II. Zener Diode

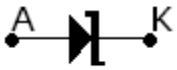
1. Introduction

The Zener diode is a PN junction component that differs from a rectifier diode since it is designed to be operated in reverse bias.

- When a Zener diode reaches reverse breakdown, its voltage remains almost constant.
- If a forward bias is applied to a Zener diode, it functions as a rectifier diode.

2. Symbol

The symbolic representation of Zener diode is shown in the figure below.

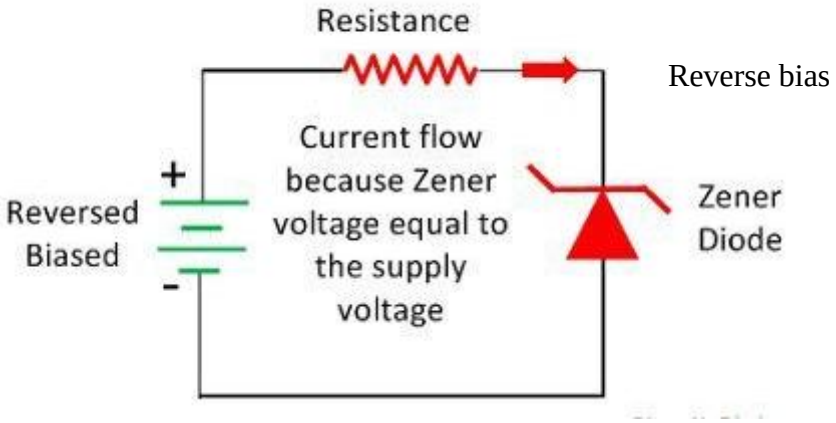


3. Zener diode biasing

The circuit diagram of the Zener diode is shown in the figure below. The Zener diode is employed in reverse biasing.

When the reverse bias applies across the diode and the supply voltage is equal to the Zener voltage then it starts conducting in the reverse bias direction.

So in order to obtain a constant voltage we will use the diagram below:



- If Ue is lower than the reverse voltage of the Zener, so Us = Ue.
- Si Ue exceeds the Zener voltage, the latter conducts strongly, and we have Us = Uz (Zener voltage)

Its Zener equivalent circuit is given in the figure below :

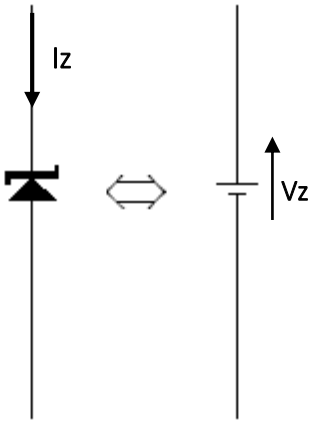


Figure 1: Perfect Model

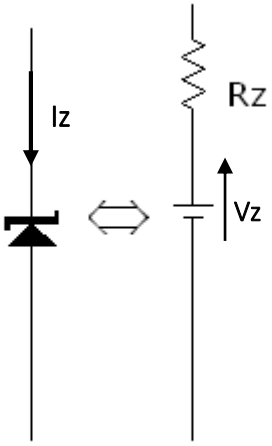


Figure 2 : Real Model

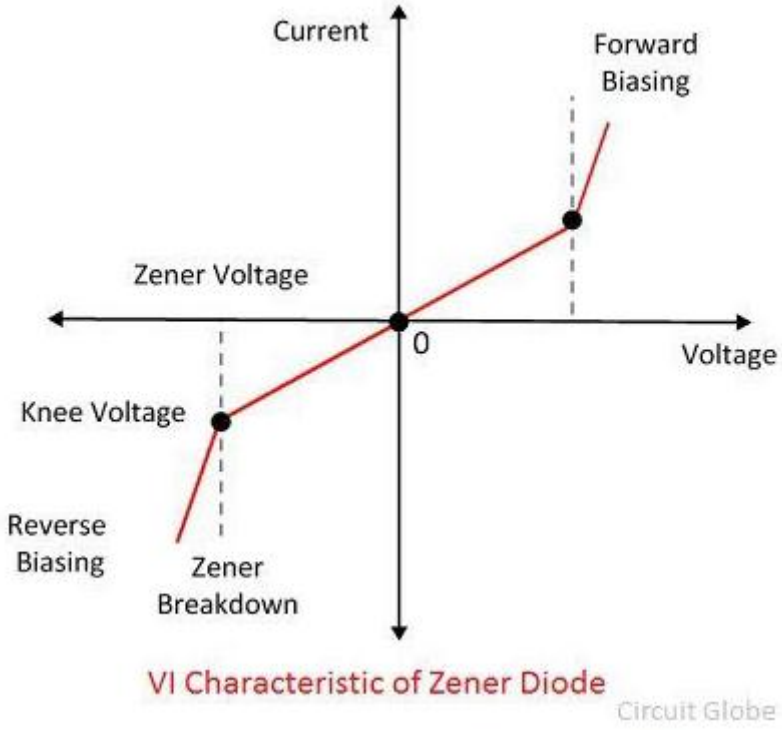
4. V(I) characteristic

$$V_Z \cong V_{Zmax} \cong V_{Zmin}$$

The VI characteristic graph of the Zener diode is shown in the figure below. This curve shows that the Zener diode,

- Zener diodes have a characteristic similar to that of a normal (ordinary)diode in forward bias.

- When the reverse voltage applies across it and the reverse voltage rises beyond the predetermined rating, the Zener breakdown occurs in the diode.



5. Applications of Zener Diode

As Voltage Stabilizer – The Zener diode is used for regulating the voltage in the power supplies.

5.1. Zener regulation with variable input voltage

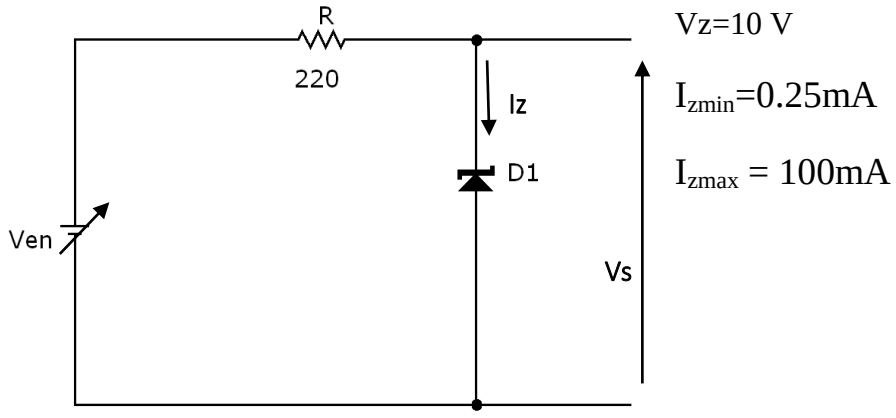


Figure 3

1. Determine the minimum and maximum input voltages for which the Zener diode will be able to maintain regulation.

Ve(max)= ? and Ve(min)= ?

$$V_e = V_Z + V_R \Rightarrow \begin{cases} V_{e(min)} = V_Z + R I_{Z min} \\ = 10 + 220 \times 0{,}25 \cdot 10^{-3} \\ = 10{,}055\ V \\ V_{e(max)} = V_Z + R I_{Z(max)} = \\ = 10 + 220 \cdot 100 \cdot 10^{-3} = \\ = 32\ V \end{cases}$$

5.2. Zener regulation with variable load

La diode Zener maintient une tension constante aux bornes de R charge aussi longtemps que le courant Zener est supérieur à I_{zmin} et inférieur à I_{zmax}. Ce procédé est appelé régulation de charge.

The Zener diode maintains a constant voltage across R load as long as the Zener current is greater than Izmin and less than Izmax. This process is called load regulation.

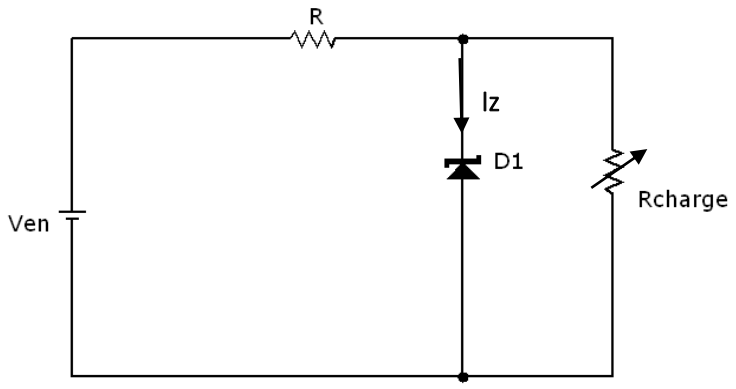


Figure4

Example: Consider the circuit in the figure bellow:

Given : V_z = 12V, I_{zmin} = 1mA et I_{zmax} = 50 mA ?

1. Déterminez les courants de charge minimale et maximale pour lesquels la diode Zener pourra maintenir la régulation.
2. Quelle valeur minimale peut-on utiliser pour R charge :

1. Determine the minimum and maximum load currents for which the Zener diode will be able to maintain regulation.

2. What is the minimum value that can be used for Rload?

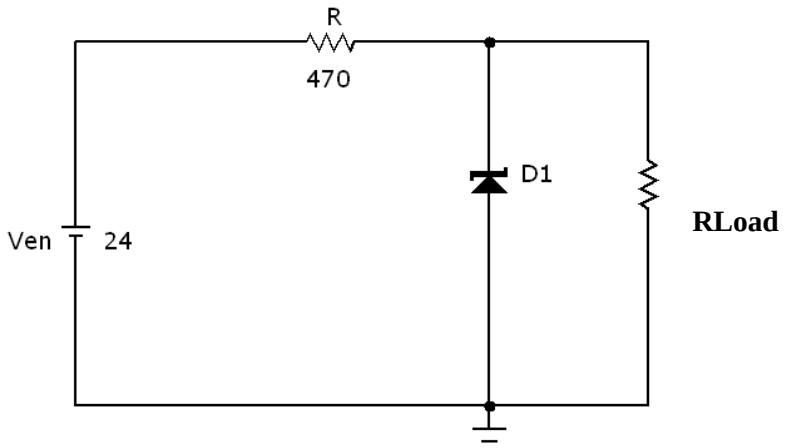
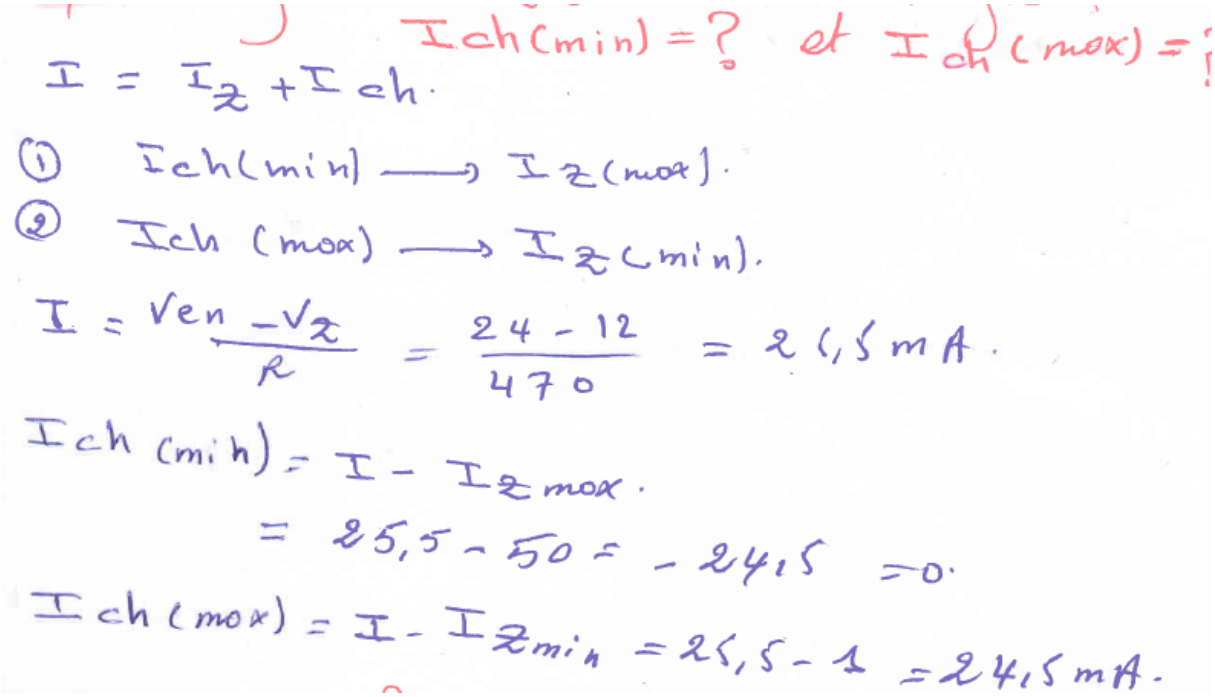
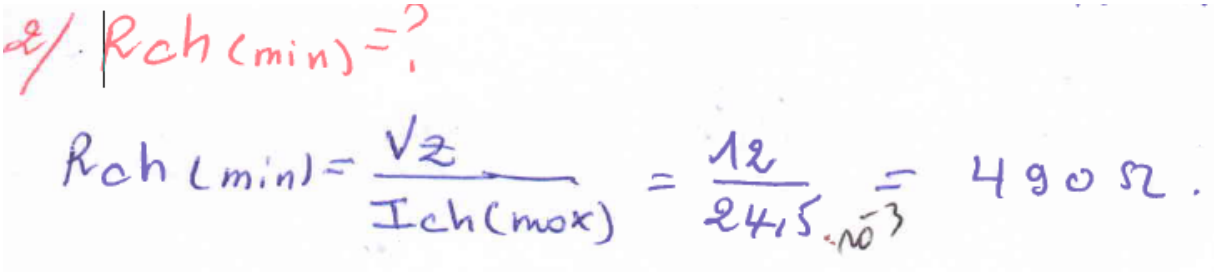


Figure 5





5.3. Zener limiter

In addition to voltage regulation applications, Zener diodes can be used in AC applications to limit voltage ripples to desired levels.

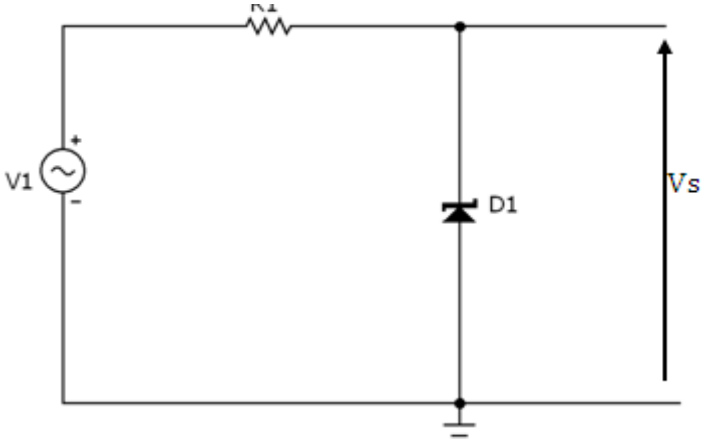


Figure 6

➢ - Plot the shape of the output signal VS(t) and V1(t)on the same graph.

1) Analysis of operation

A(+) :

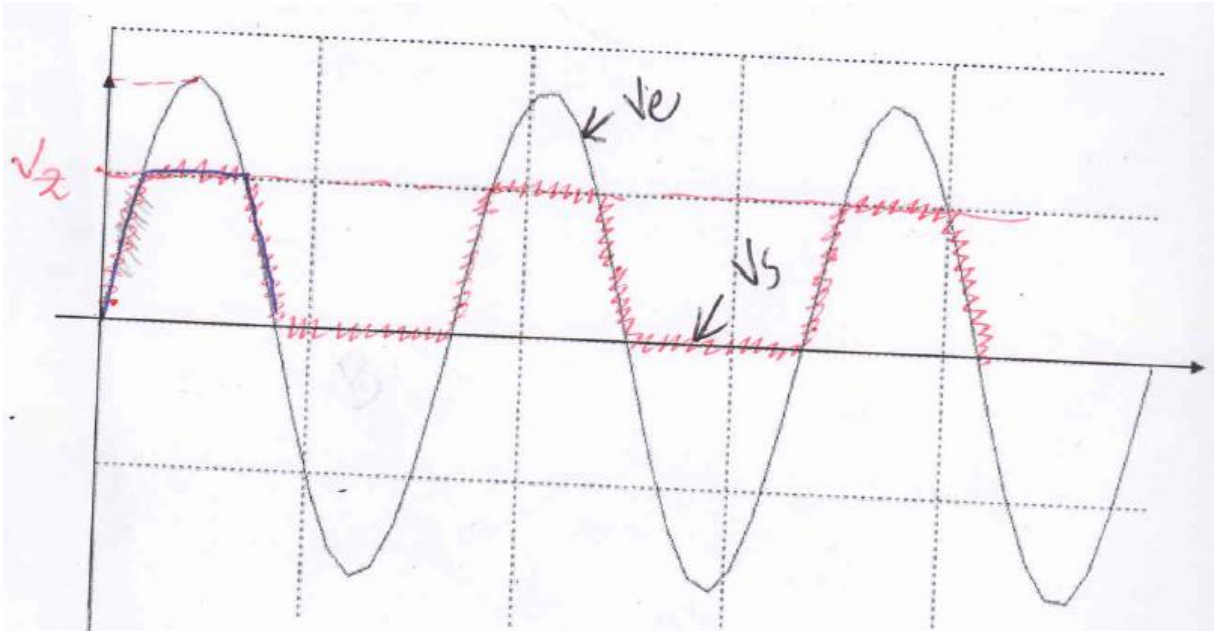
- Ve>Vz : The Zener diode works as a voltage limiter ➔ **Vs=Vz**

- Ve<Vz : Zener diode works as a rectifier diode in the state "off "➔ **Vs=Ve**

A(-)

During the negative wave, the Zener diode acts like an ideal diode in forward bias ➔ **Vs=0**

 The shape of the output voltage.


Ve
Vs