Department of Computer Engineering
Digital Hardware Systems
CpEA 2202 – Electronic Circuits

Laboratory Report

Laboratory Exercise No.:	3	**Date Performed:**	February 08, 2025
Laboratory Exercise Title:	Zener Regulator Circuit		
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Part I

A Zener diode is a specially doped semiconductor device designed to function in the reverse direction. Engineered with a wide range of Zener voltages and certain types are even adjustable to achieve variable voltage regulation. It functions similarly to a regular diode when forward-biased. However, in reverse-biased mode, a small leakage current flows through the diode. As the reverse voltage rises and approaches the predetermined breakdown voltage (Vz), current begins to flow through the diode. This current reaches a maximum value set by the series resistor before stabilizing and remaining constant throughout a wide range of applied voltages.

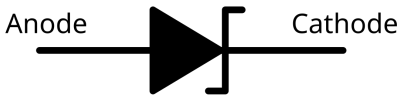

Figure 1 - Zener Diode Symbol

There are two types of breakdowns in a Zener Diode: Avalanche Breakdown and Zener Breakdown. Avalanche Breakdown occurs in both normal diodes and Zener diodes when subjected to high reverse voltage. When a sufficient reverse voltage is given to the PN junction, the liberated electrons obtain enough energy to speed up rapidly. These high-velocity electrons clash with other atoms, ejecting more electrons. In Zener Breakdown, when the reverse bias voltage applied to a zener diode approaches its zener voltage, the electric field within the depletion region becomes strong enough to attract and remove electrons from their valence band. In this exercise, we will use the Zener region potential to be able to be used as a voltage regulator.

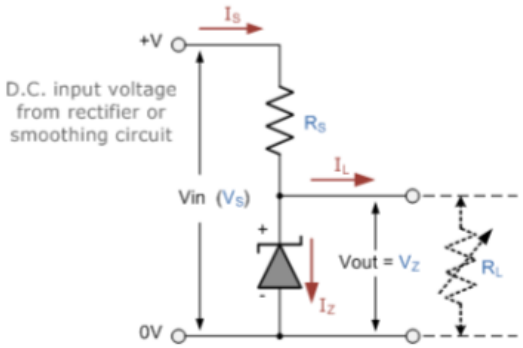

Figure 2 - Simple Zener Regulator Circuit Diagram

Part II

Table 1 - Zener Diode Specifications (1N4733)

Rating/Characteristics	Value
Forward Voltage (V_F)	1.2V
Nominal Zener Voltage (V_Z)	5.1V
Maximum Reverse Leakage Current (I_R)	10 uA
Current Surge	890 mA
Maximum Average Power Dissipation (P_Z)	1W

Part III

Table 2 - Zener Regulator Circuit Output Voltage

Vs	V_{out} = Vz	Vs	V_{out} = Vz	Vs	V_{out} = Vz
1V	0.958	6V	5.054	11V	5.172
2V	1.811	7V	5.079	12V	5.182
3V	2.851	8V	5.100	13V	5.201
4V	3.663	9V	5.123	14V	5.228
5V	4.643	10V	5.147	15V	5.241

Table 3 - Zener Regulator Circuit Values

Parameters	Value
Maximum Current	55 mA
Series Resistance (R_S)	127.2727 **Ω**
Load Current (I_L)	5 mA
Zener Current (I_Z)	50 mA
Measured Output Voltage (V_{out})	5 V

Calculations:

$$I_Z = \frac{Pz}{4Vz} = \frac{1\,W}{4(5V)} = 50\,mA$$

$$I_L = \frac{Vout}{R_L} = \frac{5}{1000} = 5\,mA$$

$$R_S = \frac{Vin - Vout}{Imax} = \frac{12 - 5}{55\,mA} = 127.2727\,\Omega$$

$$I_{max} = I_Z + I_L = 50 + 5 = 55\,mA$$

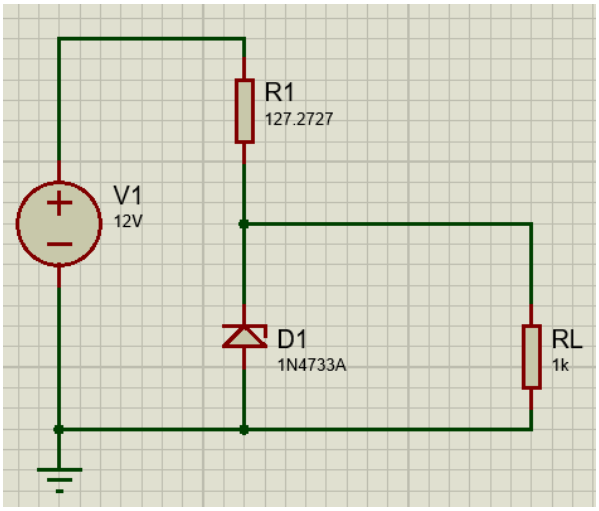

Figure 3 - Zener Regulator Circuit Schematic Diagram

Part IV

Observe the data in Table 2, at what input voltage levels did the circuit regulate? Why?

- The circuit is regulated at input voltages of 6V or higher, as shown in Table 2, with the output voltage stabilizing around 5V independent of input voltage. This occurs because the Zener diode maintains a practically constant voltage across it when operating in the breakdown area, as long as the input voltage is sufficient to sustain the Zener current.

Will the circuit in Step 3 can be modified to regulate the voltage output to 9 V from a 12 V input? Why or why not?

- Yes, the circuit can be modified to regulate **9V from a 12V input** by replacing the **5.1V Zener diode** with a **9V Zener diode**. The series resistor would also need to be recalculated to ensure proper current flow and maintain regulation.

Other than a voltage regulator, what are other applications of Zener diodes?

- Aside from voltage regulation, Zener diodes perform a variety of tasks in electronic circuits. They provide reliable voltage references for power supply and measuring equipment, ensuring precision. Overvoltage protection clamps high voltages to protect components. They also help with waveform clipping and shaping, which limits signal amplitudes in communication and audio circuits. Furthermore, Zener diodes are employed in switching applications such as transient suppression and voltage threshold detection to maintain controlled voltage levels in circuits. Their capacity to maintain a constant voltage makes them useful in a variety of applications.

References

[1] **Electronics Tutorials**, "Zener Diodes," *Electronics Tutorials*, [Online]. Available: https://www.electronics-tutorials.ws/diode/diode_7.html. [Accessed: 15-Feb-2025].

[2] **Futurlec**, "1N4733 Zener Diode Specifications," *Futurlec*, [Online]. Available: https://www.futurlec.com/Diodes/1N4733.shtml. [Accessed: 15-Feb-2025].

[3] **BYJU'S**, "Zener Diode - Definition, Construction, Working, and Characteristics," *BYJU'S*, [Online]. Available: https://byjus.com/physics/zener-diode/. [Accessed: 15-Feb-2025].

