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|---|---|---|---|
| **Course Name:** | **EEEE** | **Semester:** | **I** |
| **Date of Performance:** | **6/12/2022** | **Batch No:** | **C2-2** |
| **Faculty Name:** | **Jyoti Varavedkar** | **Roll No:** | **16010122109** |
| **Faculty Sign & Date:** | | **Grade/Marks:** | |

# Experiment No: 6
# Title: Zener diode voltage regulator

**Aim and Objective of the Experiment:**

- To understand the working of Zener diode as voltage regulator
- To calculate line and load regulation of Zener diode based shunt regulator

**Requirements:**

Zener diode, resistor, potentiometer, voltmeter, ammeter, DC source and bread board.

**Link for virtual lab:**
https://portal.coepvlab.ac.in/vlab/auth/home?dept=2&lab=10

**Theory:**

A zener diode functions as an ordinary diode when it is forward biased. It is a specially designed device to operate in the reverse bias. When it is in the reverse breakdown region, the voltage ($V_z$) across Zener diode remains almost constant irrespective of the current ($I_z$) flowing through it. A series resistor A series resistor *Rs* is used to limit the zener current below its maximum current rating. The current through *Rs* is given by the expression is $I_S=I_Z+I_L$ , where $I_L$ is the current through the load resistor . The value of *Rs* must be properly selected to ensure break down of the Zener diode and also to keep *Iz* in limited in specified current limit.

$$Rs_{min}= (V_{in}-V_z)/Iz_{max} \quad (1)$$

$$Rs_{max}= (V_{in}-V_z)/(Iz_{min} + I_L) \quad (2)$$

Design steps:

1. If for regulator

   Desired output parameters Vo=5.6 V, $I_{Lmax}$= 5mA

Input voltage in the range $V_{IN}$ = 8 V- 14 V

2. Choose Zener diode (5.6 V, 45 mA)
3. Choose potentiometer of value 4.7 kΩ so that $I_L$ can be varied from 5.6/4.7 kΩ ≈ 1.2 mA.
4. $I_{Zmax}$ = 45 mA so $I_{Zmin}$ = 10% of $I_{Zmax}$ = 4.5 mA
5. $R_{Smax} = (V_{INmin} - V_Z) / (I_{Zmin} + I_{Lmax}) = (8-5.6)\ V/(4.5+5.0)\ mA \approx 253\ \Omega$

$R_{Smin} = (V_{INmax} - V_Z) / I_{Zmax} = (14-5.6)V/(45\ mA) \approx 186\ \Omega$

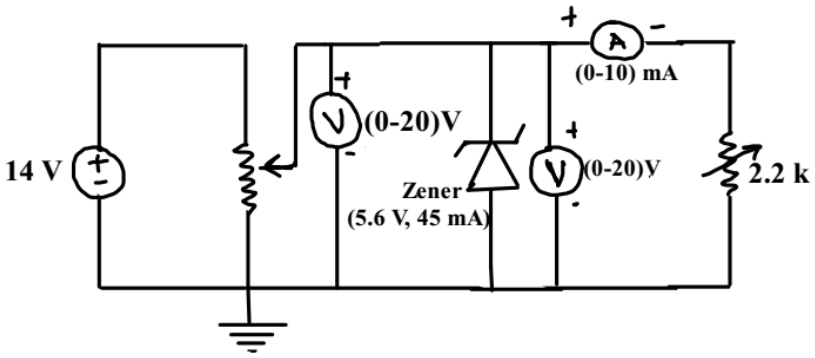
Choose $R_{Smin} < Rs < R_{Smax}$ so Rs = 220 Ω and Power rating $(I_{max})^2 \times R_S$

$I_{max} = (V_{IN} - V_Z) / Rs = (14-5.6) / 220 = 38$ mA

Power rating = $(38\ mA)^2 \times 220 = 0.32$ watt ≈ 0.5 watts.

## Circuit Diagram/ Block Diagram:

**Note: Perform this experiment either on virtual Lab or Proteus simulator**




## Stepwise-Procedure:

1. Design circuit and connect it as shown in the circuit diagram using Proteus simulator.
2. Keep $V_{IN}$ more than 8V and adjust Potentiometer $R_L$ such that $I_L$= 5 mA. Vary $V_{IN}$ and Note $V_O$ for finding line regulation.
3. Keep $V_{IN}$ = 10 V and vary Potentiometer $R_L$ such that $I_L$ changed from 0 to 5 mA and not $V_O$ for finding load regulation.
4. Plot the graph $V_o$ Vs $V_{IN}$ for line regulation and $V_o$ Vs $I_L$ for load regulation.

## V-Lab/Proteus Screen shots

Line Regulation:
DC volt = variable
Zener diode = 5.6v
Resistance (Rs) = 200 ohm
Resistance (Rl) = 1100 ohm

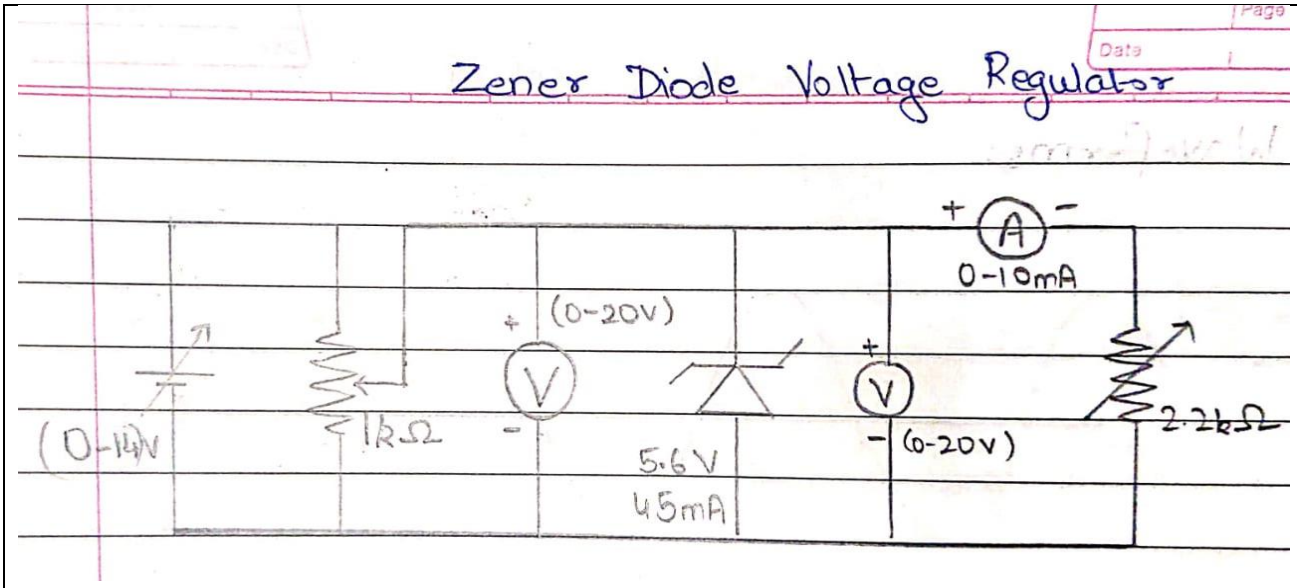
| Serial No. | Unregulated supply voltage($V_S$) V | Load Current($I_L$) mAmp | Zener Current($I_Z$) mAmp | Regulated Output Voltage($V_O$) V | % Voltage Regulation |
|---|---|---|---|---|---|
| 1 | 2 | 5.09 | 0 | 2 | 100 |
| 2 | 3 | 5.09 | 0 | 3 | 100 |
| 3 | 4 | 5.09 | 0 | 4 | 100 |
| 4 | 5 | 5.09 | 0 | 5 | 100 |
| 5 | 5.6 | 5.09 | 0 | 5.6 | 100 |
| 6 | 6 | 5.09 | -3.091 | 5.60 | 83.3 |
| 7 | 6.6 | 5.09 | -0.091 | 5.60 | 83.3 |
| 8 | 7 | 5.09 | 1.909 | 5.60 | 71.4 |
| 9 | 7.6 | 5.09 | 4.909 | 5.60 | 71.4 |
| 10 | 8 | 5.09 | 6.909 | 5.60 | 62.5 |
| 11 | 8.6 | 5.09 | 9.909 | 5.60 | 62.5 |
| 12 | 9 | 5.09 | 11.909 | 5.60 | 55.6 |
| 13 | 9.6 | 5.09 | 14.909 | 5.60 | 55.6 |
| 14 | 10 | 5.09 | 16.909 | 5.60 | 50.0 |

Load Regulation:

DC volt = 10v (Fixed)
Zener diode = 5.6v
Resistance (Rs) = 200 ohm
Resistance (Rl) = variable

| Serial No. | Load Resistance($R_L$) Ohm | Load Current($I_L$) mAmp | Zener Current($I_Z$) mAmp | Regulated Output Voltage($V_O$) V | % Voltage Regulation |
|---|---|---|---|---|---|
| 1 | 1250 | 4.48 | 17.5 | 5.60 | 13.8 |
| 2 | 1121 | 5.00 | 17.0 | 5.60 | 15.1 |
| 3 | 1000 | 5.60 | 16.4 | 5.60 | 16.7 |
| 4 | 934 | 6.00 | 16.0 | 5.60 | 17.6 |
| 5 | 700 | 8.00 | 14.0 | 5.60 | 22.2 |
| 6 | 560 | 10.0 | 12.0 | 5.60 | 26.3 |
| 7 | 468 | 12.0 | 10.0 | 5.60 | 29.9 |
| 8 | 400 | 14.0 | 8.00 | 5.60 | 33.3 |
| 9 | 350 | 16.0 | 6.00 | 5.60 | 36.4 |
| 10 | 311 | 18.0 | 3.99 | 5.60 | 39.1 |
| 11 | 280 | 20.0 | 2.00 | 5.60 | 41.7 |
| 12 | 233 | 24.0 | 0 | 10 | 46.2 |
| 13 | 215 | 26.0 | 0 | 10 | 48.2 |
| 14 | 200 | 28.0 | 0 | 10 | 50.0 |
| 15 | 186 | 30.1 | 0 | 10 | 51.8 |

**Observation Table:**




**Line Regulation: Set $I_L$= 5 mA** **Load Regulations: Set $V_{IN}$= 10 V**

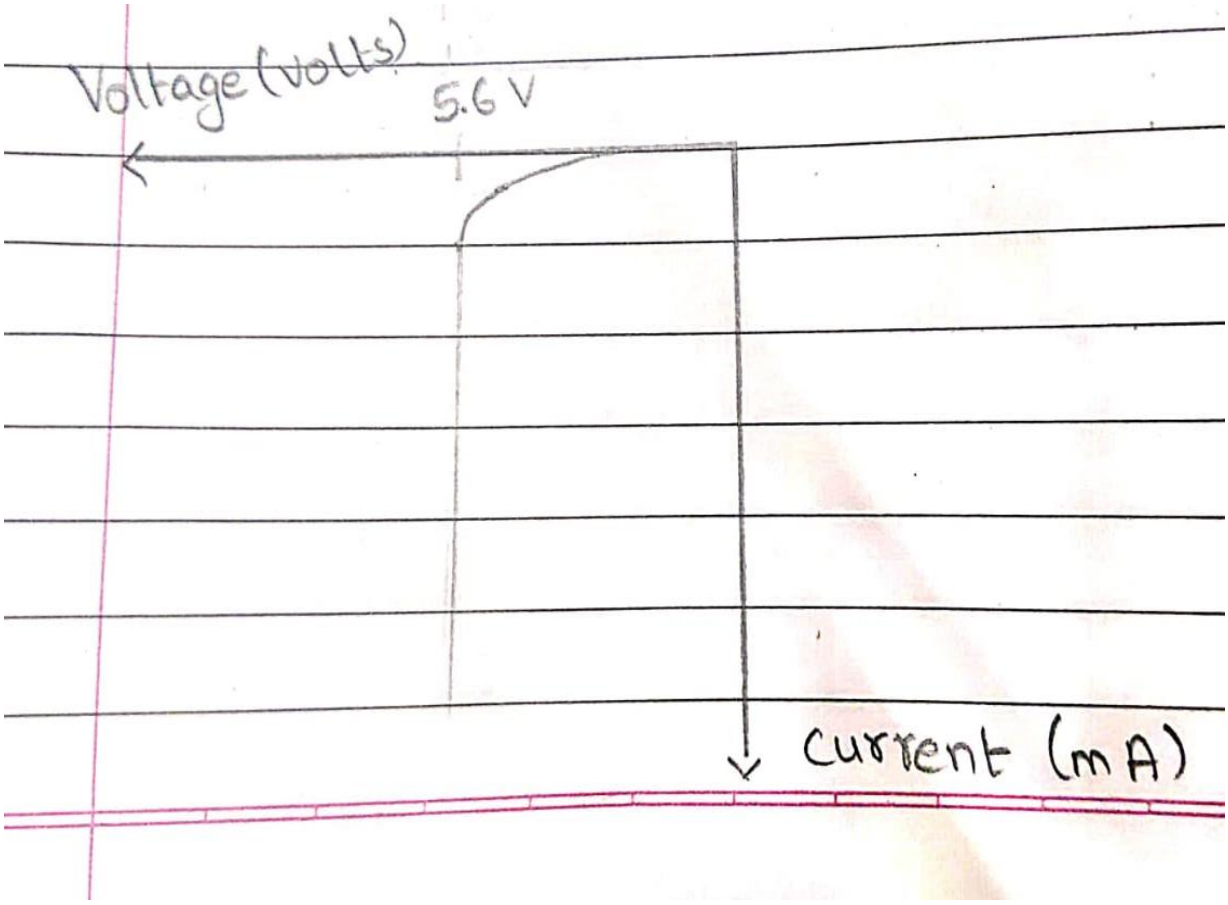
| $V_{IN}$ (V) | Vo (V) | $I_L$ (mA) | Vo (V) |
|---|---|---|---|
| 2 | 2 | 4.48 | 5.6 |
| 3 | 3 | 5 | 5.6 |
| 4 | 4 | 5.6 | 5.6 |
| 5 | 5 | 6 | 5.6 |
| 5.6 | 5.6 | 8 | 5.6 |
| 6 | 5.6 | 10 | 5.6 |
| 6.6 | 5.6 | 12 | 5.6 |
| 7 | 5.6 | 14 | 5.6 |
| 7.6 | 5.6 | 16 | 5.6 |
| 8 | 5.6 | 18 | 5.6 |
| 8.6 | 5.6 | 20 | 5.6 |
| 9 | 5.6 | 24 | 10 |
| 9.6 | 5.6 | 26 | 10 |

| | | | | |
|---|---|---|---|---|
| 10 | 5.6 | | 28 | 10 |
| | | | 30 | 10 |

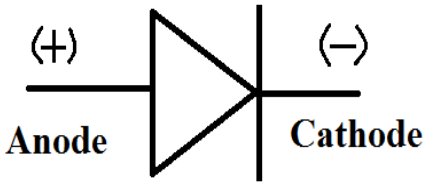
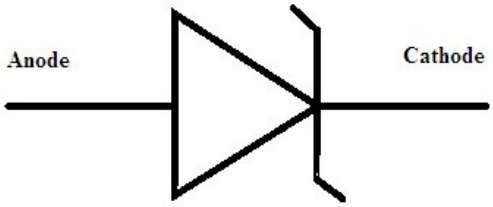
**Post Lab Subjective/Objective type Questions:**

1. Draw and explain I-V characteristics of Zener diode.
2. What is difference between PN junction diode and Zener diode?

1] Zener diode is p–n junction diode which is manufactured to operate in breakdown region.Its forward bias characteristic is same as that of ordinary junction diode. This means current does not flow until bias is less than barrier potential. Current increases rapidly beyond it with increase in forward voltage. In reverse bias, initially a small reverse saturated current flows and at particular value of reverse voltage, increases suddenly. This voltage is zener breakdown voltage (Vz).



2] The differences between pn junction and zener diode are:

| sr. no. | PN Junction | Zener Diode |
|---|---|---|
| 1 | The electricity flows in one direction. | The electricity flows in both direction. |
| 2 | The reverse bias permanently damages the depletion layer. | The reverse bias makes the electricity flow in both direction. |
| 3 | Used for rectification. | Used for regulation. |
| 4 | The width of depletion layer is larger because the p and n junction region is lightly doped. | The width of depletion layer is narrow because the p and n junction region is heavily doped. |
| 5 | Symbol:   | Symbol:   |

**Conclusion:**

Thus, we learnt the working of Zener diode as voltage regulator and how to calculate line and load regulation of Zener diode .

**Signature of faculty in-charge with Date:**