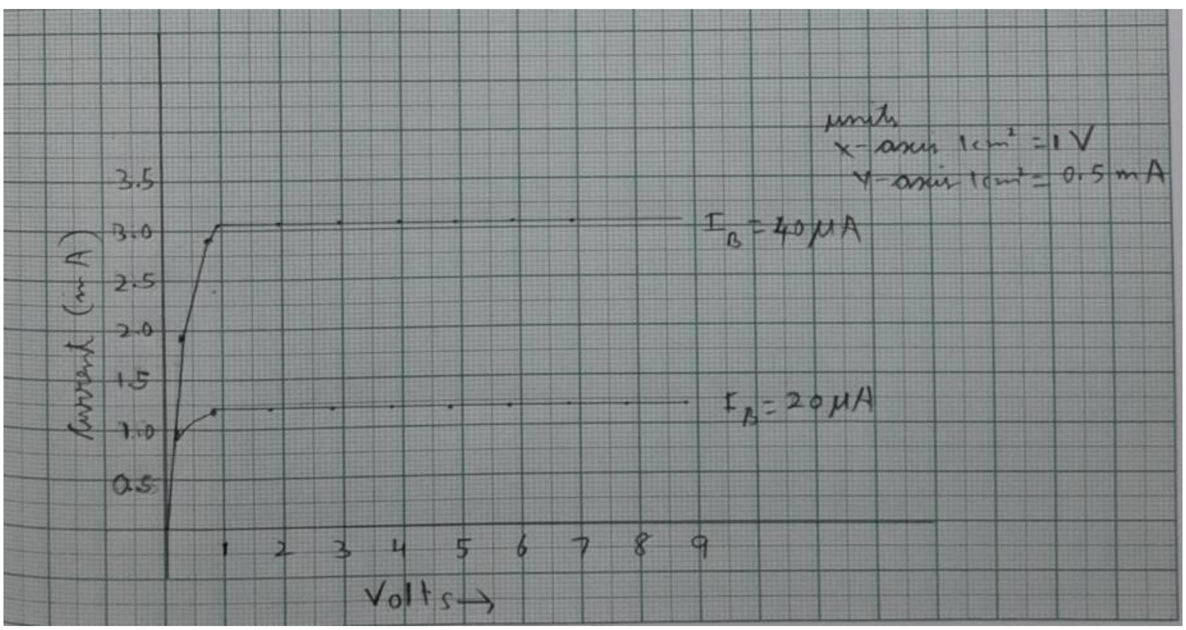
V_{ce} = 0 v		V_{ce} = 2 v	
V_{be}(v)	I_b(μA)	V_{be}(v)	I_b (μA)
0.1	2.7 p	0.1	0
0.2	151.9 p	0.2	2.9 p
0.3	8.27 n	0.3	161 p
0.4	387 n	0.4	8.77 n
0.45	4.3µ	0.495	408 n
0.5	11.83µ	0.555	4.4µ
0.504	29.5µ	0.591	20µ
0.516	48.3µ	0.592	40.7µ
0.534	96.5µ	0.594	90.5µ
0.544	145µ	0.595	140µ

Output Characteristics

I_B=20µA		I_B = 40µA	
V_{ce}	I_c	V_{ce}	I_c
0.119	880uA	0.075	924.58uA
0.803	1.2mA	0.107	1.89mA
1.8	1.2mA	0.157	2.84mA
2.8	1.2mA	0.910	3.09mA
3.8	1.2mA	1.91	3.09mA
4.8	1.2mA	2.91	3.09mA
5.8	1.2mA	3.91	3.09mA
6.8	1.2mA	4.91	3.09mA
7.8	1.2mA	5.91	3.09mA

GRAPH:





Result

POST LAB QUESTIONS

1 What is Punch through voltage?

Punch through voltage is the reverse-bias voltage applied to the drain terminal that results in significant drain-to-source current even though the transistor is biased in its off state.

2 What is early effect?

The early impact is the variety in the width of the base in a bipolar semiconductor because of a variety in the applied base-to-authority voltage. For instance a more noteworthy converse predisposition over the authority base intersection builds the gatherer base consumption width.

3 State maximum rating of transistor.

For semiconductors, the greatest permissible current, voltage, power scattering and different boundaries are indicated as most extreme appraisals.

In planning a semiconductor circuit, understanding greatest evaluations is essential to guarantee that semiconductors work inside the objective working time and with adequate unwavering quality.

4. What is leakage current and mention its range?

A leakage current is an electric current in an unwanted conductive path under normal operating conditions.
If the conductors are separated by a material with a small conductivity rather than a perfect dielectric, then a small leakage current flows directly between them.

5. What is base – width modulation?

Base width modulation is also known as ***Early effect*** is a phenomenon that occurs in transistor biased in active region(emitter -base forward bias & collector -base reverse bias)