Course Name:	**Elements of Electrical and Electronics Engineering Laboratory**	**Semester:**	**I/II**
Date of Performance:	18/10/2024	**Batch No:**	C4 (01)
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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

COs to be achieved:

CO4: Explain rectifier-filter circuits using PN junction diode and voltage regulator circuits using Zener diode

Requirements:

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

Theory:

The Zener diode is like a general-purpose signal diode. When biased in the forward direction it behaves just like a normal signal diode, but when a reverse voltage is applied to it, the voltage remains constant for a wide range of currents.

Avalanche Breakdown: There is a limit for the reverse voltage. Reverse voltage can increase until the diode breakdown voltage reaches. This point is called Avalanche Breakdown region. At this stage maximum current will flow through the Zener diode. This breakdown point is referred as "Zener voltage".

Fig 1: Zener Diode

The Zener Diode is used in its "reverse bias". From the I-V Characteristics curve we can study that the zener diode has a region in its reverse bias characteristics of almost a constant negative voltage regardless of the value of the current flowing through the diode and remains nearly constant even with large changes in current as long as the zener diodes current remains between the breakdown current $I_{Z(min)}$ and the maximum current rating $I_{Z(max)}$.

This ability to control itself can be used to great effect to regulate or stabilise a voltage source against supply or load variations. The fact that the voltage across the diode in the breakdown region is almost constant turns out to be an important application of the zener diode as a voltage regulator.

Zener I-V Characteristics:

Figure 2 shows the current versus voltage curve for a Zener diode. Observe the nearly constant voltage in the breakdown region.

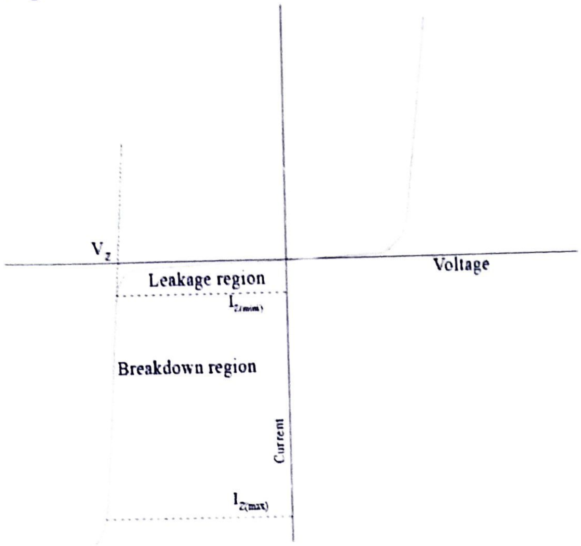


Fig 2: Zener diode characteristic curve

The forward bias region of a Zener diode is identical to that of a regular diode. The typical forward voltage at room temperature with a current of around 1 mA is around 0.6 volts. In the reverse bias condition the Zener diode is an open circuit and only a small leakage current is flowing as shown on the exaggerated plot. As the breakdown voltage is approached the current will begin to avalanche. The initial transition from leakage to breakdown is soft but then the current rapidly increases as shown on the plot. The voltage across the Zener diode in the breakdown region is very nearly constant with only a small increase in voltage with increasing current. At some high current level the power dissipation of the diode becomes excessive and the part is destroyed. There is a minimum Zener current, Iz(min), that places the operating point in the desired breakdown. There is a maximum Zener current, Iz(max), at which the power dissipation drives the junction temperature series resistance and the Zener diode. Shunt regulators have an inherent current limiting advantage under load fault conditions because the series resistor limits excess current. 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:

a) 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.

Percentage of line regulation can be calculated by = $\frac{\Delta Vout}{\Delta Vin} \times 100$

where V_0 is the output voltage and V_{IN} is the input voltage and ΔV_0 is the change in output voltage for a particular change in input voltage ΔV_{IN}.

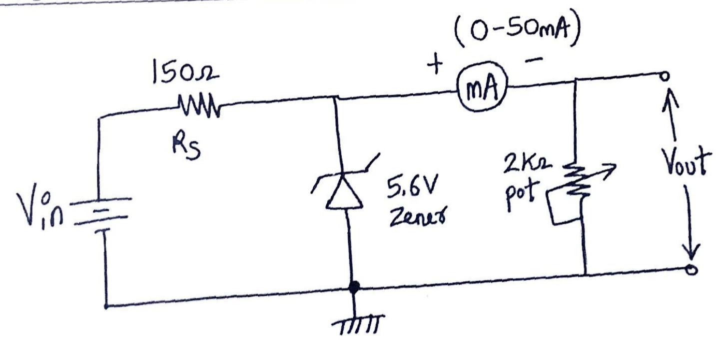
b) Load Regulation:

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.

Percentage of load regulation = $\left[\frac{VNL-VFL}{VNL}\right] \times 100$

where VNL is the null load resistor voltage (ie. remove the load resistance and measure the voltage across the Zener Diode) and VFL is the full load resistor voltage

Circuit Diagram:



Zener as Voltage Regulator Circuit

Stepwise-Procedure:

1. Design circuit and connect it as shown in the circuit diagram using Proteus simulator.
2. Keep V_{IN} around 4V and adjust Potentiometer R_1 such that I_l = 5 mA. Vary V_{IN} and note V_{OUT} for finding line regulation.
3. Keep V_{IN} = 10 V and vary Potentiometer R_1 such that I_l changed from 3mA to 15 mA and note V_{OUT} for finding load regulation.
4. Plot the graph V_{OUT} Vs V_{IN} for line regulation and V_{OUT} Vs I_l for load regulation.

Observation Table:

Line Regulation: (Keep I_L = 5mA constant)

Unregulated supply voltage (Vin)	Regulated output voltage (Vo)
4V	3.75 v
5V	4.64 V
6V	5.48 V
7V	5.59 V
8V	5.61 V
10V	5.66 V
12V	5.72 V
14V	5.77 V
16V	5.83 V

i) Line regualation % $= \frac{\Delta V_{out}}{\Delta V_{in}} \times 100$

$= \frac{0.06}{2} \times 100$

$= 3\%$

Load Regulation: (Keep Vin = 10V constant)

Line current I_L(mA)	Regulated output voltage (Vout)
3mA	5.68 v
4mA	5.69 v
5mA	5.67 v
7mA	5.66 v
9mA	5.65 v
10mA	5.64 V
12mA	5.63 V
14mA	5.62 V
No load value V_{NL}(Remove R_L & measure Vout)	5.71 V

ii) Load regulation % $= \frac{|V_{NL} - V_{FL}|}{V_{NL}} \times 100$

$= \frac{5.71 - 5.68}{5.71} \times 100$

$= 0.52\%$

Post Lab Subjective:

1. What is difference between PN junction diode and Zener diode?

The major difference between a PN junction diode and a zener diode is that a PN junction allows the electric current to pass in only one direction (or forward direction), while a zener diode allows the electric current to flow in both forward and reverse direction.

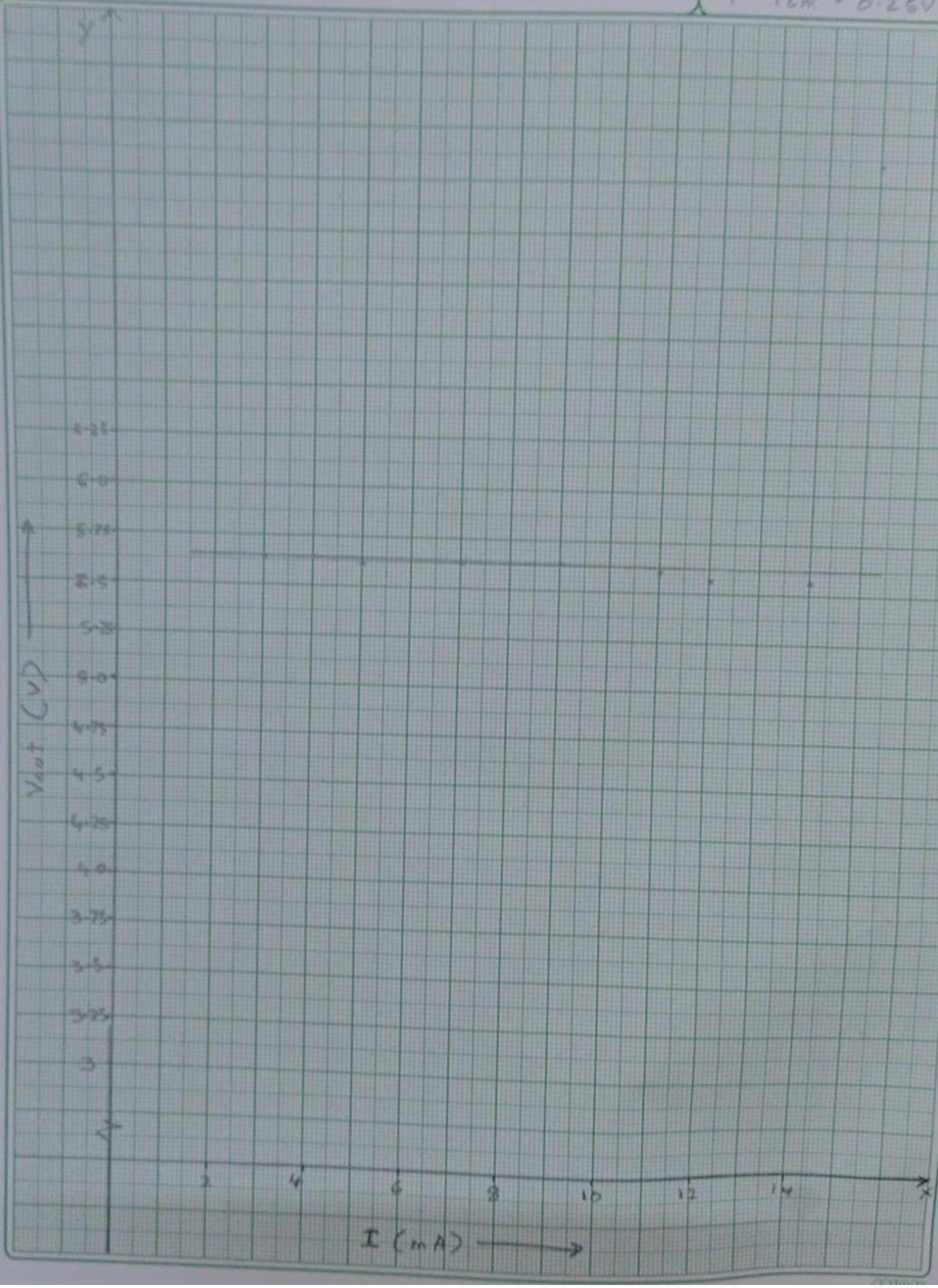
Conclusion:

In the experiment given above, we learn how to calculate line regulation and load regulation of zener diode based regulator. We also learn about it's functioning and working.

Signature of faculty in-charge with Date:

Vout vs I_L

SCALE :-
X = 1cm = 1mA
Y = 1cm = 0.25V



Vout vs Vin

SCALE :-
x = 1cm = 1 V
Y = 1cm = 0.5 V