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

Title of Experiment	:	7. **(a) PN junction diode, (b) Zener diode, Characteristics of semiconductor devices(**
Name of the candidate	:	Abdul Ahad
Register Number	:	RA2111028010094
Date of Experiment	:	18/11/2021
Date of submission	:	25/11/2021

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?

Intrinsic - A semiconductor which is extremely pure having no impurity is known as intrinsic semiconductors.

Extrinsic - A semiconductor to which an impurity at a controlled rate is added to make it conductive is known as an extrinsic semiconductor.

2. Give examples for Trivalent and Pentavalent impurity

Examples of trivalent and pentavalent impurities are as follows:

Trivalent - Boron (B), Gallium (G), Indium (In), Aluminum (Al), etc.

Pentavalent - Phosphorus (P), Arsenic (As), Antimony (Sb), etc.

3. What is the need for Zener diode?

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

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 needed to keep voltages within the prescribed range that can be tolerated by the electrical equipment using that voltage.

5. Give the different types of semiconductor devices with symbols

Symbol	Name
	Semiconductor Diode
	Zener Diode
	Schottky Diode
	Light Emitting Diode
	Photodiode

Experiment No. 7 a)	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

a. Connect the circuit as per the diagram.
b. Vary the applied voltage V in steps of 0.1V.
c. Note down the corresponding Ammeter readings I.
d. Plot a graph between V & I

Observations

1. Find the d.c (static) resistance = V/I.

$$\frac{V_2 - V_1}{I_2 - I_1}.$$

2. Find the a.c (dynamic) resistance r = δV / δI (**r = ∆V/∆I) =**
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.**

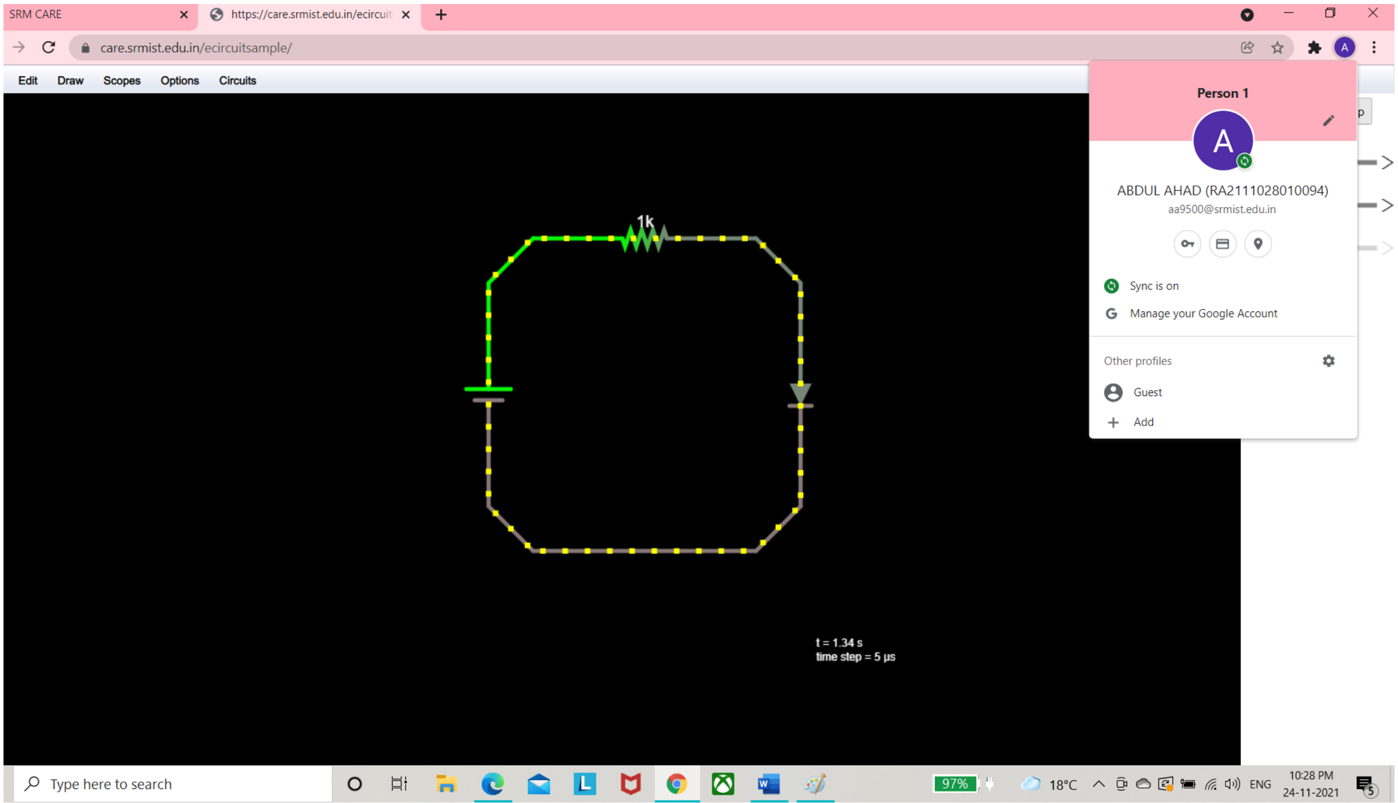
Formula for Reverse Saturation Current (I_O):

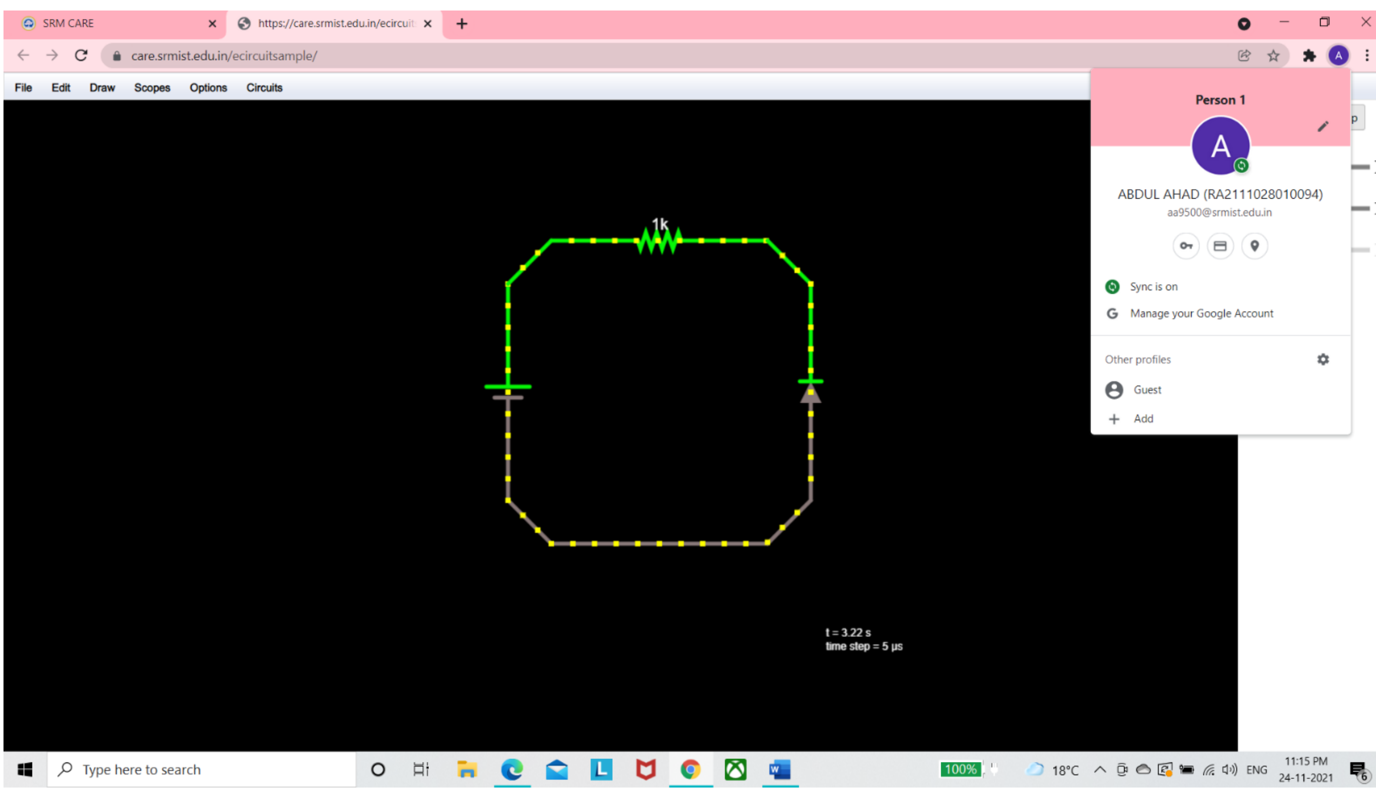
$$I_o = \partial I/[\exp(\partial V/\eta V_T)]-1$$

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.

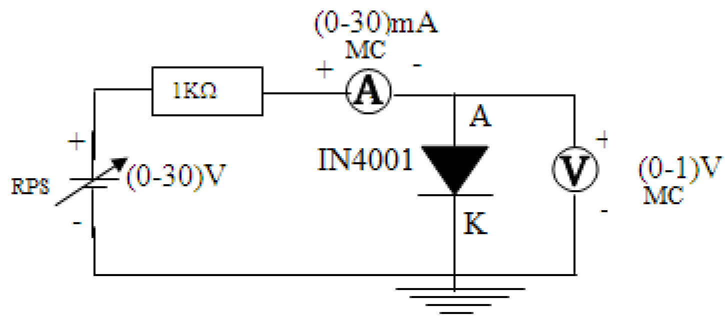
η =1 for Silicon and 2 for Germanium

Circuit Diagram

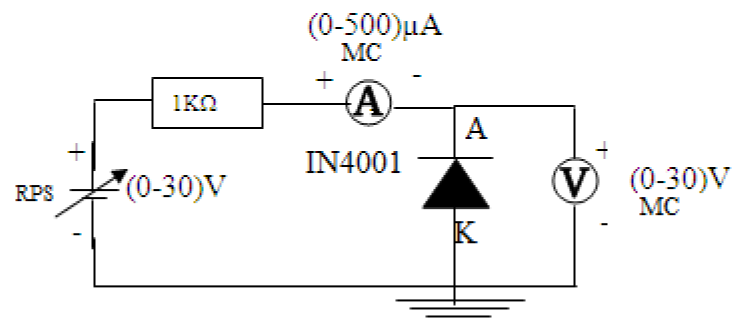




Forward Bias



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

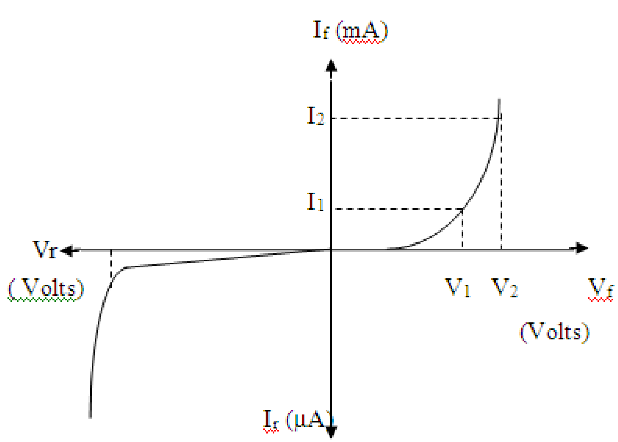
Tabular Column Forward Bias

S.No.	Voltage (In Volts)	Current(In mA)
1	0.2	29.8 * 10^-9
2	0.4	88.5 * 10^-6
3	0.55	44.5 * 10^-3
4	0.59	0.21
5	0.61	0.39
6	0.64	1.36
7	0.65	2.35
8	0.66	3.34
9	0.67	4.33
10	0.69	11.31
11	0.7	14.3
12	0.71	24.29
13	0.72	29.28

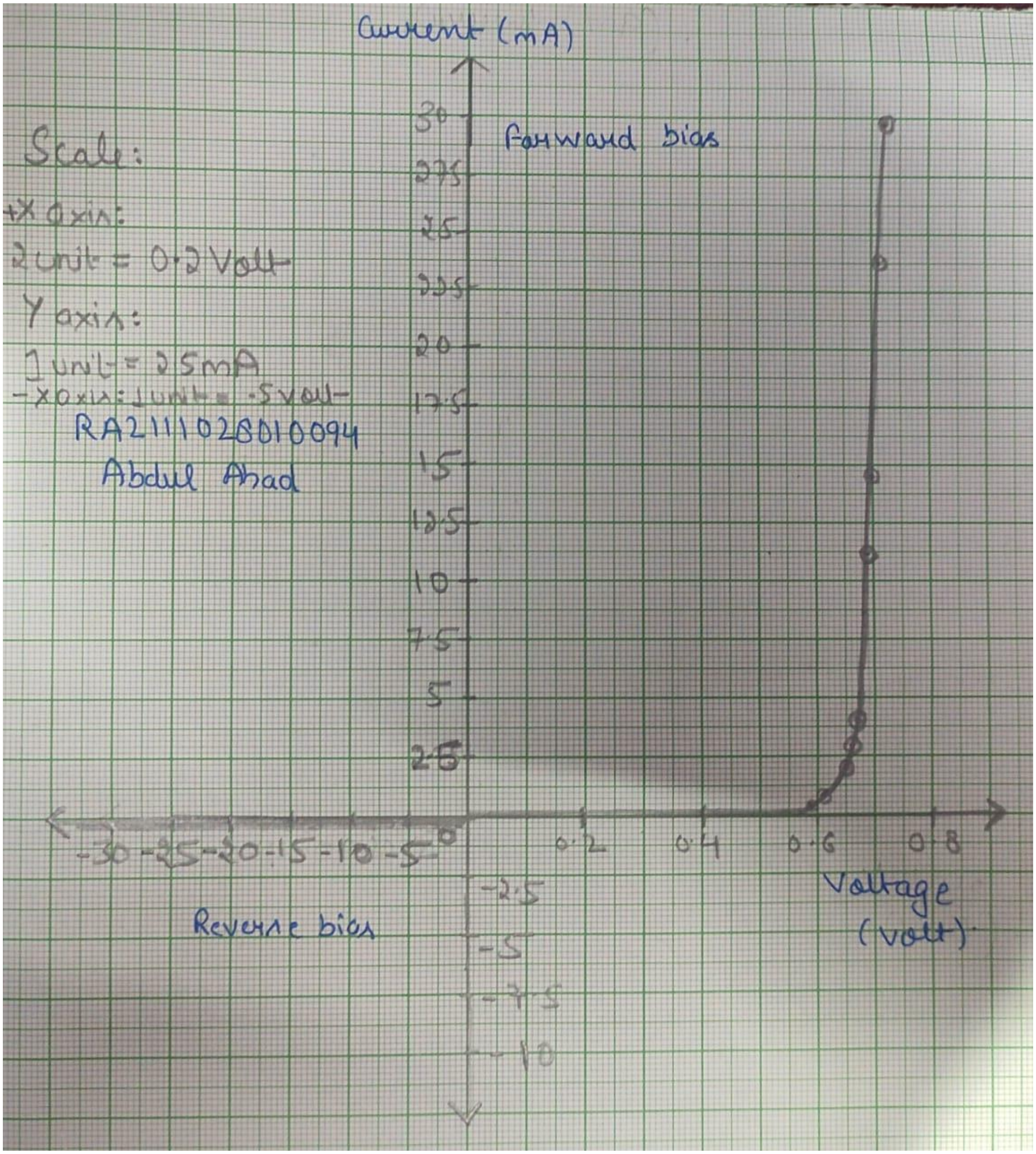
Reverse bias

S.No.	Voltage (InVolts)	Current (In pA)
1	-1	-0.01
2	-3	-0.01
3	-6	-0.01
4	-9	-0.01
5	-12	-0.01
6	-15	-0.01
7	-18	-0.01
8	-21	-0.01
9	-24	-0.01
10	-27	-0.01
11	-30	-0.01

Model Graph



Graph



Result

Thus, the forward and reverse bias reading is taken from PN junction diode.

Experiment No. 7 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.

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

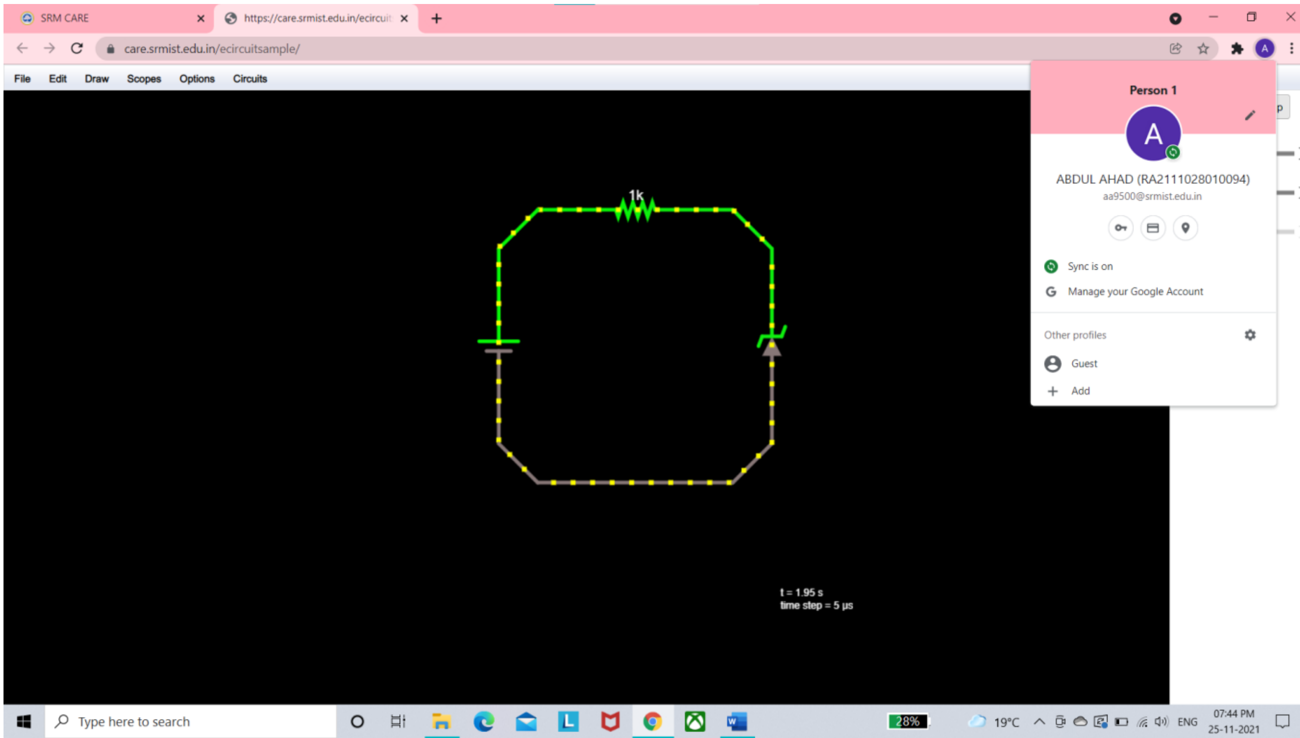
Forward Bias

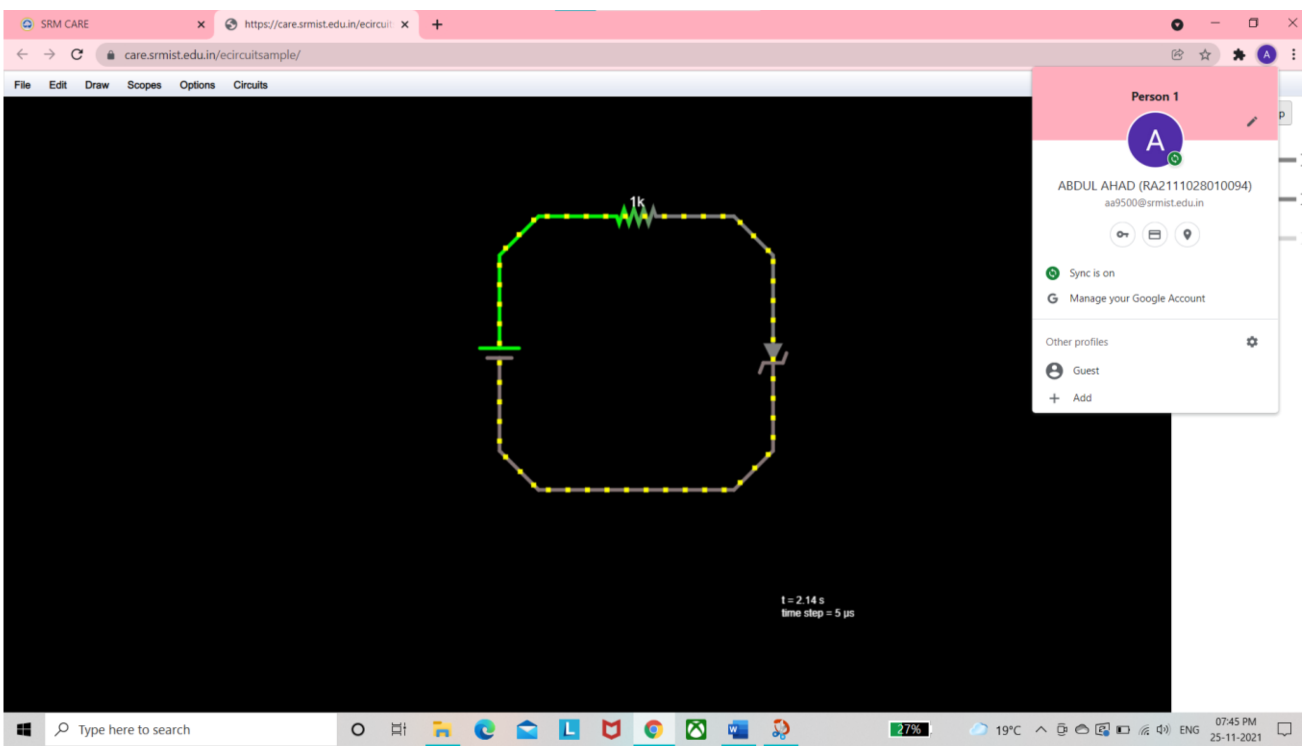
1. Connect the circuit as per the circuit diagram.
2. Vary the power supply in such a way that the readings are taken in steps of 0.1V in the voltmeter till the needle of power supply shows 30V.
3. Note down the corresponding ammeter readings.
4. Plot the graph :V (vs) I.
5. Find the dynamic resistance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

Reverse Bias

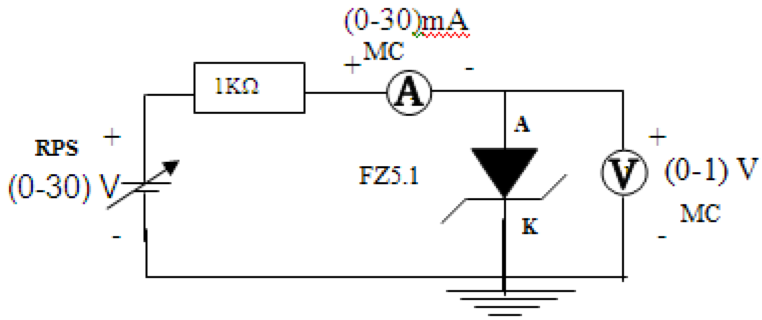
1. Connect the circuit as per the diagram.
2. Vary the power supply in such a way that the readings are taken in steps of 0.1V in the voltmeter till the needle of power supply shows 30V.
3. Note down the corresponding Ammeter readings I.
4. Plot a graph between V & I
5. Find the dynamic resistance **r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

Circuit Diagram

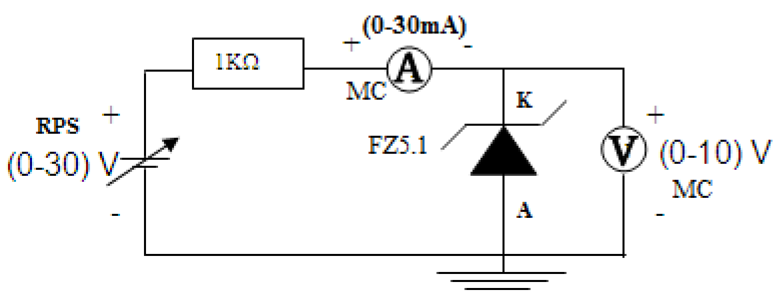




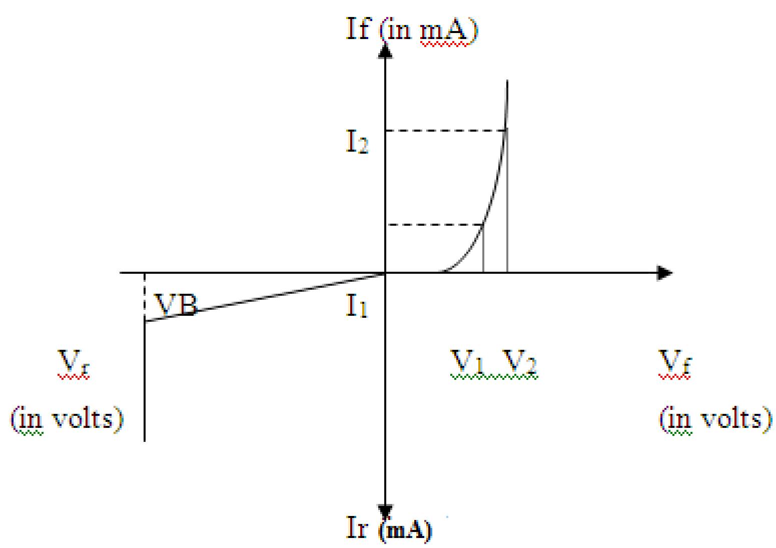
Forward Bias



Reverse Bias



Zener Diode



Tabular Column

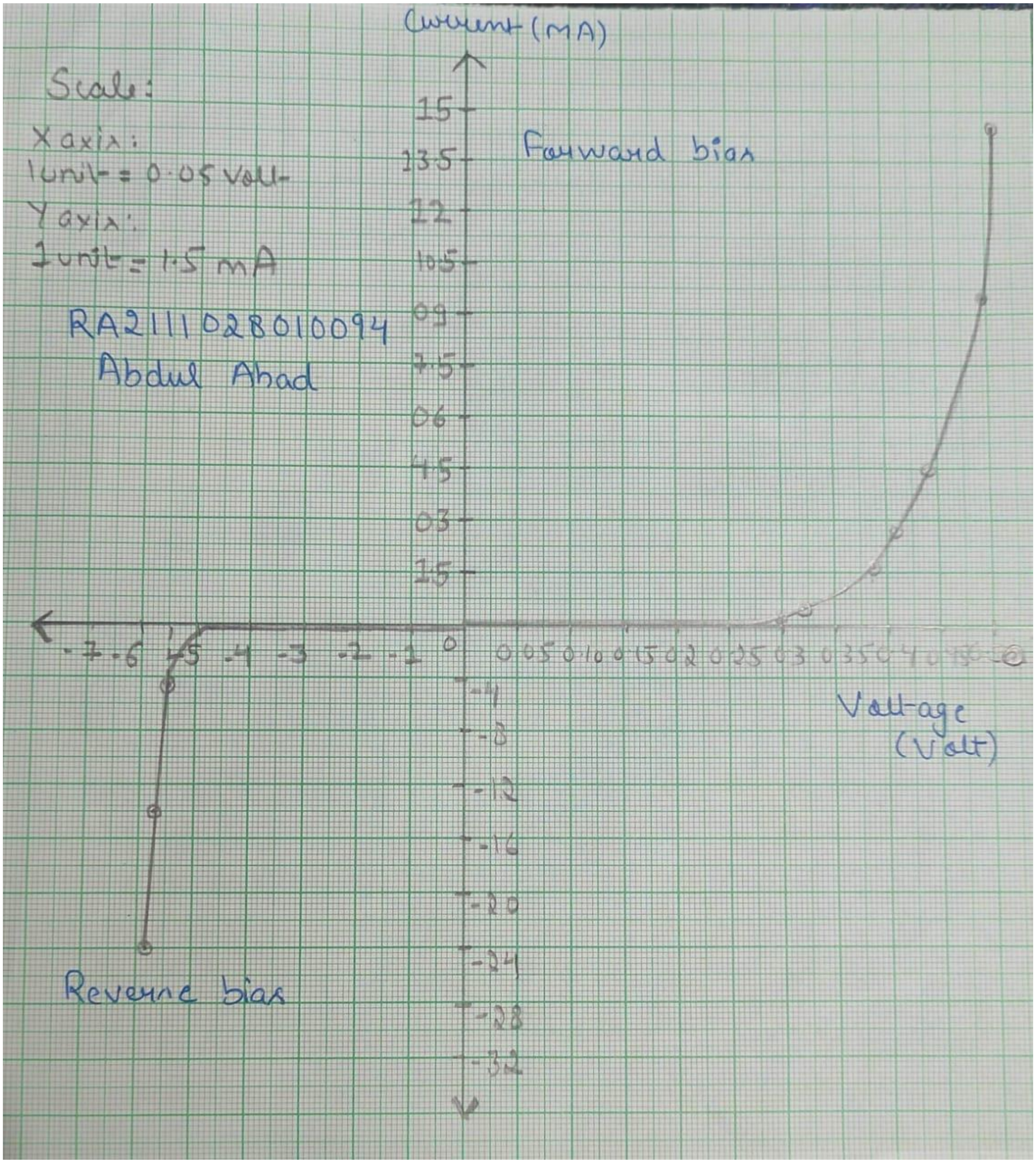
Forward Bias

S.No.	Voltage (In Volts)	Current(In mA)
1	0.15	0.046
2	0.23	0.166
3	0.27	0.323
4	0.30	0.495
5	0.32	0.675
6	0.38	1.62
7	0.41	2.59
8	0.44	4.55
9	0.49	9.50
10	0.52	14.47

Reverse bias

S.No.	Voltage (In Volts)	Current(In mA)
1	-195.26 * 10^-3	-4.74 * 10^-3
2	-395.01 * 10^-3	-4.99 * 10^-3
3	-595 * 10^-3	-5 * 10^-3
4	-795 * 10^-3	-5 * 10^-3
5	-995 * 10^-3	-5 * 10^-3
6	-2	-5 * 10^-3
7	-4.99	-5.52 * 10^-3
8	-5.59	-4.41
9	-5.67	-14.33
10	-5.7	-24.3

Graph



Result:

Thus ,The forward and reverse bias reading is taken from Zener diode.