UNSE
Universidad Nacional
de Santiago del Estero

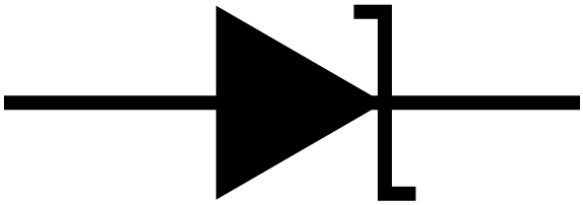
Facultad de Ciencias
Exactas y Tecnologías

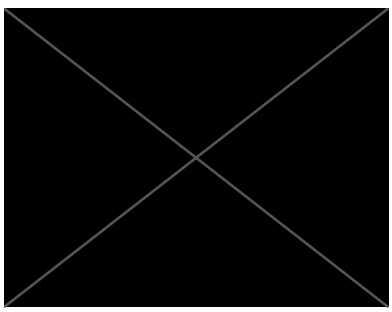
Santiago del Estero, 15 de mayo del 2025

Ingeniería eléctrica

TP N° 3: Zener Diode Wave Clipper

Electronica II





- Chevauchey Clément

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Objectives

- Design a wave clipper circuit with Zener diodes whose output is 4.6 V and 6.3 V.

Introduction

Wave clipper circuits

Wave clipper circuits, also known as clippers, are electronic configurations used to limit the amplitude of an input signal by clipping the parts that exceed certain voltage levels. They are widely used in circuit protection, signal shaping, and audio processing applications.

One variant of these circuits uses Zener diodes to establish more precise clipping limits. Unlike regular diodes, Zener diodes are designed to conduct in reverse when the applied voltage reaches the breakdown (or Zener) voltage, which enables their use as voltage regulators and overvoltage protection elements.

This report analyzes the design and operation of a dual-threshold clipper circuit that uses Zener diodes to limit the output signal between two defined levels: 4.6 V and 6.3 V.

Materials used

- **Transformer**
  - Input voltage: 230 V AC
  - Output voltage: (12 + 12) V AC
  - Output current: 1 A
- **Oscilloscope Rigol DS1052t**
  - 2 channels
  - 50 MHz
- **Breadboard**
- **Zener diodes**
  - 1N4734A: 3.9 V / 1 W
  - 1N4732A: 5.6 V / 1 W
- **Resistors**
  - 150 Ω / 1 W × 2
- **Multimeter**
  - AM-105TRMS

Development

During the lab, only one half of the transformer was used (12 V AC between one of the outputs and neutral). Based on this signal, a wave-clipper circuit was built with two diodes 1N4734A, 1N4732A and two resistors.

The circuit was assembled on a breadboard, connecting the diodes so that one conducts during the positive half-cycle of the signal and the other during the negative half-cycle (anti-series).

In circuit 1, the current was limited with a series resistor to protect the Zeners.

At this stage, voltage measurements were taken to observe the behavior of the wave at the input and output of the clipper (Image 1, Graph 1).

These measurements were used to observe how the AC signal is clipped at the values defined in the objective.

Subsequently, to evaluate the circuit's behavior with different loads, another resistor of the same value was connected in parallel, which reduced the equivalent resistance to half (Image 2).

The voltage at the clipper terminals was measured (Graph 2).

In addition, it was decided to evaluate the behavior of the circuit with a load in parallel with the clipper. Starting from circuit 1, another resistor of the same value was connected in parallel with the diodes (Image 3).

The voltage at the clipper terminals (Graph 3) and the current through the parallel resistor were measured.

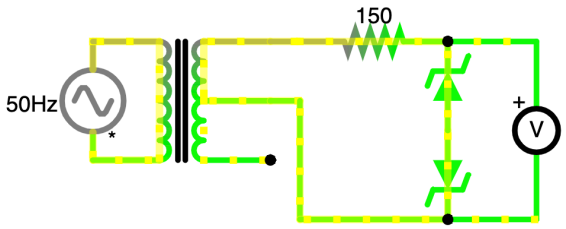


Image1[1]

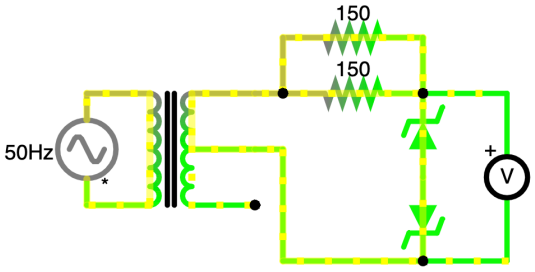


Image2[2]

[1] Paul Falstad. (2025, April 26). *Circuits builder*. Falstad. https://www.falstad.com/
[2] Paul Falstad. (2025, April 26). *Circuits builder*. Falstad. https://www.falstad.com/

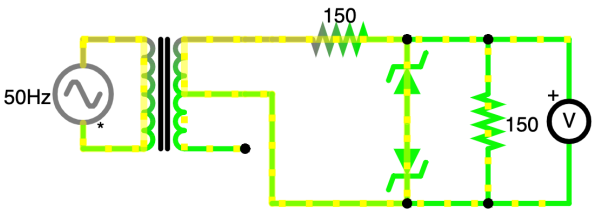
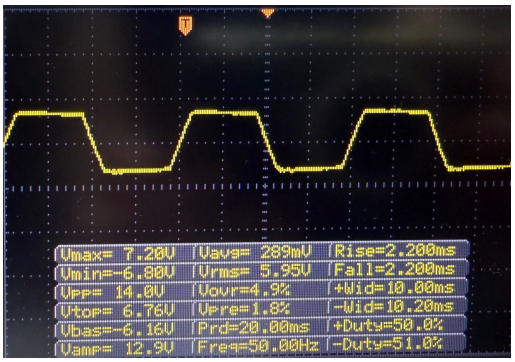
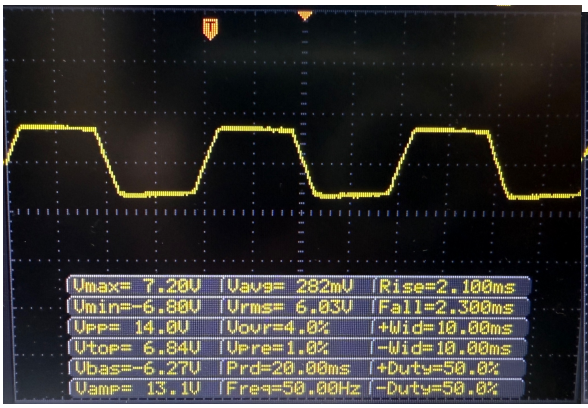


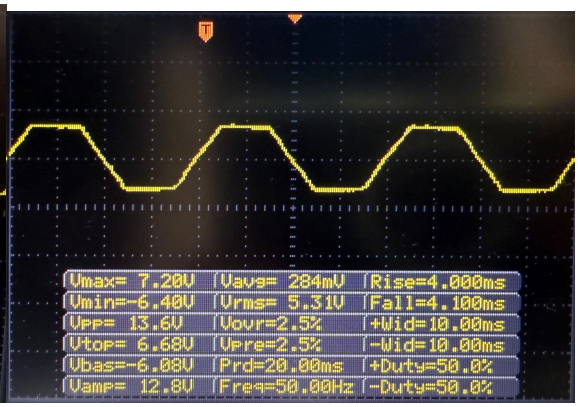
Image 3 [3]



Graphic 1



Graphic 2



Graphic 3

Data and calculations

Zener configuration

In the positive half-cycle:

- The 5.6 V Zener operates in reverse breakdown.
- The 3.9 V Zener acts as a rectifier diode in forward bias (0.7 V drop).
- Output voltage: $V_{Z1} + V_\gamma = 5{,}6\,V + 0{,}7\,V = 6{,}3\,V$

In the negative half-cycle:

- The 3.9 V Zener operates in reverse breakdown.
- The 5.6 V Zener acts as a rectifier diode in forward bias.
- Output voltage: $V_{Z2} + V_\gamma = 3{,}9\,V + 0{,}7\,V = 4{,}6\,V$

[3] Paul Falstad. (2025, April 26). *Circuits builder*. Falstad. https://www.falstad.com/

Series-limiting resistor:

- ➔ Transformer peak voltage: $V_{pico} = 12\,V\,.\sqrt{2}\ = 17\,V$
- ➔ Maximum current: $I_{max} = \frac{V_{pico} - V_R}{R} = \frac{17\,V - 6{,}3\,V}{150\,\Omega} = 71\,mA$
- ➔ Power in the resistor: $P = I^2\,.R = (0{,}071\,A)^2\,.150\,\Omega = 0{,}76\,W$
  - ✓ A 1 W resistor will be used

Potencia en los Zener

- ➔ Maximum current: $I_{max} = 71\,mA$
- ➔ Power in the Zeners:
  - ◆ $P_{Z1} = I\ \ .V_{Z1}\ =\ 0{,}071\,A\,.\,5{,}6 = \boldsymbol{0{,}397}\,W$
  - ◆ $P_{Z2} = I\ \ .V_{Z2}\ =\ 0{,}071\,A\,.\,3{,}9 = \boldsymbol{0{,}277}\,W$
    - ✓ 1 W Zeners will be used

Minimum current in the Zeners

The manufacturer indicates a minimum current required in the Zeners of 4 mA to 10 mA.

Current calculation in circuit 3

- ➔ $I_{R1} = I_{R2} + I_Z$
- ➔ I $V_{rms} = 5{,}31\,V\ (medido)\ \rightarrow\ I_{R2} = \frac{V_{rms}}{R} = \frac{5{,}31\,V}{150\,\Omega} = 35{,}4\,mA$ (33,4A were measured)

- ➔ $I_Z = 71\,mA - 33{,}4\,mA = 37{,}6\,mA$

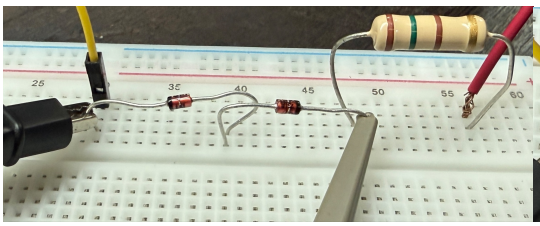
<u>Conclusion</u>

The Zener-diode clipper circuit did not exactly meet the objective of limiting the signal between −4.6 V and 6.3 V as theoretically expected, but it managed to clip it at approximately −6.0 V and 7.20 V.

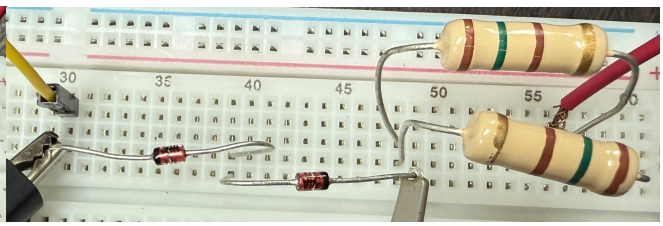
The operation of the circuit was verified through laboratory measurements. Tests with different load configurations showed that the clipping behavior is maintained, although small variations in voltage are evident depending on the equivalent resistance. Current and power calculations confirmed that the components used (1 W Zeners and 1 W resistors) are suitable for the transformer voltage.

Taken together, the work allowed us to understand in practice how Zener clippers operate and how they behave under different load conditions.

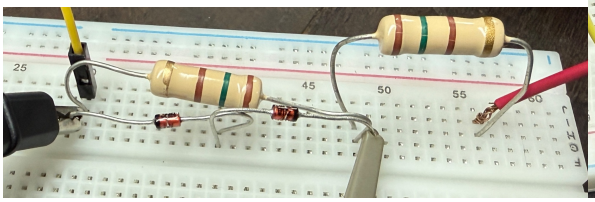
Annex



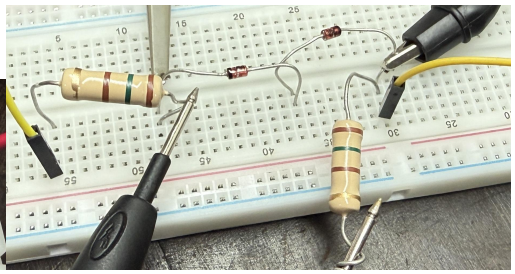
Circuit 1



Circuit 2



Circuit 3



Circuit 4

References

Paul Falstad. (2025, May 10). *Circuits builder*. Falstad. https://www.falstad.com/

Floyd, T. L. (2012). *Principios de Circuits eléctricos* (9.ª ed.). Pearson Educación.