North South University
Department of Electrical & Computer Engineering
LAB REPORT
Analog Electronics Lab
EEE111L

Experiment Number: 4

Experiment Name: Zener Diode Applications

Experiment Date: 15/11/2021

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Section: 7 **Group No:** 2

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Remarks:	Score

Objectives:

• Our objective in this experiment is to study the applications of Zener diode.

Theory:

A Zener diode is a special type of device designed to operate in the Zener breakdown region. Zener diodes acts like normal p-n junction diodes under forward biased condition but it can also allow electric current in the reverse direction if the applied reverse voltage is greater than the Zener voltage. Zener diode is always connected in reverse direction because it is specifically designed to work in reverse direction.

The Zener Diode is a reverse bias diode that operates at the Zener Voltage (Vz). The study of Zener diode-based networks is quite similar to that of semiconductor diodes. The Zener diode is a protection device that can be used to establish reference voltage levels. The usage of a Zener diode as a regulator will then be discussed in depth, as it is one of the diode's most common applications. A regulator is a set of components that ensures that a supply's output voltage remains relatively consistent.

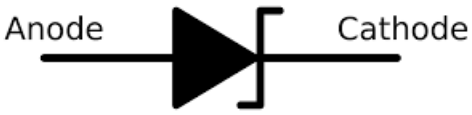

Figure: Zener Diode

The Zener diode used in circuits looks like the above figure.

The use of the Zener diode as a regulator is so common that three conditions surrounding the analysis of the basic Zener regulator are considered.
I. Fixed quantities.
II. Fixed supply voltage and a variable load.
III. Fixed load and a variable supply.

The Zener region is the sudden change in the characteristic at any breakdown voltage. The Zener voltage is the voltage that causes a diode to enter the Zener region of functioning (VZ).

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. The above figure shows the I-V characteristics curve of the 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 Vz over most of the breakdown region.

Zener Diode Equivalent Circuits: For the equivalent circuit of the Zener Diode, two approximations are employed.

- **First Approximation:** The first approximation considers the Zener diode to be a constant voltage source since the voltage across it remains constant as the current changes across it.
- **Second Approximation:** A Zener resistance is in series with the ideal voltage source is approximated.

Equipment List:

• Zener diode (5 volts) – 1 piece
• Resistor (220Ω, 470Ω, 1kΩ) – 1 piece each
• POT (10kΩ) – 1 unit
• Trainer Board
• DC Power Supply
• Digital Multimeter
• Cords and wires

Circuit Diagram:

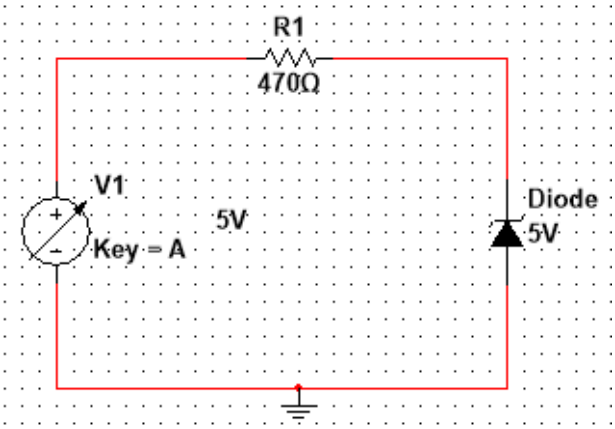

Figure 1 – Reverse Biased Zener Circuit

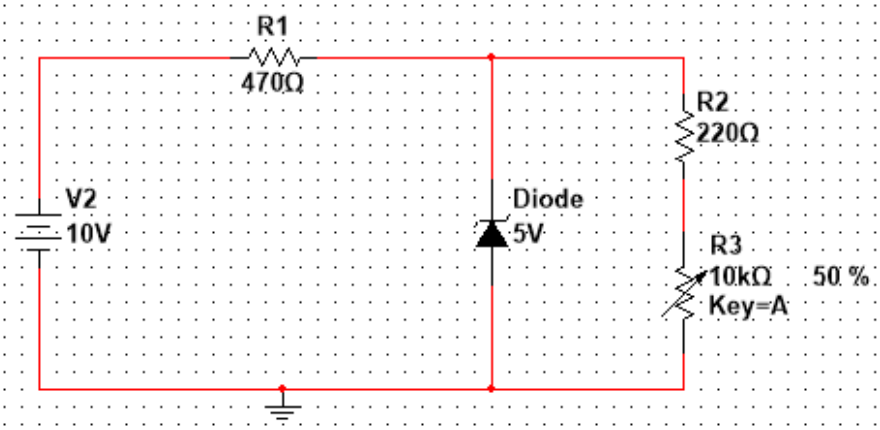

Figure 2 – Load Regulation Circuit

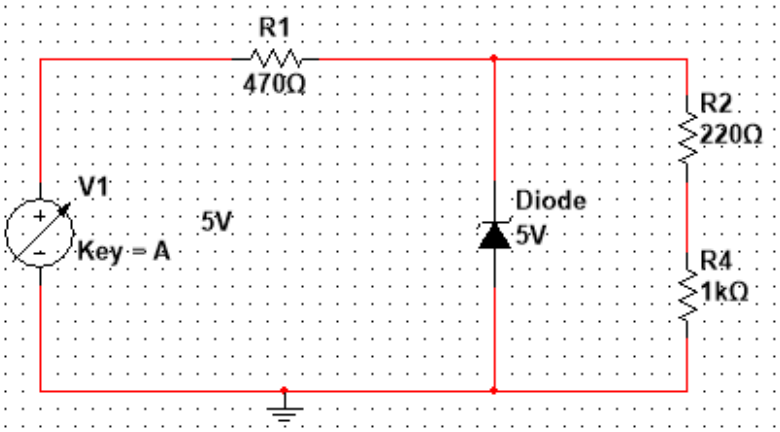

Figure 3 – Line Regulation Circuit

Data & Table:

Table 1: Data for I - V characteristics

V (volts)	V_R (volts)	V_z (volts)	$I_Z = V_R / R$ (mA)
0.1	9.448 µV	99.991 mV	19.999 nA
0.3	28.342 µV	299.972 mV	59.996 nA
0.5	47.236 µV	499.953 mV	99.992 nA
0.7	66.13 µV	699.934 mV	139.988 nA
1.0	94.472 µV	999.906 mV	199.984 nA
2.0	188.943 µV	2 V	399.969 nA
3.0	283.414 µV	3 V	599.965 nA
4.0	377.885 µV	4 V	799.938 nA
5.0	92.521 mV	4.907 V	196.848 µA
6.0	1.044 V	4.956 V	2.221 mA
7.0	2.031 V	4.969 V	4.321 mA
8.0	3.023 V	4.977 V	6.431 mA
9.0	4.017 V	4.983 V	8.547 mA
10.0	5.013 V	4.987 V	10.665 mA

Table 2: Data for Load Regulation

POT_R (kΩ)	V_{220} (mV)	V_L (volts)	I_L (Amp)= V220/220
1 kΩ	897.643 mV	4.978 V	4.08 mA
2 kΩ	493.783 mV	4.983 V	2.244 mA
3 kΩ	340.542 mV	4.984 V	1.548 mA
4 kΩ	259.886 mV	4.985 V	1.181 mA
5 kΩ	210.119 mV	4.986 V	0.955 mA
6 kΩ	176.349 mV	4.986 V	0.802 mA
7 kΩ	151.931 mV	4.986 V	0.691 mA
8 kΩ	133.452 mV	4.986 V	0.607 mA
9 kΩ	118.981 mV	4.986 V	0.541 mA
10 kΩ	107.341 mV	4.986 V	0.488 mA

Table 3: Data for Line Regulation

V (volts)	V_L (volts)
1.0	0.722V
3.0	2.166V
6.0	4.331V
8.0	4.958V
9.0	4.97V
10.0	4.978V
11.0	4.983V
12.0	4.988V

Result Analysis & Discussion:

In this experiment at first, we had to build the circuits with different components using Multisim. After that we had to check the value to define points. Then we just had to go to the simulation and parameter sweep to fill up the data table. After that we built the load and line regulation circuit by maintaining the same procedure. We just put the operating point with display results in a table to show the table. After that we have done some calculations to get VR, VZ, IZ, VL, IL etc. Now if we look into the values of Table 3, we can see that the values differ from the values we get after increasing the POT value with 1kΩ. So overall, this lab is very helpful for us as in this lab we learned about the different applications of Zener diode. So, it was a very beneficial lab for us.

Questions / Answers:

Answer to question 1:

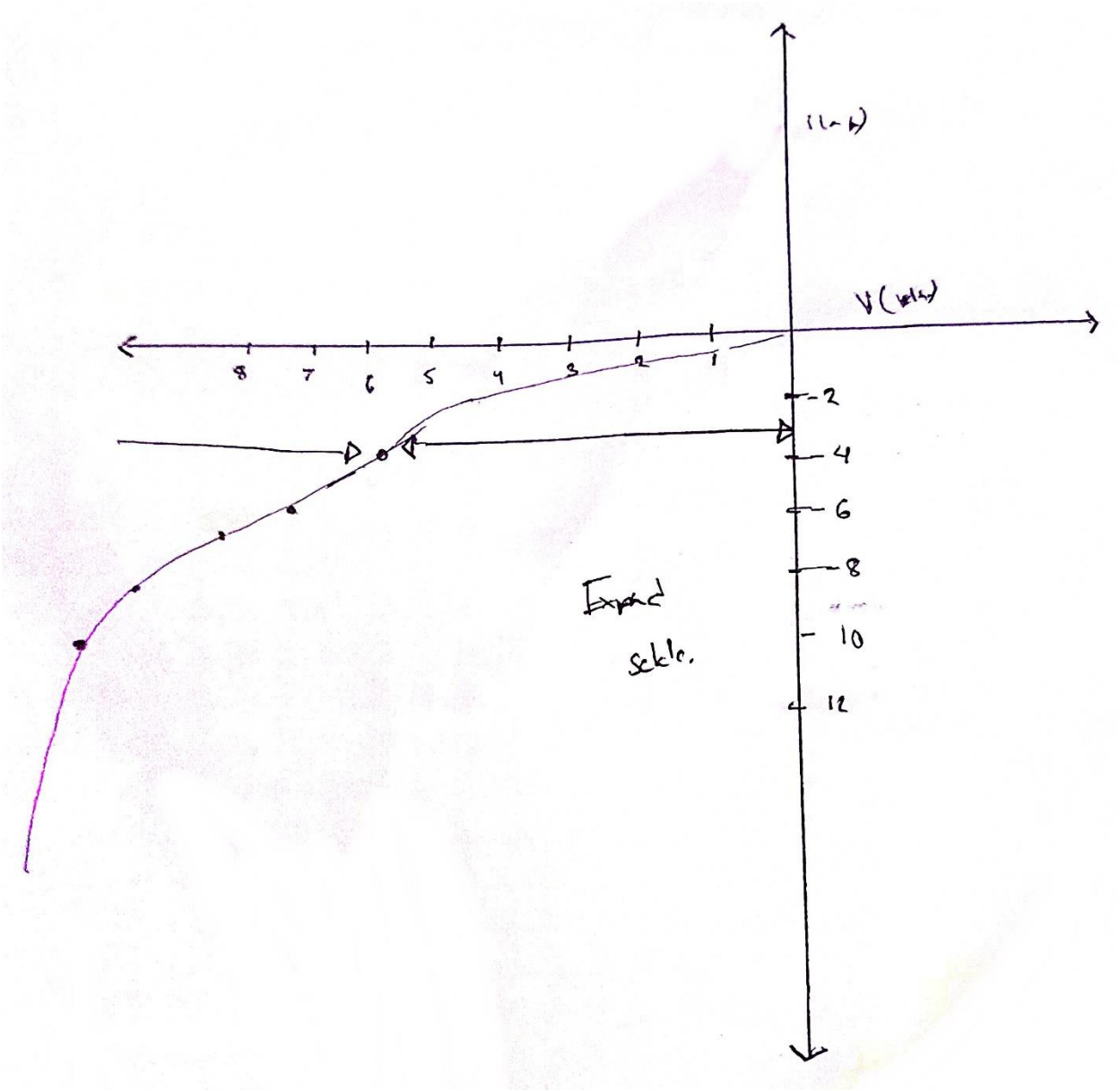

Figure 4: I-V Characteristics Graph of a Zener diode (Reverse Bias Region)

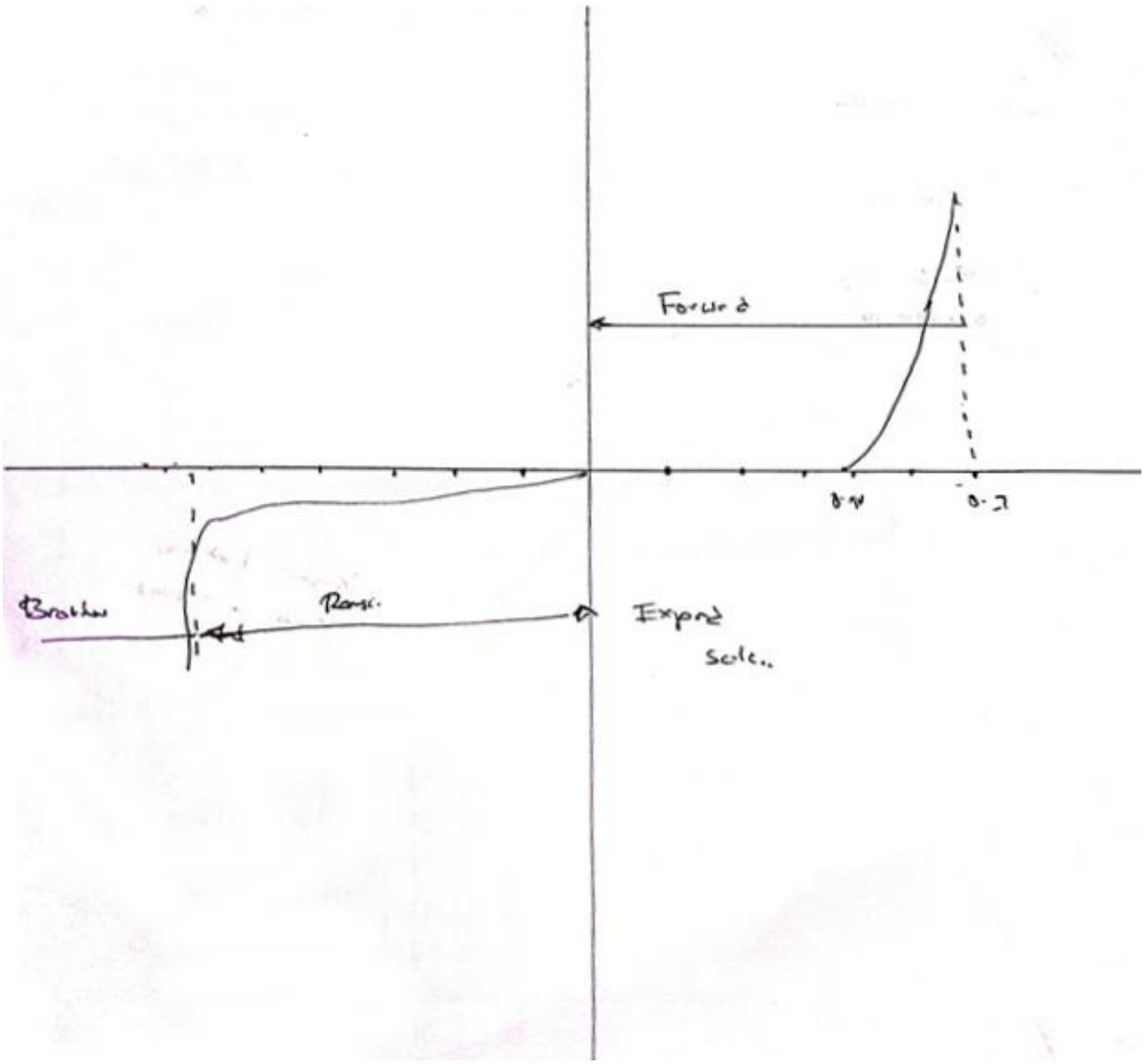

Figure 5: I-V Characteristics Graph of a Zener diode

Answer to question 2:

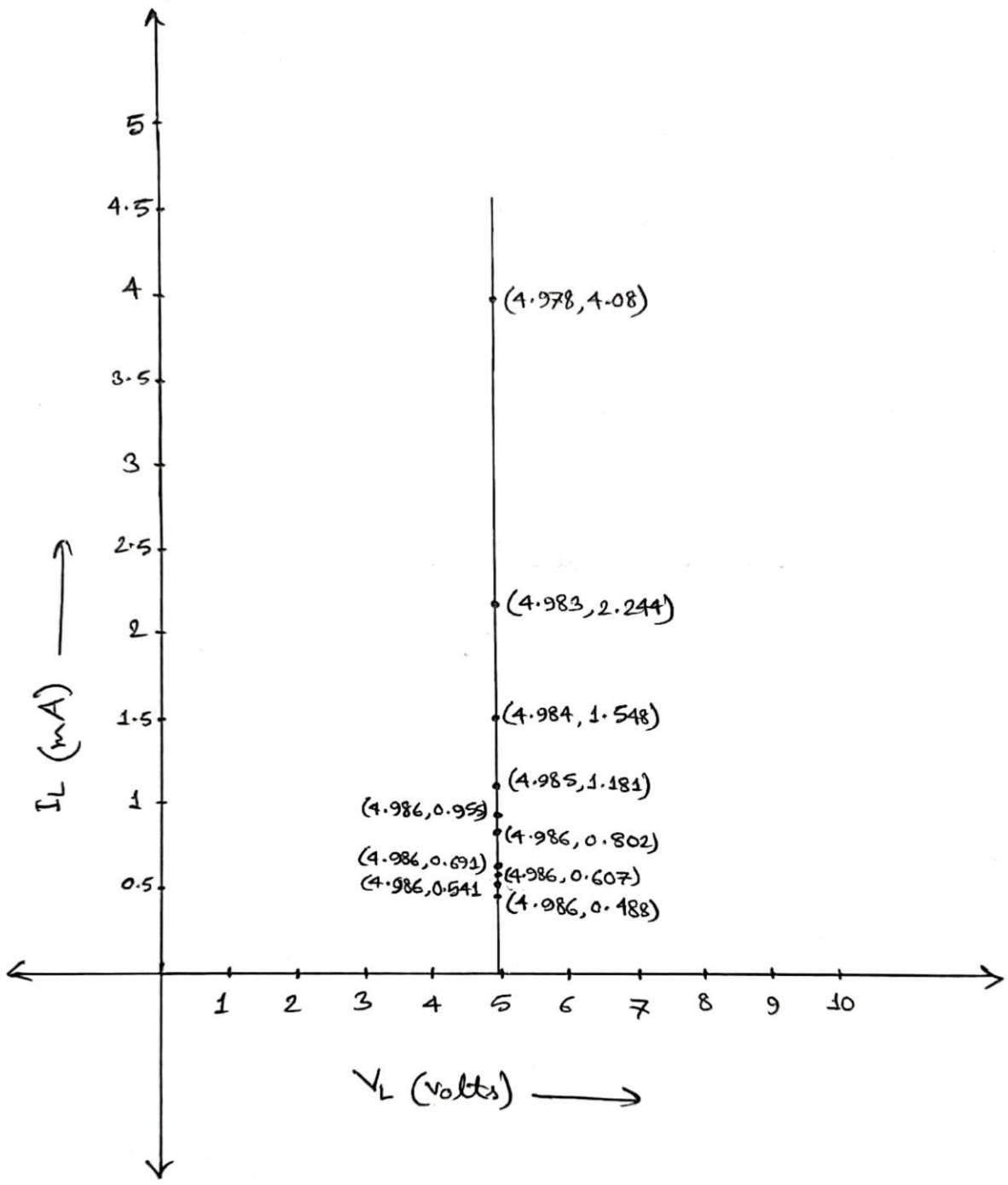

Figure 6: I_L vs V_L Graph using Table 2

Answer to question 3:

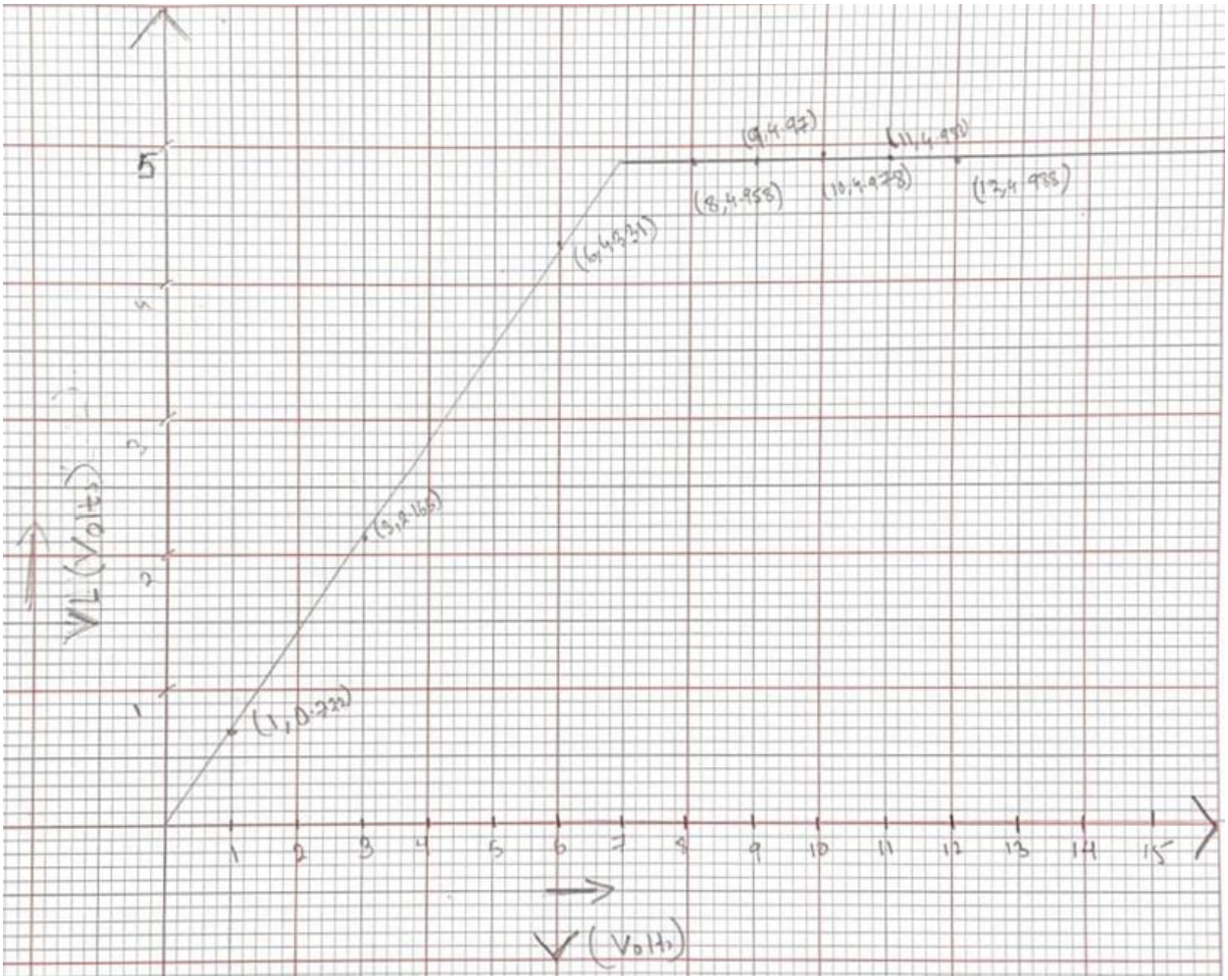

Figure 7: V_L vs V Graph using Table 3

Contributions:

Name & ID	Contribution
Tusher Saha Nirjhor – 1921793642 (**Report Writer)**	Data & Table
Fardin Bin Islam - 1721588642	Questions/Answers
Md Kawser Islam – 1912296642	Result Analysis & Discussion
Yusuf Abdullah Tonmoy – 1620456042	Theory
Md. Rifat Ahmed - 1931725042	Circuit Diagram, Equipment List, Attachment

Attachment:

Task: 01

Table 4.1: Data for I - V characteristics

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Table 4.2: Data for Load Regulation

POT_R (k ohm)	V_{220} (mV)	V_L (volts)	I_L (Amp)= $V_{220}/220$
1 k	897.643 mV	4.978 V	4.08 mA
3 k	340.542 mV	4.984 V	1.548 mA
5k	210.119 mV	4.986 V	955.092 µA
9k	118.981 mV	4.986 V	540.828 µA
10k	107.341 mV	4.986 V	487.92 µA

Table 4.3: Data for Line Regulation.

V (volts)	V_L (volts)
1.0	721.844 mV
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11.0	4.983 V
12.0	4.988 V

Task: 02

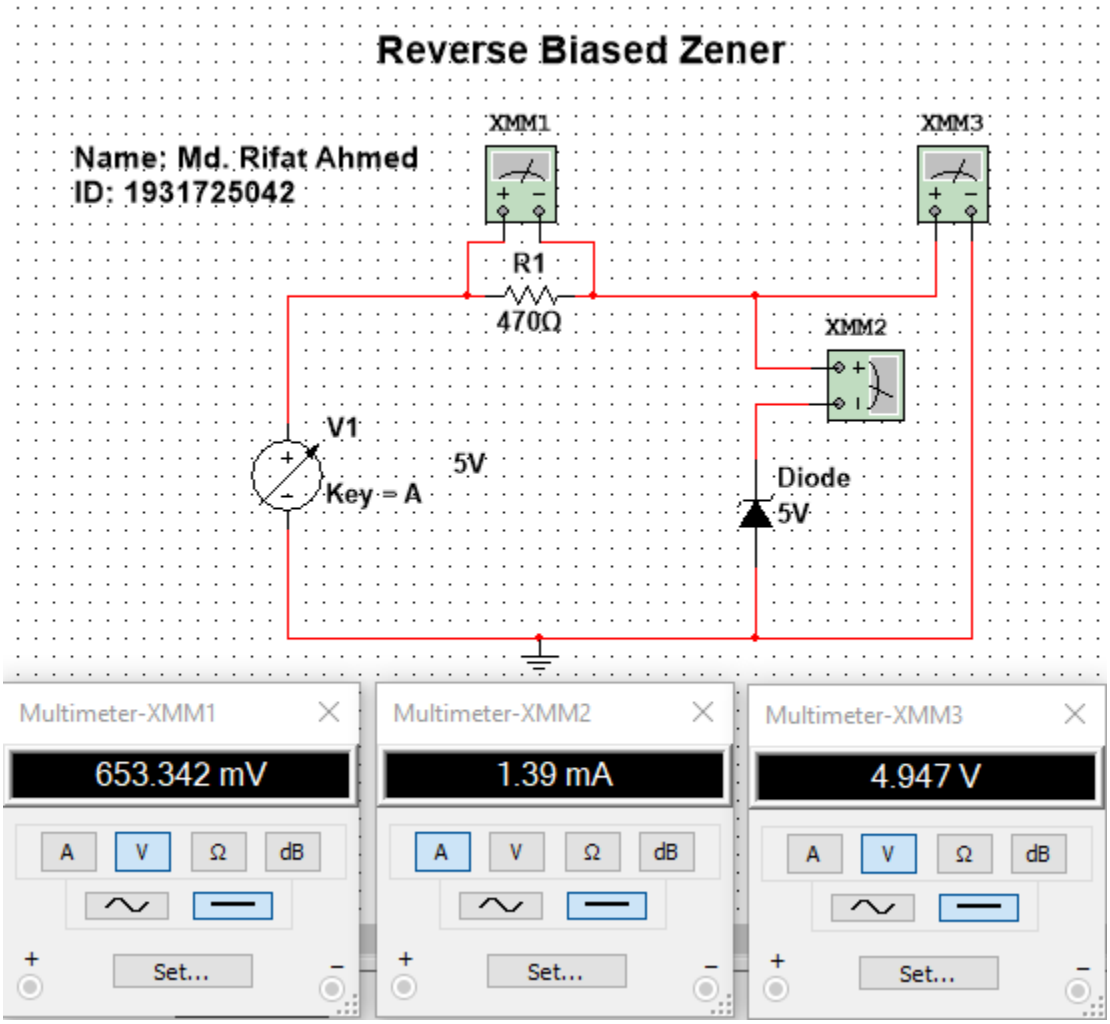

Figure 1: Reverse Biased Zener Circuit

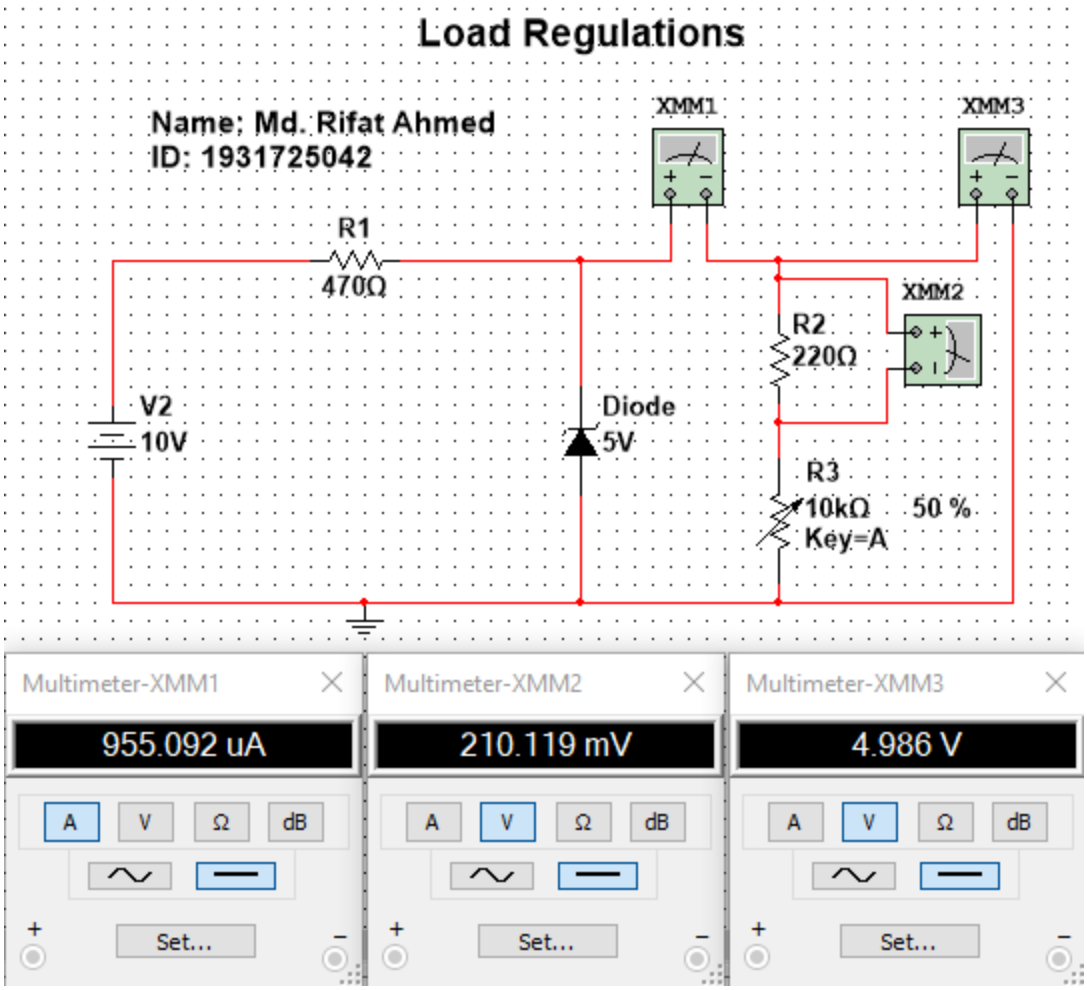

Figure 2: Load Regulations Circuit

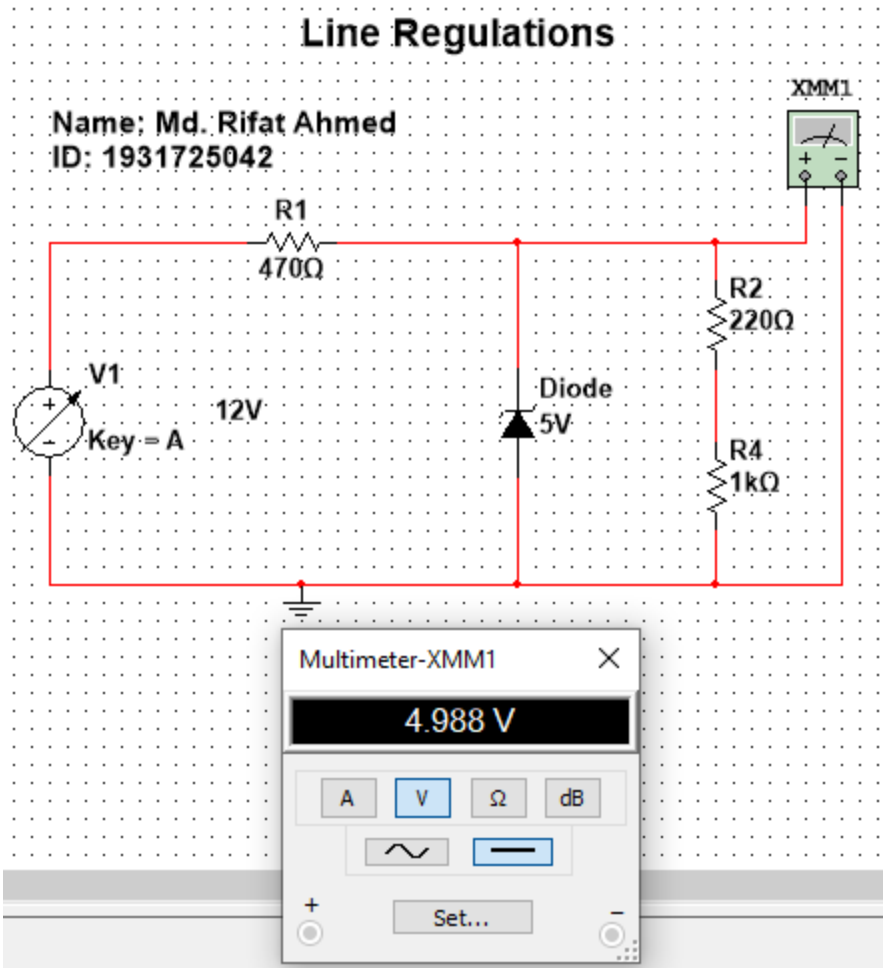

Figure 3: Line Regulations Circuit

Task: 03

1. What is the difference between a Zener Diode and a diode?

Ans: A normal diode only conducts in the forward bias region and does not conduct when reverse biased because they might be damaged if they're reverse biased. But on the other hand, a Zener diode can conduct in three regions: forward, leakage and breakdown. In forward bias region it acts like a normal silicon diode, in the leakage region it can conduct a small amount of reverse saturation current and in the breakdown region it works for a fixed amount of voltage.

2. What is called a Zener Voltage?

Ans: The voltage that causes a diode to enter the Zener region in the negative bias region is called Zener voltage (V_Z).

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