2. ZENER DIODE

AIM:

(i) To draw I-V characteristics

(ii) To determine the knee voltage (V_K), zener voltage (V_Z) and dynamic Resistance (R) in breakdown region

APPARATUS:

1. Zener diode
2. DC power supply (0 to 20V)
3. Digital Voltmeter
4. Digital Ammeter
5. Resistor circuit unit

THEORY:

Diode is the combination of two electrodes- ntype, ptype. Generally all semiconductors are in intrinsic form. When the doping takesplace on the intrinsic semiconductors, either n-type or p-type semiconductor will form. By joining these two, we will get a junction between n-type semiconductor and p-type semiconductor.

After the formation of junction, the process of diffusion and recombination takes place. The holes in p-type and n-type electrons will diffuse from oneside to other side without any force and then recombination of these electrons and holes will happen. As a result, the junction will be void

Of mobile charges and the transfer of charge result in the development of potential barrier.

Then we will start biasing externally, by applying some voltage, we will make the junction how we want either forward bias or reverse bias.

If p-type semiconductor is connected to positive and n-type with negative then it is said to be in forward bias. In this condition the width of barrier potential will decrease due to the applied voltage and there will be a flow of current.

If p-type semiconductor is made negative with respect to n-type, the junction is in reversed bias. In this case there will be increase in the width of barrier potential. So it can't overcome the charges and go through the potential barrier.

Current across the junction is given by the equation,

$$I = I_0\left[\exp\left(\frac{eV}{kT}\right) - 1\right]$$

I_0 is the saturation current

e is the electron charge

V is the applied voltage. when V is +ve (i.e forward bias the current varies exponentially, when V is -ve (i.e reverse bias) the current is constant)

k is the Boltzmann constant

T is the room temperature.

Zener diode is a special type of diode. It is a bi-directional device which means it will work in both forward bias and reverse bias. The zener diode wdon't obey ohm's law. For zener diode heavy doping takes place (almost 1000 times extra doping than for normal diode). Hence the depletion width is narrow. As a result, it works more better in Reverse bias condition. So it measures very high breakdown voltage. Hence used as Voltage Regulator.

PROCEDURE:

1) Forward biasing:-

The circuit for forward biasingprocess is shown in Figure-1. The zener diode is connected in such a way that p-type with +ve terminal and n-type with negative terminal. In forward biasing, the current is in milliAmpere. So we should connect millime ammeter in series to measure the current. By changing the voltage slightly, note the respective current measurements in a table. The forward voltage at which the current starts increasing rapidly is called "Knee Voltage" (VK)

2) Reverse biasing:-

The circuit for reverse biasing process is kshown in Figure-2. The zener diode is connected in such a way that p-type with negative terminal and n-type is with positive terminal. In reverse biasing, the current is in microamperes so we should connect microammeter in series to measure

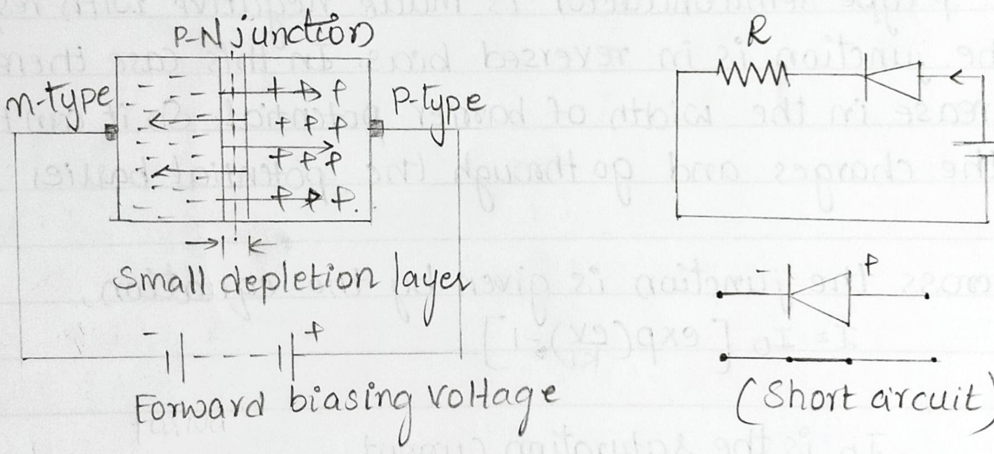


Fig 1: Forward biasing circuit diagram

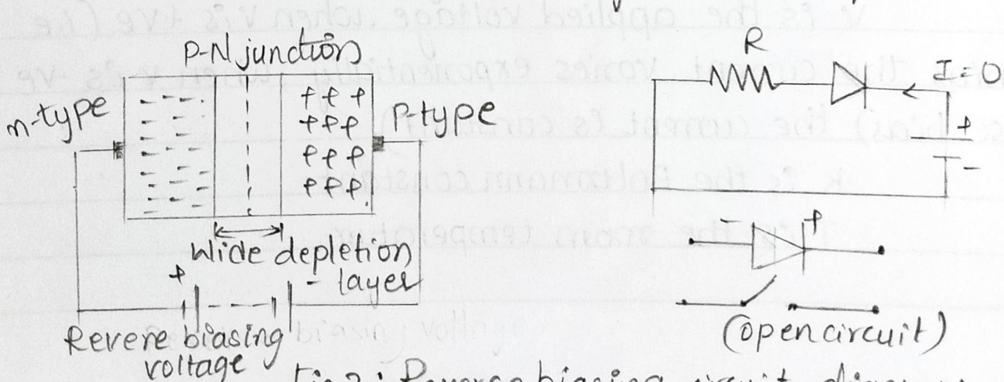
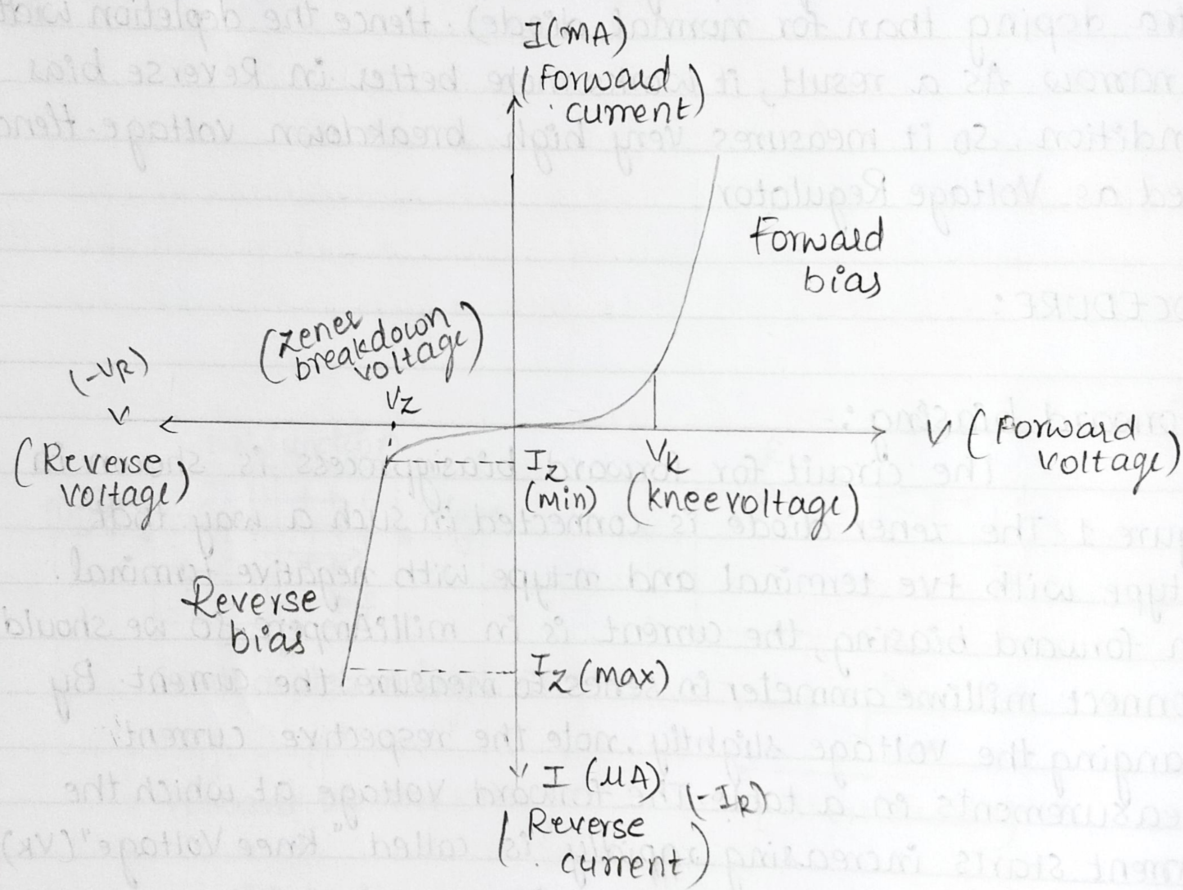


Fig 2: Reverse biasing circuit diagram

I-V Graph :-

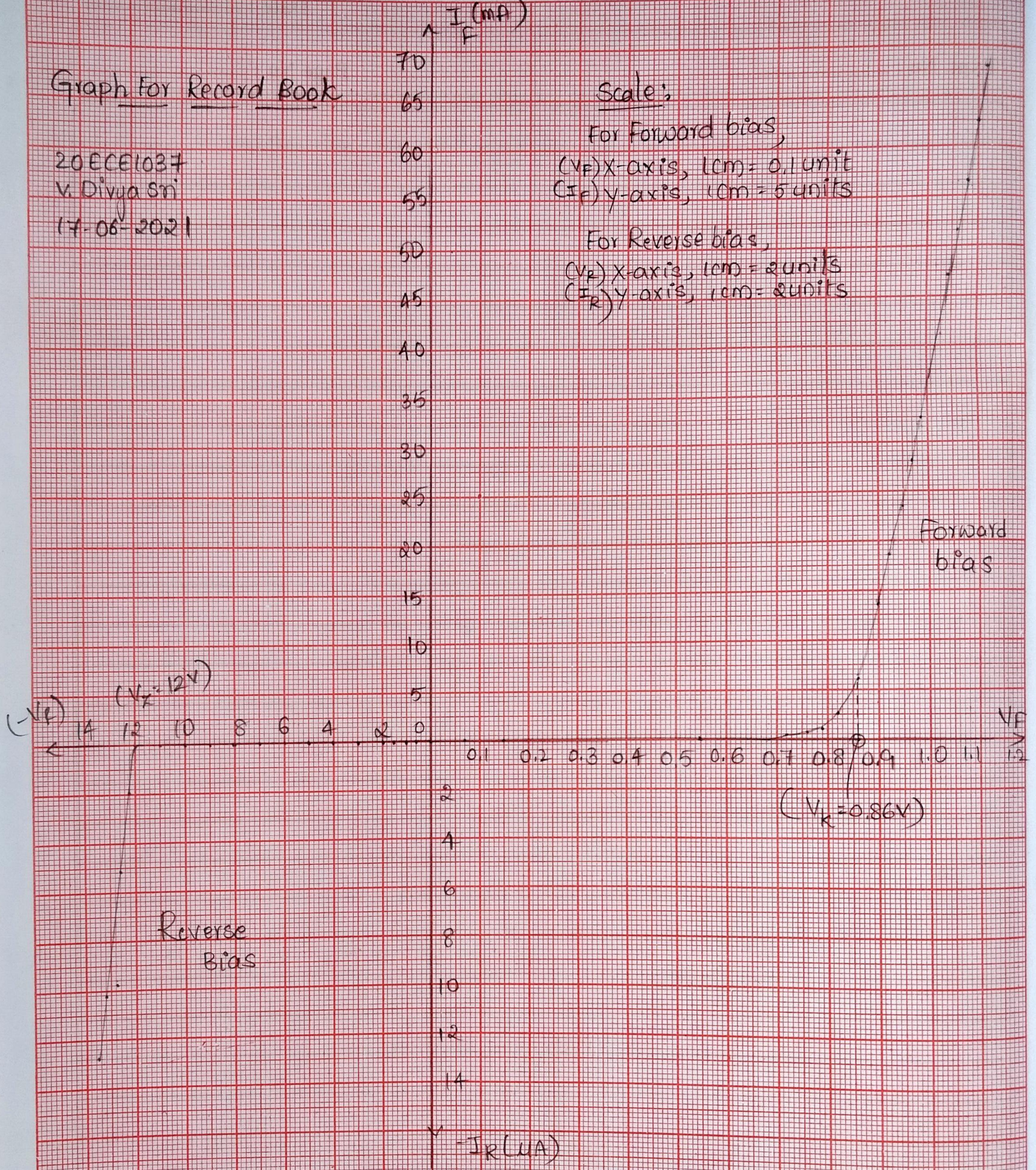

I(mA) (Forward current)
Forward bias
(Zener breakdown voltage)
(-VR)
V
Vz
V (Forward voltage)
(Reverse voltage)
Iz (min)
Vk (kneevoltage)
Reverse bias
Iz (max)
I (μA) (-IR)
(Reverse current)

OBSERVATION TABLE:

Sl. No	F.b (V) (Forward bias) voltage	F.b I (mA) (Forward bias) Current	R.b (V) (Reverse bias) voltage	R.b I (μA) (Reverse bias) Current
1	0	0	0	0
2	0.07	0	0.5	0
3	0.15	0	1	0
4	0.55	0	1.5	0
5	0.72	0.1	2	0
6	0.77	0.5	3	0
7	0.79	1.3	4	0
8	0.82	2.4	5	0
9	0.86	6.1	6	0
10	0.90	13.7	7	0
11	0.92	18.6	8	0
12	0.95	23.2	9	0
13	0.99	31.5	10	0
14	1.01	36.9	11	0
15	1.03	41.3	12	0
16	1.04	47.2	12.25	0.07
17	1.06	51.7	12.35	1.8
18	1.08	56.5	12.55	5.2
19	1.10	62.4	12.70	9.8
20	1.12	68.5	13.58	12.7

Graph for Record Book

20ECE1037
V. Divya Sri
17-06-2021



CALCULATION:

From table, $V_K = 0.79V$

$V_Z = 12.35V$

$$R = \frac{1}{\text{slope}} = \frac{1}{\left(\frac{18-0}{12.35-4}\right)} = \frac{8.35}{1.8\mu} = 4.64 \times 10^{6}\,\Omega$$

From graph, $V_K = 0.86V$

$V_Z = 12V$

$$R = \frac{1}{\text{slope}} = \frac{1}{\left(\frac{12.7-0}{13.58-12}\right)} = \frac{1.58}{12.7 \times 10^{-6}} = 0.1244 \times 10^{6}\,\Omega$$

$$V_K(\text{avg}) = \frac{0.86+0.79}{2} = 0.825V$$

$$V_Z(\text{avg}) = \frac{12.35+12}{2} = 12.175V$$

$$R = \frac{4.64+0.1244}{2} = 2.3822 \times 10^{6}\,\Omega$$

the current. By changing the voltage slightly, note down the respective current measurements in a table. The reverse voltage at which the junction of the diode breakdown with sudden rise in reverse current is known as "Zener break down Voltage".

The ratio of small change in applied voltage (ΔV) to the corresponding change in current (ΔI) is called the Dynamic Resistance of the diode. $R_d = \frac{\Delta V}{\Delta I}$

I-V Graph :-

The graph voltage versus current for forward bias and reverse bias is plotted at a time (in same graph) by choosing appropriate scale. The straight line obtained in reverse bias is extended, the point at which it cuts the voltage is called Zener breakdown voltage and by using slope of the line dynamic resistance is calculated.

$$R = \frac{1}{slope} = \frac{1}{\left(\frac{\Delta I}{\Delta V}\right)} = \frac{\Delta V}{\Delta I}$$

Results :

(i) knee Voltage (V_K) = 0.825 V

(ii) Zener breakdown voltage (V_Z) = 12.175 V

(iii) Dynamic resistance (R) = $2.3822 \times 10^6 \, \Omega$

= $2.3822 \, M\Omega$

Date : ....

Expt. No : .... Page No : ....

CONCLUSION:

From the experiment, the Knee voltage values obtained from table and graph are 0.79V and 0.86V Respectively. The zener breakdown voltage values obtained from table and graph are 12.35V and 12V respectively.

The Dynamic resistance values obtained from table and graph are 4.64 MΩ and 0.1244 MΩ respectively ($M\Omega \to 10^6 \Omega$)

APPLICATIONS:

Applications of diodes -

1) Communication systems
2) Computer systems as logic gates
3) Power supply systems as rectifiers and inverters.

Applications of zener diodes -

1) Voltage regulator
2) Surge suppressor
3) Switching applications.

Teacher's Signature : ________