Experiment 1

Zener Diode In Basic Application (Simulation)

I. OBJECTIVES

- To analyze Zener diode circuits using PSPICE software.

II (a) Zener diode

A diode which is different from the conventional semiconductor diode is the *Zener diode.* The Zener diode's forward-biased characteristic is the same as that of a conventional diode. But, the reverse bias characteristic is the same as an ordinary diode up to a specific value known as the *Zener voltage.* An attempt to increase the reverse bias voltage beyond the Zener voltage results only in an increase in the reverse current and the diode voltage tends to remain constant ( see Fig.1).



**Fig. 1**: Zener diode application. **a)** Circuit. **b)** Ideal transfer characteristic.

The I-V characteristic of a Zener Diode is shown in Fig. 2. In the forward bias region, it is very similar to an ordinary diode (p-n junction). In the reverse bias region, there is Zener breakdown which limits the voltage to Vz. The operating region shown in Fig. 2 is where voltage regulation is effective. In other words, the output would be limited to Vz even if input exceeds it. At any point in the operating range, an incremental resistance rz can be defined as follows.

rz = ΔV/ΔI (1)

Here ΔV and ΔI are voltage and current change in the operating region respectively. The value of rz can readily be obtained from the slope in the operating region. Another quantity of interest is line regulation which essentially tells us as to how effective the regulator is, in limiting the output voltage to Vz and eliminating the ripple or noise. It is defined as follows.

Line Regulation = ΔVo/ΔVin (2)

Here, ΔVo and ΔVin are fluctuation in output and input voltage respectively. Please see figure 4. One can measure these two quantities and then determine line regulation. A theoretical analysis gives the following expression for line regulation.

Line Regulation =  (3)

Here rz is defined in equation (1) and RS is shown in Fig.1. If there is load attached to the output then rZ should be replaced by $\frac{r\_{Z}×R\_{L}}{(r\_{Z} + R\_{L})}$. Here RL is the load.

**I**

**V**

**Vz0**

Operating range

**Figure 2**

**III. ZENER REGULATOR**

1. Using PSPICE Capture draw the circuit in Fig. 3. While drawing this figure use the part D1N750 for the Zener diode from the EVAL section of the library.
2. Set the value of the voltage source Vin to 10Vdc. Create a new simulation profile “DC”.
3. Set the Simulation Settings as follows: Analysis Type to “Bias Point”. Run the simulation.
4. Press V and I icons “Enable Bias Voltage/Current Display” button K and N in figure 6 of page 14.
5. Record the results in the following table: Note that IL is the current through load RL and IZ is the current through Zener diode.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 10K |  |  |  |
| 1k |  |  |  |
| 100 |  |  |  |
| 10 |  |  |  |

1. Comment on the above results and explain how the Zener diode regulated the voltage at the output. What is the Zener breakdown voltage here? What is the smallest load for which this circuit can work as a regulator?



Fig. 3: Zener diode experiment