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

Title of Experiment	: 7. **Characteristics of semiconductor devices (a) PN junction diode, (b) Zener diode, (c)BJT**
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Register Number	: RA2011004010051
Date of Experiment	: 01.06.2021
Date of submission	**:** 01.06.2021

Sl. No.	Marks Split up	Maximum marks (50)	Marks obtained
1	Pre Lab questions	5	
2	Preparation of observation	15	
3	Execution of experiment	15	
4	Calculation / Evaluation of Result	10	
5	Post Lab questions	5	
Total		**50**	

Staff Signature

PRE LAB QUESTIONS

1. **What are intrinsic and extrinsic semiconductors?**

The pure form of the semiconductor is known as the intrinsic semiconductor and the semiconductor in which intentionally impurities is added is for making it conductive is known as extrinsic semiconductor.

2. Give examples for Trivalent and Pentavalent impurity.

Trivalent impurity atoms have 3 valence electrons. Some examples are Boron(B), Gallium(G) and Aluminium(Al).
Pentavalent impurity atoms have 5 valence electrons. Some examples are Phosphorus(P), Arsenic(As) and Antimony(As).

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. The load voltage equals the breakdown voltage VZ of the diode.

4. What is voltage regulation and mention its significance?

Voltage regulation is a measure of change in the voltage magnitude between the sending and receiving end of a component. It is necessary to maintain the supply voltage of the equipment supplied by the transformer as the supply voltage directly affects the performance of the equipment.

5. Give the different types of semiconductor devices with symbols.

Diode, LEDs, Zener Diode, Photo Diode, Photo Cell, Solar Cell, Transistor, Rectifier etc.

Experiment No. 7 a) Date :	CHARACTERISTICS OF PN JUNCTION DIODE 01.06.2021

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):

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

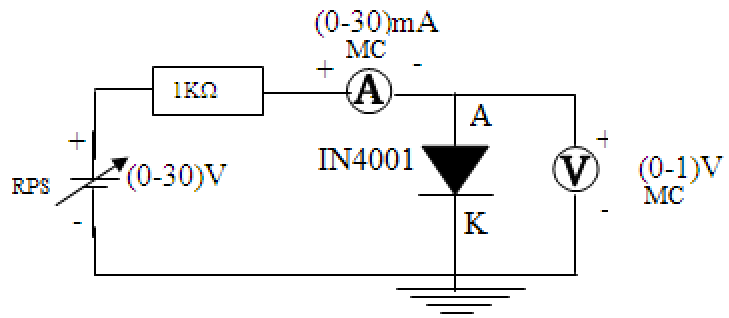
Where V_T is the voltage equivalent of Temperature = kT/q

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

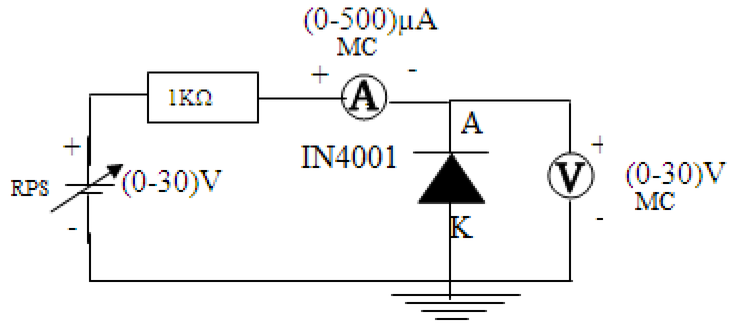
η =1 for Silicon and 2 for Germanium

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

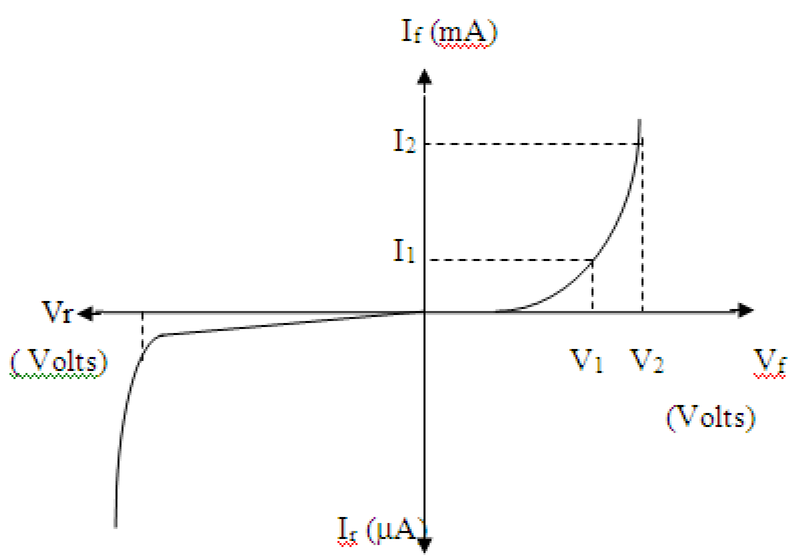
Forward Bias

S.No.	Voltage (In Volts)	Current (In mA)
1.	0.1	0
2.	0.2	0
3.	0.3	0
4.	0.4	0
5.	0.5	0
6.	0.6	2.05
7.	0.7	14.3
8.	0.72	19.3
9.	0.74	31.3
10.	0.76	44.2
12.	0.765	49.2

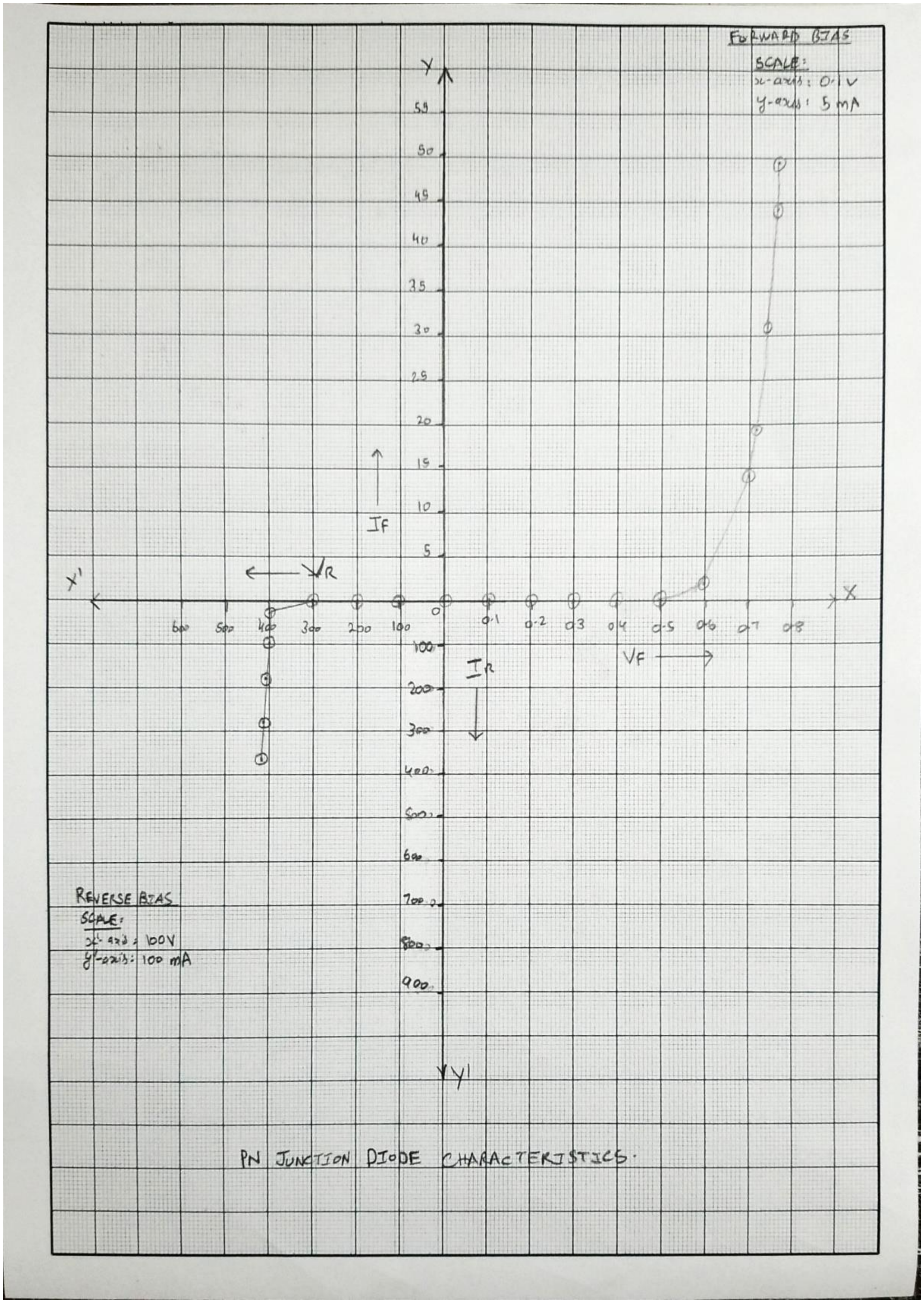
Reverse Bias

S.No.	Voltage (In Volts)	Current (In µA)
1.	100	0
2.	200	0
3.	300	0
4.	400	8322.1
5.	400.08	99933
6.	400.098	183251
7.	400.11	266574
8.	400.12	349900

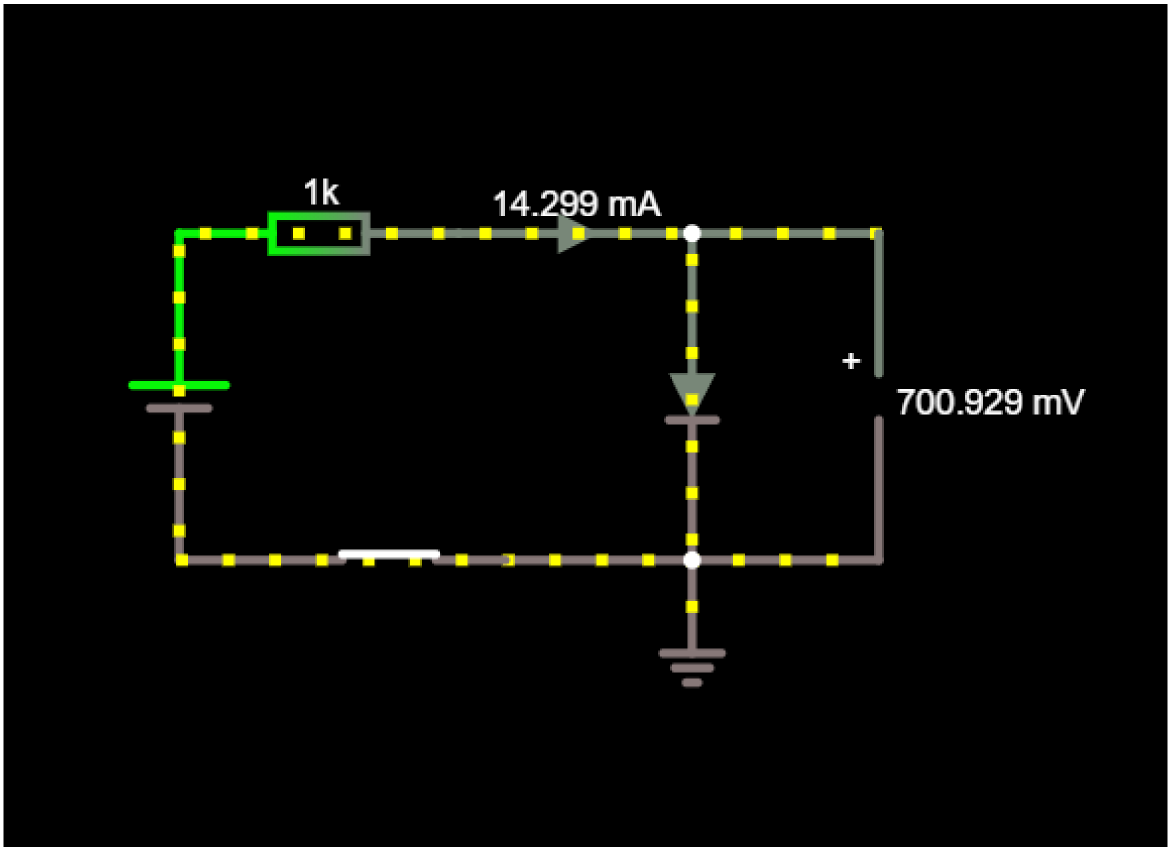
Model Graph

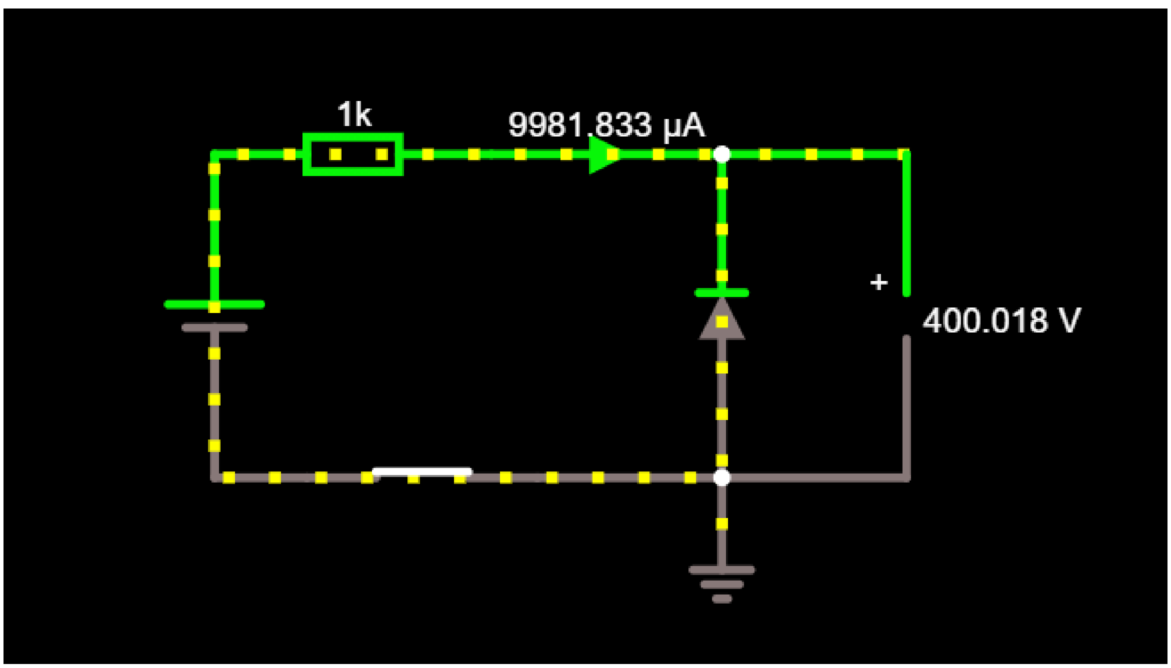


Graph:


FORWARD BIAS
SCALE:
x-axis: 0.1 V
y-axis: 5 mA
Y
X
X'
Y'
IF
VR
IR
VF
REVERSE BIAS
SCALE:
x'-axis: 100V
y'-axis: 100 mA
PN JUNCTION DIODE CHARACTERISTICS.

Result:





Experiment No. 7 b) Date :	CHARACTERISTICS OF ZENER DIODE 01.06.2021

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.

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

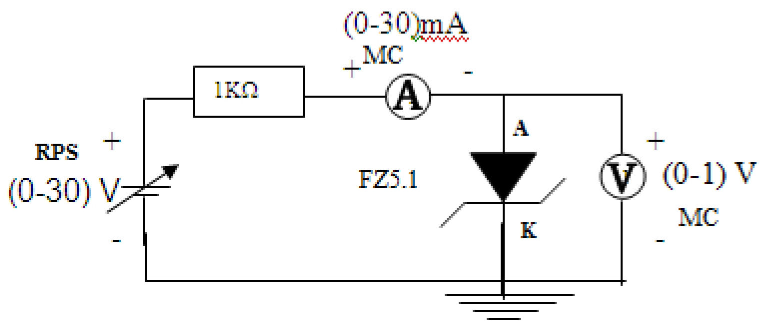
1. Connect the circuit as per the circuit diagram.
2. Vary the power supply in such a way that the readings are taken in steps of 0.1V in the voltmeter till the needle of power supply shows 30V.
3. Note down the corresponding ammeter readings.
4. Plot the graph :V (vs) I.
5. Find the dynamic resistance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

Reverse Bias

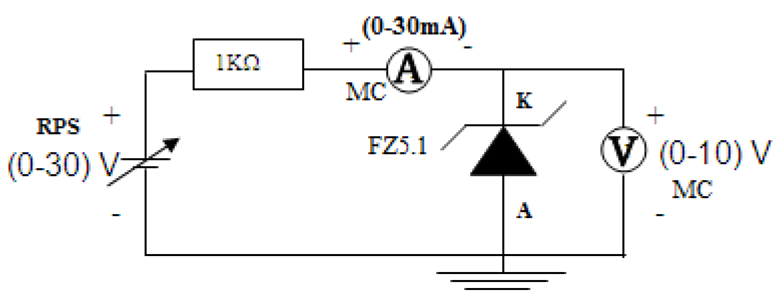
1. Connect the circuit as per the diagram.
2. Vary the power supply in such a way that the readings are taken in steps of 0.1V in the voltmeter till the needle of power supply shows 30V.
3. Note down the corresponding Ammeter readings I.
4. Plot a graph between V & I
5. Find the dynamic resistance **r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

Circuit Diagram

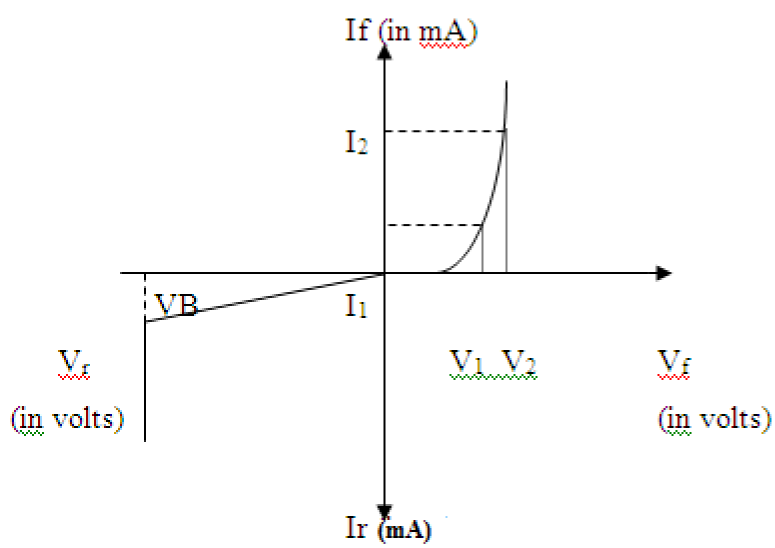
Forward Bias



Reverse Bias



Zener Diode



Tabular Column

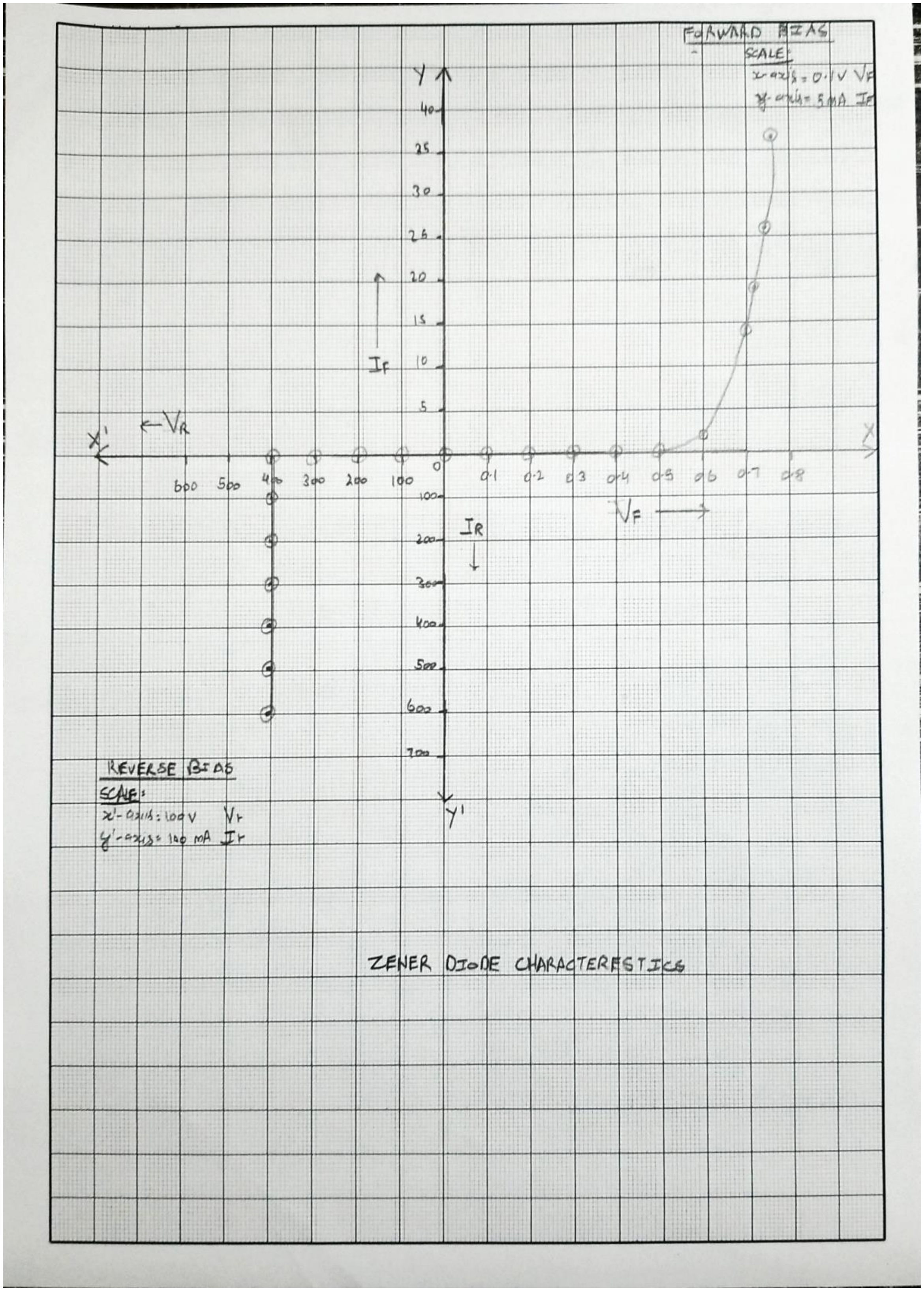
Forward Bias

S.No.	Voltage (In Volts)	Current (In mA)
1.	0.1	0
2.	0.2	0
3.	0.3	0
4.	0.4	0
5.	0.5	0
6.	0.6	2.08
7.	0.7	14.1
8.	0.71	17..3
9.	0.73	25.3
10.	0.75	36.8

Reverse Bias

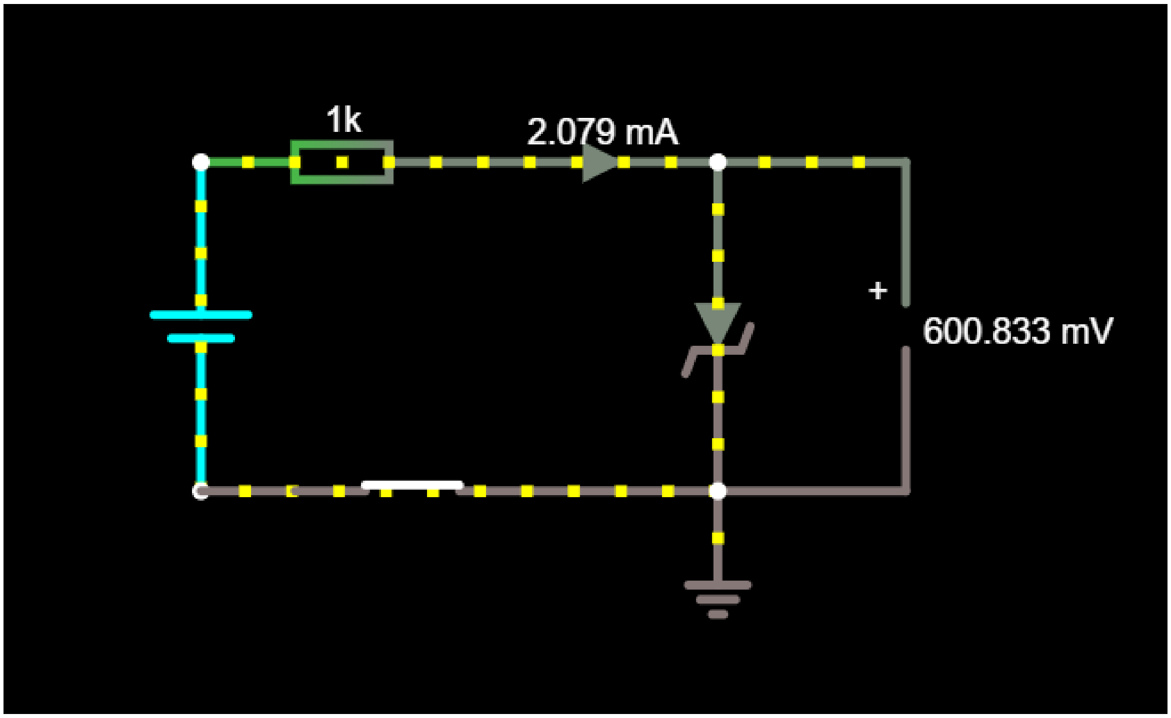
S.No.	Voltage (In Volts)	Current (In mA)
1.	100	0
2.	200	0
3.	300	0
4.	400	0
5.	400.08	99.92
6.	400.1	199.9
7.	400.11	299.9
8.	400.12	399.9
9.	400.13	499.9
10.	400.14	599.9

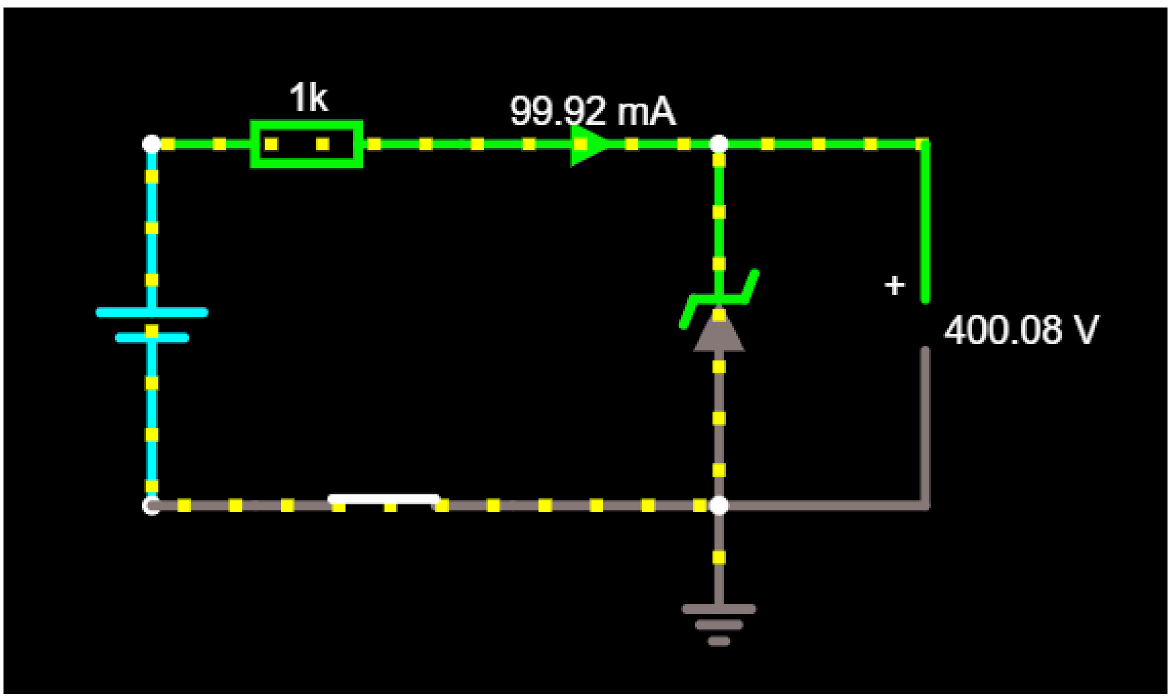
Graph:



FORWARD BIAS
SCALE:
REVERSE BIAS
SCALE:
ZENER DIODE CHARACTERESTICS

Result:





Experiment No. 7 c) **Date :**	**CHARACTERISTICS OF BJT (CE CONFIGURATION)** **01.06.2021**

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

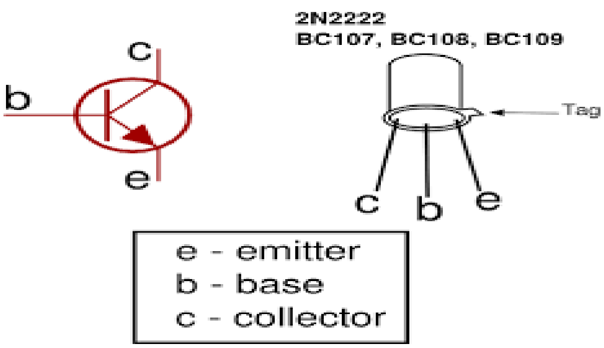
Input Characteristics

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

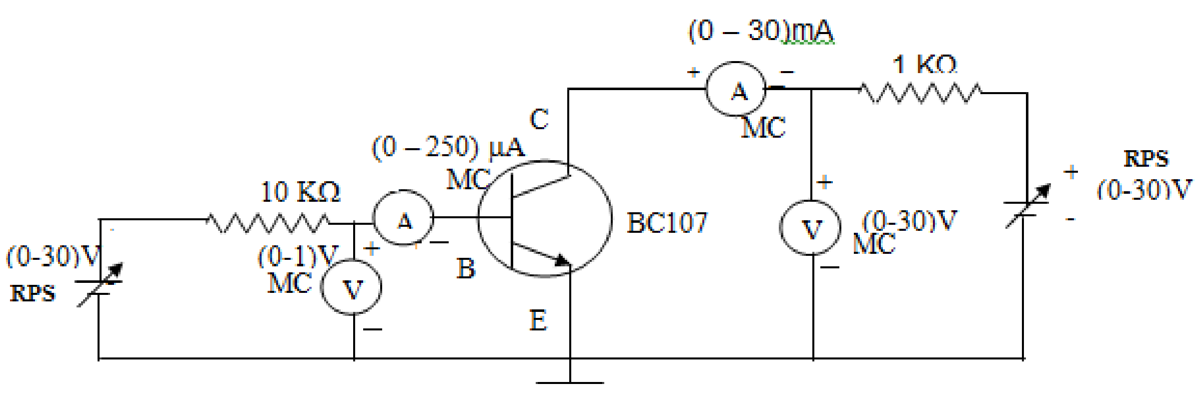
1. Connect the circuit as per the circuit diagram.
2. Set I_B, Vary V_{CE} in regular interval of steps and note down the corresponding I_C reading. Repeat the above procedure for different values of I_B.
3. Plot the graph: V_{CE} Vs I_C for a constant I_B.

Pin Diagram



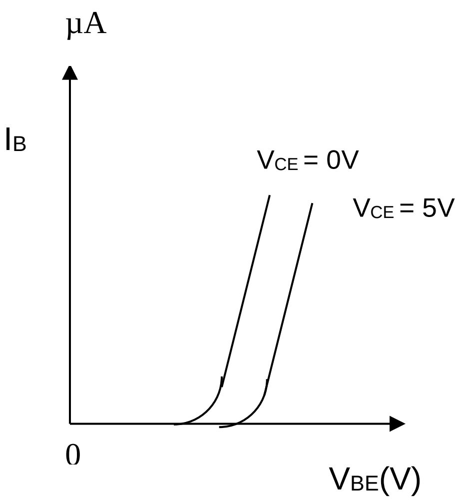
Specification: BC107/50V/0.1A,0.3W,300 MH

Circuit Diagram

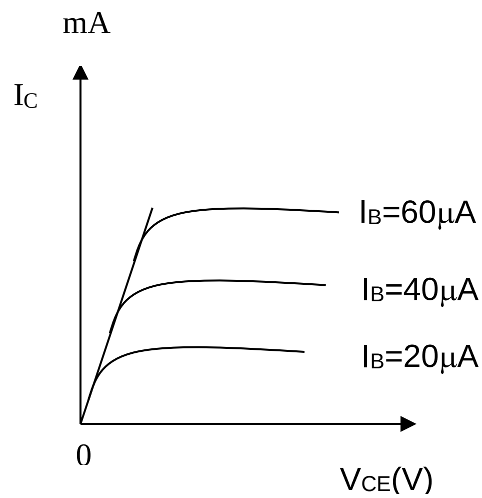


Model Graph

Input Characteristics



Output Characteristics



Tabular Column

Input Characteristics

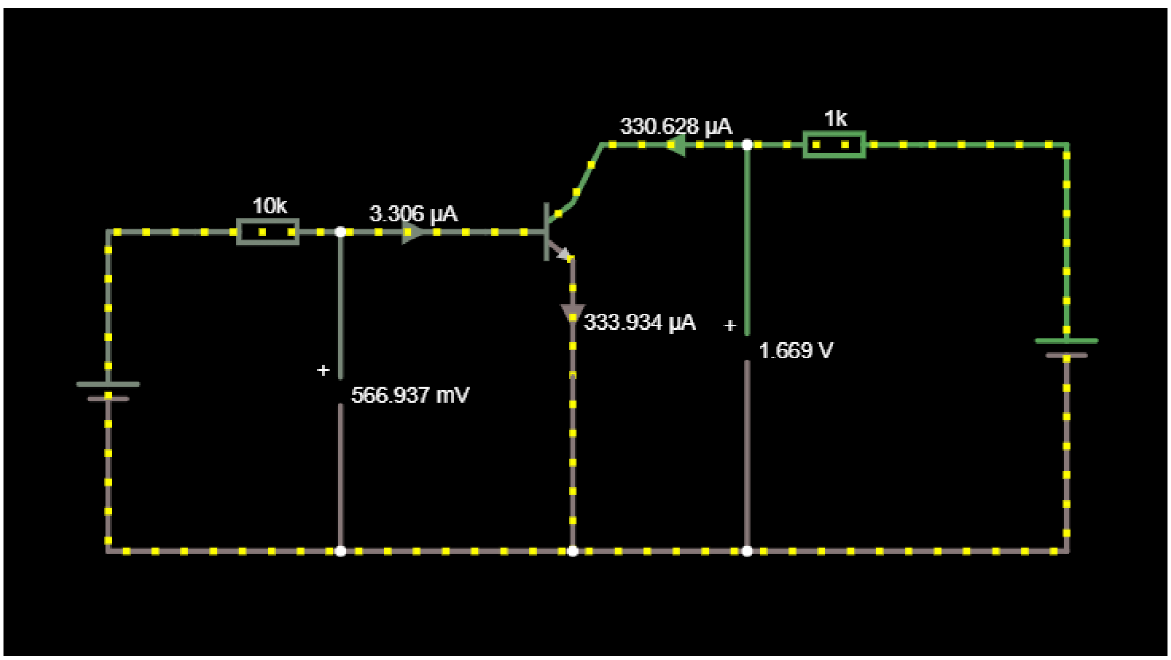
V_{CE} = 0 V		RPS(V)	V_{CE} = 2V	
V_{BE}(V)	I_B(µA)		V_{BE}(V)	I_B(µA)
0	0	0	0	0
0.1	0	0.1	0.1	0
0.2	0	0.2	0.2	0
0.3	0	0.3	0.3	0
0.4	4.2	0.5	0.49	0.2
0.5	19.6	0.7	0.59	10
0.52	37.6	0.9	0.6	28
0.53	47	1	0.61	38

Output Characteristics

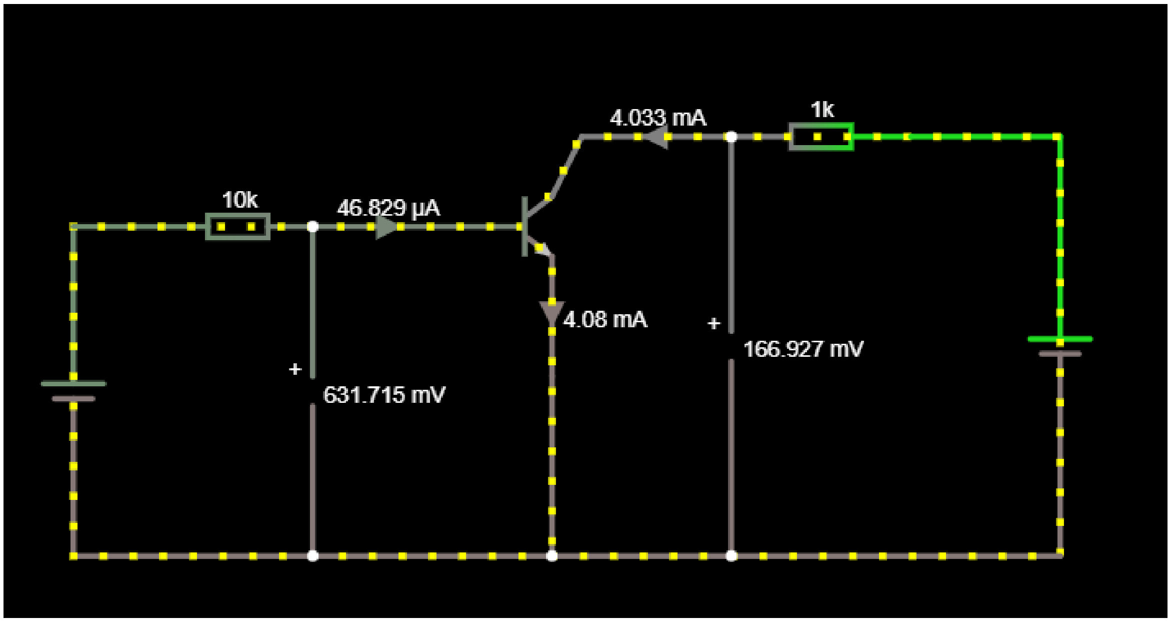
I_B=20μA		I_B=40μA	
V_{CE}(V)	I_C(mA)	V_{CE}	I_c(mA)
0	0	0	0
5	2	5	4
10	2	10	4
15	2	15	4
20	2	20	4
25	2	25	4
30	2	30	4
40	2	40	4

Result:

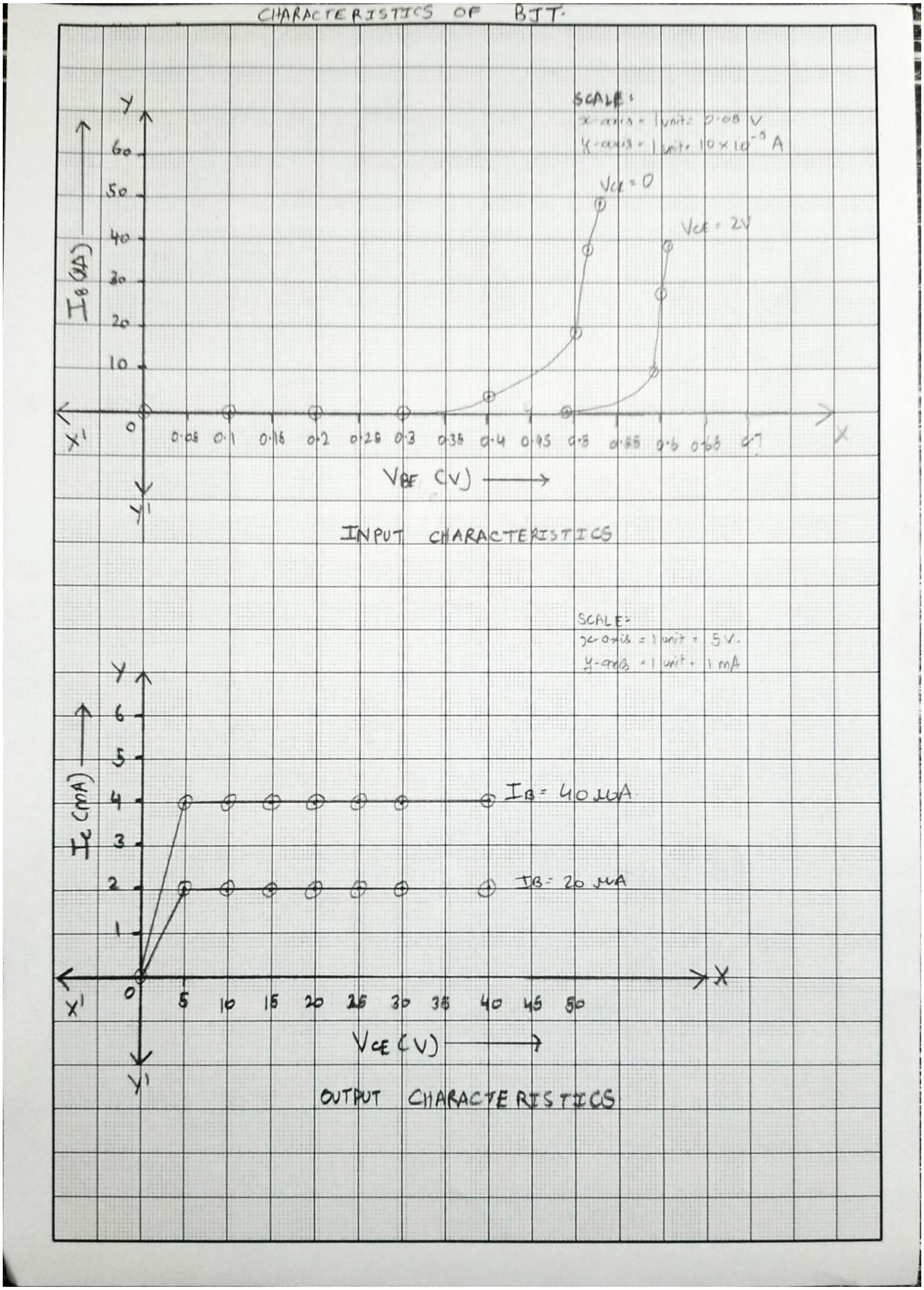
Input Characteristics:



Output Characteristics:



Graph:



CHARACTERISTICS OF BJT
SCALE:
x-axis = 1 unit = 0.05 V
y-axis = 1 unit = 10 × 10⁻⁶ A
Vce = 0
Vce = 2V
IB (μA)
VBE (V)
INPUT CHARACTERISTICS
SCALE:
x-axis = 1 unit = 5V
y-axis = 1 unit = 1 mA
IC (mA)
IB = 40 μA
IB = 20 μA
VCE (V)
OUTPUT CHARACTERISTICS

POST LAB QUESTIONS

1 What is Punch through voltage?

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 effect, named after its discoverer James M. Early, is the variation in the effective width of the base in a bipolar junction transistor (BJT) due to a variation in the applied base-to-collector voltage.

3 State maximum rating of transistor.

A transistor is a common device used to amplify or switch electronic signals and electrical power. The maximum rating of a transistor is the maximum amount of power that a device can dissipate in a typical operating environment.

4. What is leakage current and mention its range?

Leakage current is the current that flows through the protective ground conductor to ground. In the absence of a grounding connection, it is the current that could flow from any conductive part of the surface of non-conductive parts to ground if a conductive path was available. Usually, the level of the leakage current if from about 10mA to some 100mA.

5. What is base – width modulation?

The base-width modulation is the variation of the width of the base in a bipolar transistor to a variation in the applied base-to-collector voltage. It is produced by applying the modulating voltage to the base of a transistor amplifier.