Ayush Nagpure
Batch – 2024
Application No - 158377
Subgroup – 1H3

Experiment: Zener Diode as Voltage Regulator

Aim: To study Zener diode as voltage

Apparatus: Using Virtual Lab (http://vlabs.iitkgp.ernet.in/be/)

Theory:

A Zener Diode is a special kind of diode which permits current to flow in the forward direction as normal, but will also allow it to flow in the reverse direction when the voltage is above the breakdown voltage or 'zener' voltage. Zener diodes are designed so that their breakdown voltage is much lower - for example just 2.4 Volts.
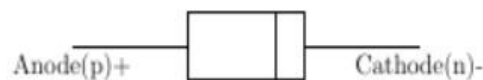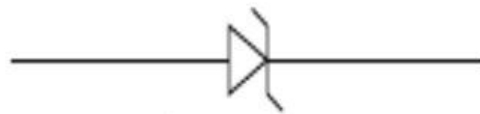

Figure:1

Figure:2

Function of Zener Diode

Zener diodes are a special kind of diode which permits current to flow in the forward direction.

Zener diodes will also allow current to flow in the reverse direction when the voltage is above a certain value. This breakdown voltage is known as the Zener voltage. In a standard diode, the Zener voltage is high, and the diode is permanently damaged if a reverse current above that value is allowed to pass through it.

In the reverse bias direction, there is practically no reverse current flow until the breakdown voltage is reached. When this occurs there is a sharp increase in reverse current. Varying amount of reverse current can pass through the diode without damaging it. The breakdown voltage or zener voltage (VZ) across the diode remains relatively constant.

Zener Diode As A Voltage Regulator

A voltage regulator is an electronic circuit that provides a stable DC voltage independent of the load current, temperature and AC line voltage variations. A Zener diode of break down voltage VZ is reverse connected to an input voltage source VI across a load resistance RL and a series resistor RS. The voltage across the zener will remain steady at its break down voltage VZ for all the values of zener current IZ as long as the current remains in the break down region. Hence a regulated DC output voltage V0=VZ is obtained across RL, whenever the input voltage remains within a minimum and maximum voltage. Basically there are two type of regulations such as:

Line Regulation: In this type of regulation, series resistance and load resistance are fixed, only input voltage is changing. Output voltage remains the same as long as the input voltage is maintained above a minimum value.

Load Regulation: In this type of regulation, input voltage is fixed and the load resistance is varying.

Output volt remains same, as long as the load resistance is maintained above a minimum value.
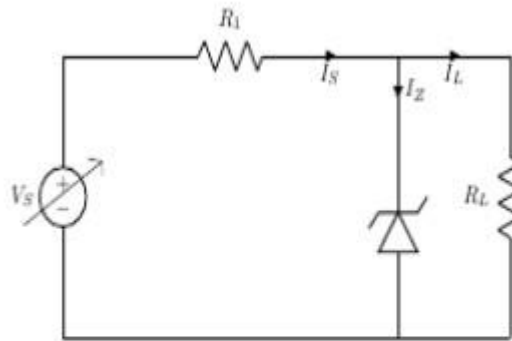
Line Regulation

Figure:3

In Line Regulation, Load resistance is constant and input voltage varies. V_I must be sufficiently large to turn the Zener Diode ON.

$V_L = V_Z = V_{Imin} \times R_L (R_S + R_L)$

So, the minimum turn-on voltage V_{Imin} is :

$V_{Imin}=V_Z\times(R_S+R_L)*R_L$

The maximum value of V_I is limited by the maximum zener current I_{Zmax}

$I_{Rmax}=I_{Zmax}+I_L$

I_L is fixed at : V_ZR_L

Since,$V_L=V_Z$, So maximum V_I is

$V_{Imax}=V_{Rmax}+V_Z$

or,

$V_{Imax}=I_{Rmax}\times R+V_Z$

For $V_I<V_Z$,; $V_O=V_I$

For $V_I>V_Z$,

$V_O=V_I-I_s\times R_s$

Procedure: (http://vlabs.iitkgp.ernet.in/be/exp10/znrli.html)

1. Set the Zener Voltage(VZ)
2. Set the Series Resistance (RS) value.
3. Set the Load Resistance (RL) value.
4. Vary DC voltage.
5. Voltmeter is placed parallel to load resistor and ammeter series with the series resistor.
6. Choose appropriate DC voltage such that zener diode is 'on'.
7. Now note the Voltmeter and Ammeter reading for various DC voltage. 8. Note the Load current(IL), zener current(IZ), Output voltage(VO)
9. Calculate the voltage regulation.

Observation Table :

EXPERIMENTAL TABLE

Zener Voltage(V_Z): 5.1 V
Series Resistance(R_S): 1 KΩ
Load Resistance (R_L): 2 KΩ

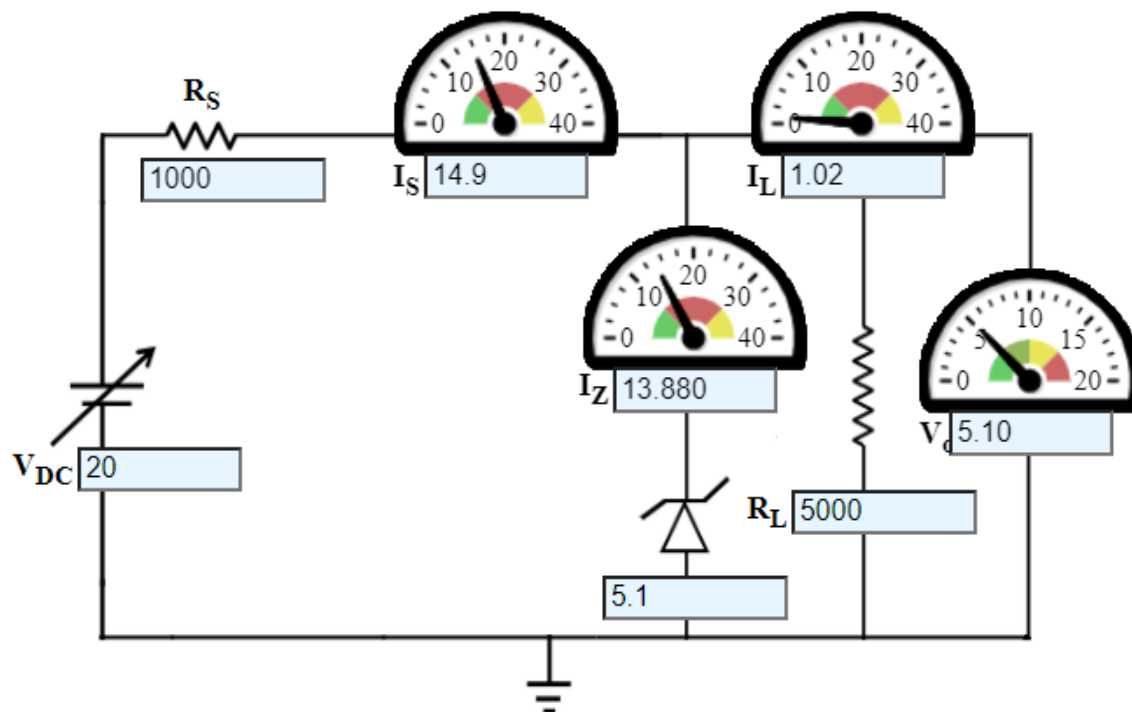| Serial No.	Unregulated supply voltage(V_S) V	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation
1	0	2.55	0	0	NaN
2	2	2.55	0	2	100
3	4	2.55	0	4	100
4	6	2.55	-1.650	5.10	83.3
5	8	2.55	0.350	5.10	62.5
6	10	2.55	2.350	5.10	50.0
7	12	2.55	4.350	5.10	41.7
8	14	2.55	6.350	5.10	35.7
9	16	2.55	8.350	5.10	31.3
10	18	2.55	10.350	5.10	27.8
11	20	2.55	12.350	5.10	25.0

EXPERIMENTAL TABLE

Zener Voltage(V_Z): 5.1 V
Series Resistance(R_S): 1 KΩ
Load Resistance (R_L): 5 KΩ
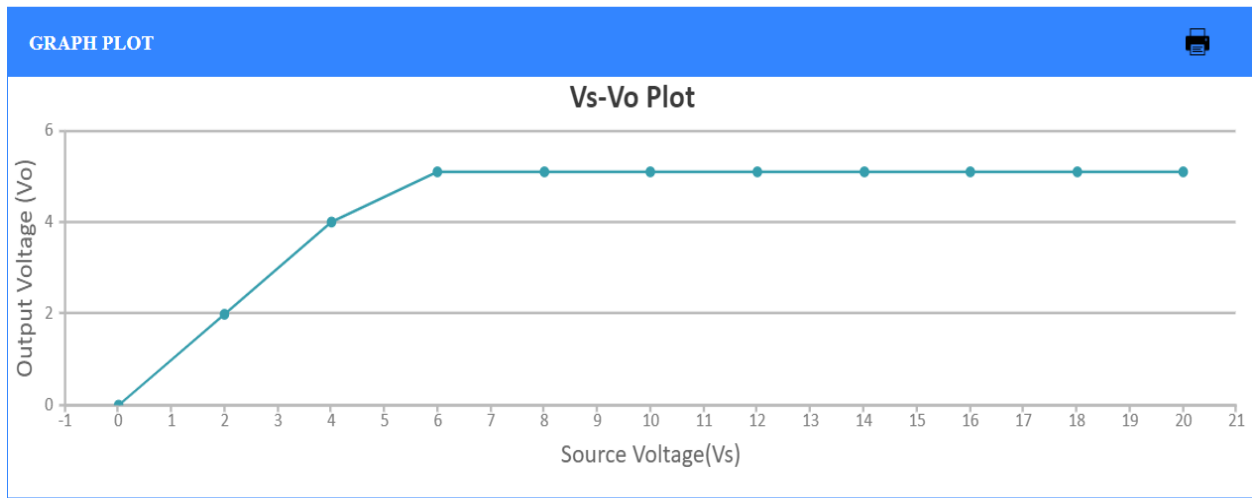
Serial No.	Unregulated supply voltage(V_S) V	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation
1	0	1.02	0	0	NaN
2	2	1.02	0	2	100
3	4	1.02	0	4	100
4	6	1.02	-0.120	5.10	83.3
5	8	1.02	1.880	5.10	62.5
6	10	1.02	3.880	5.10	50.0
7	12	1.02	5.880	5.10	41.7
8	14	1.02	7.880	5.10	35.7
9	16	1.02	9.880	5.10	31.3
10	18	1.02	11.880	5.10	27.8
11	20	1.02	13.880	5.10	25.0

Circuit Diagram (on Vlab, paste here):

Circuit 1

- R_S: 1000
- I_S 14.9
- I_L 2.55
- I_Z 12.350
- V_o 5.10
- V_{DC} 20
- R_L 2000
- 5.1

Circuit 2

- R_S: 1000
- I_S 14.9
- I_L 1.02
- I_Z 13.880
- V_o 5.10
- V_{DC} 20
- R_L 5000
- 5.1
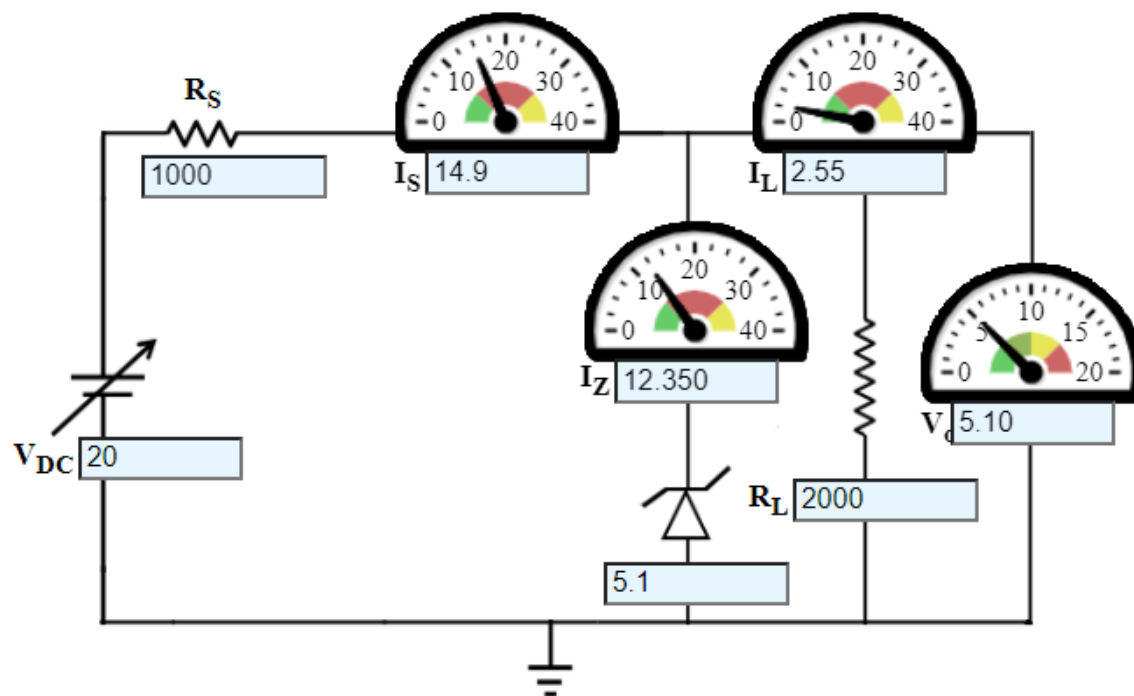
Plot:
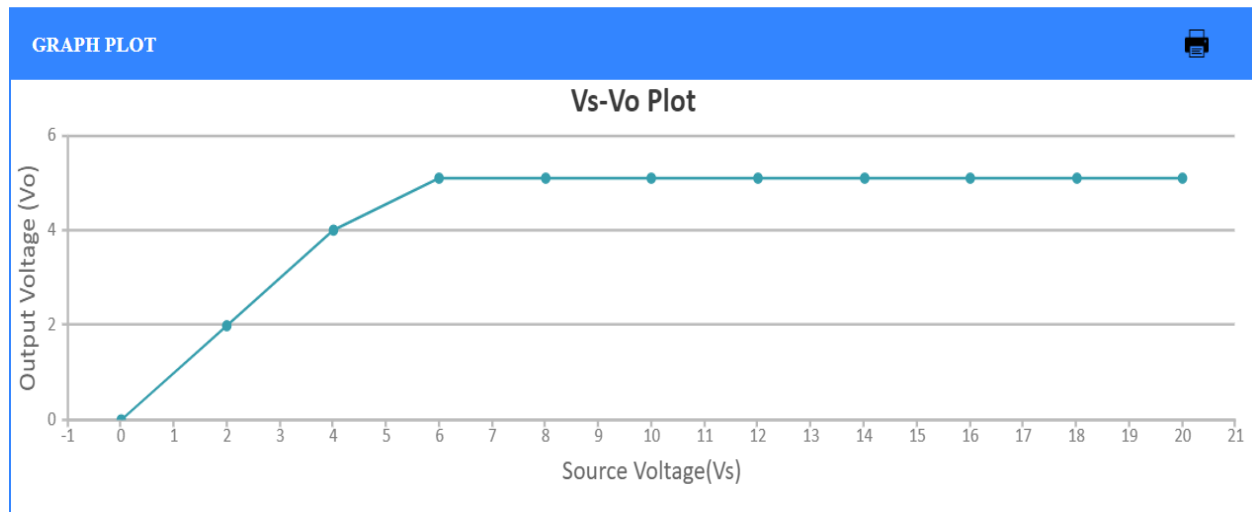
Conclusion: Hence we find that zener diode does not allow the source voltage to exceeds its breakdown voltage and hence keeps our device safe from the unregulated voltage.