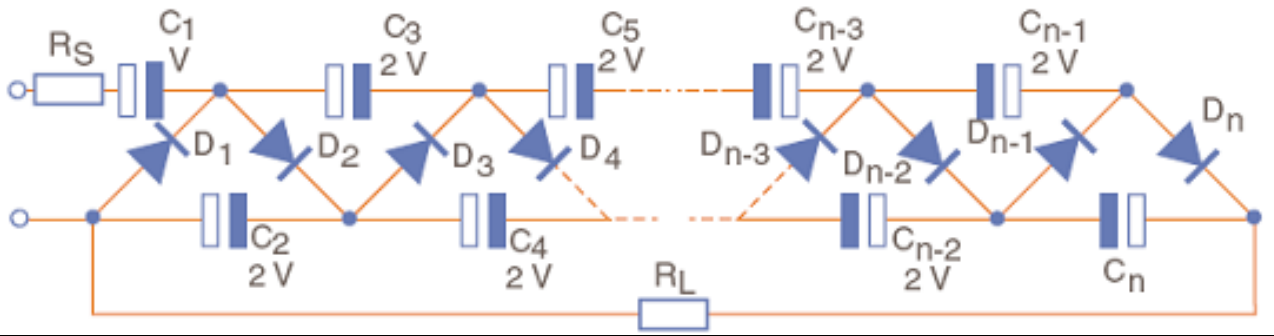
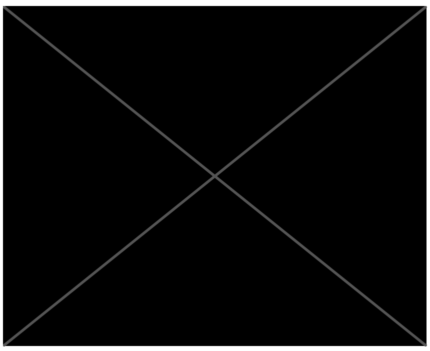
Santiago del Estero, 9 de mayo del 2025

Ingeniería eléctrica

TP N° 2: Voltage Doubler and Quintuple Multiplier with Diodes

Electronica II





- Chevauchey Clément

ÍNDICE

Objectives

- Build a voltage doubler and a voltage quintuple multiplier using rectifier diodes, and analyze their behavior with a load resistor.

Introduction

Voltage multiplier circuits

Voltage multipliers, such as doublers and quintuplers, allow obtaining output voltages higher than the input voltage without using step-up transformers. They are useful when a high DC voltage is needed from a limited AC source, as in low-power electronics, camera flashes, etc. Their operation is based on AC rectification and energy storage in capacitors, with current steering provided by diodes. In this work a doubler and a quintuple multiplier were built and analyzed experimentally using rectifier diodes.

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
- Rectifier diodes
    - 1N4007
- Capacitors
    - 1 µF / 50 V
- Resistors
    - 100 kΩ / 0.25 W
    - 1 kΩ / 1.2 W

Development

Voltage doubler

During the lab, only one half of the transformer was used (12 VAC between one end of the secondary and neutral), and a voltage doubler was assembled with two 1N4007 diodes and two 1 µF / 50 V capacitors.

The circuit was built on a breadboard, connecting the diodes so that one conducted on the positive half-cycle and the other on the negative half-cycle, and voltages were measured at the input nodes, the intermediate node (between the diodes), and the circuit output.

At this stage, measurements were taken to observe the charging behavior of the capacitors:

- Between the positive of the variac and the input of the first diode (Image 1, Graph 0).
- Between the neutral of the variac and the input of the second diode (Image 1, Graph 1).

These measurements were used to observe how the AC signal is rectified and charges the first capacitor.

Subsequently, to evaluate the circuit's behavior under load, a resistor R1 of 100 Ω / 0.25 W (characteristics calculated beforehand) was connected. The voltage across this resistor was measured, verifying the waveform, the current, and the stabilization of the output (Image 2, Graph 2).

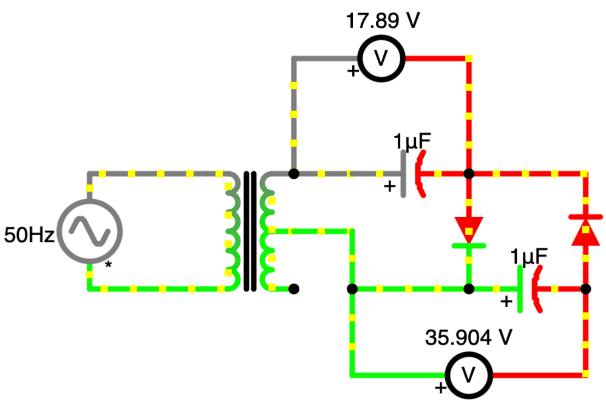


Image 1[1]

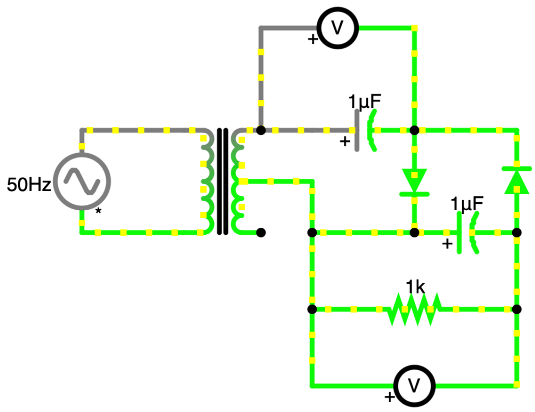
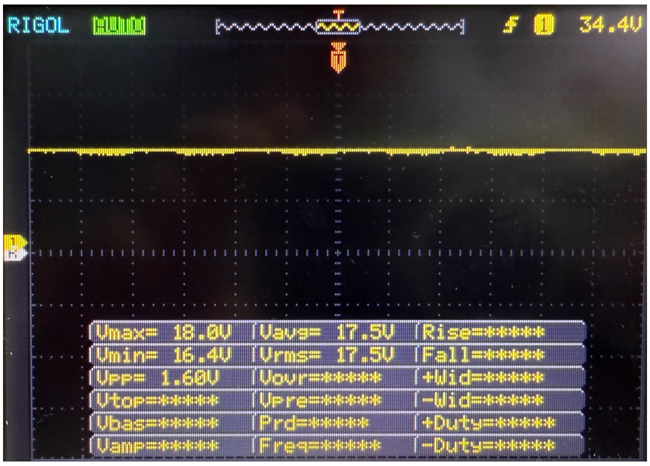
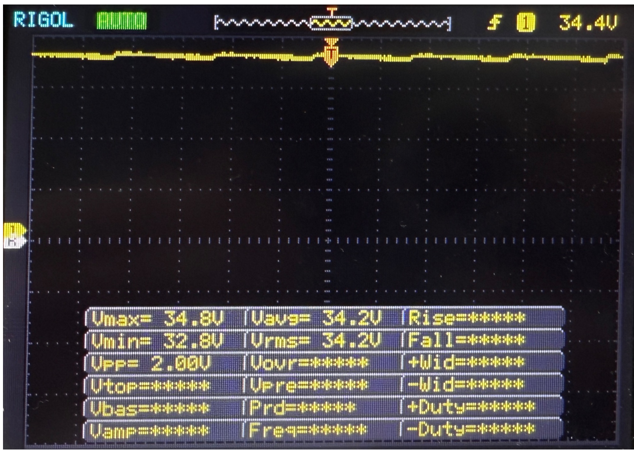


Image 2[2]

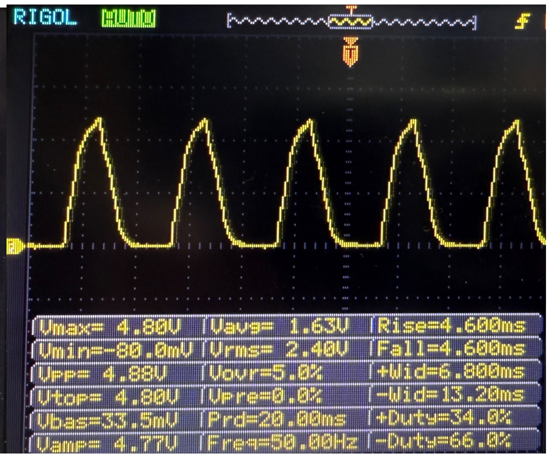
[1] Paul Falstad. (2025, April 26). *Circuits builder*. Falstad. https://www.falstad.com/
[2] Paul Falstad. (2025, April 26). *Circuits builder*. Falstad. https://www.falstad.com/



Graphic 0



Graphic 1



Graphic 2

Voltage quintuplicator

To assemble the quintuplicator, the doubler circuit was used as a starting point and successive stages were added with diodes and capacitors having the same characteristics as before.

Each new diode was connected in the same current orientation as the previous one, and each capacitor in series with the previous capacitor, forming a cascaded structure.

In total, five diodes and five capacitors were used, switching alternately with the AC signal to add the voltage of each stage (Image 3).

Once the complete circuit was assembled, the voltage was measured at different nodes of the circuit and at the output terminals (between positive and neutral) to analyze how the voltages add (Graph 3).

Finally, to observe the behavior under load, a resistor R2 (see calculation below) was connected to the output of the quintuplicator, measuring the voltage drop of the multiplier (Image 4, Graph 4).

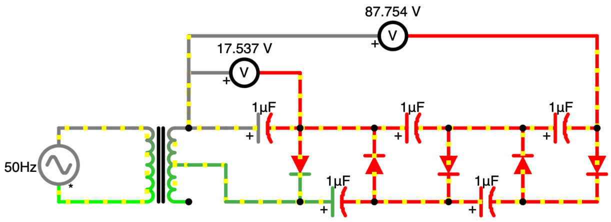


Image 3 [3]

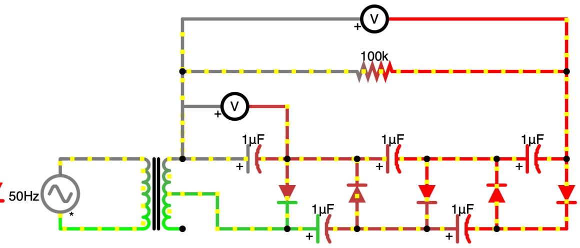
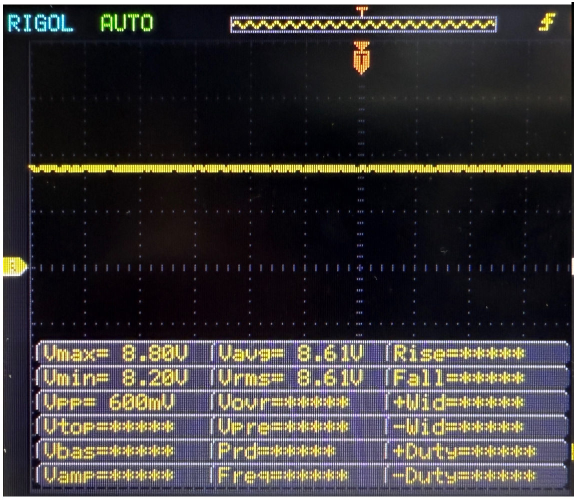
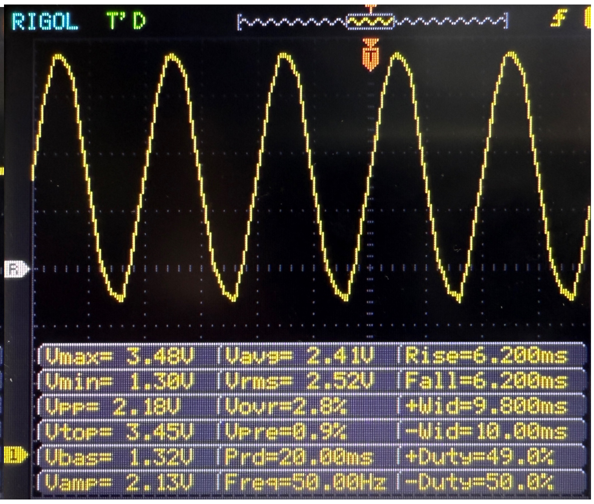


Image 4[4]



Graphic 3



Graphic 4

<u>Data and calculations</u>

Calculation of R1: the goal is to use a 1 kΩ / 1.2 W resistor.

$E_{R1} = 34{,}3V \quad \rightarrow P_{max} = \frac{(34{,}3V)^2}{1000} = 1{,}17\ W \rightarrow$ ✔ It can be used in our circuit.

Calculation of R2: the goal is to use a 1 kΩ / 1.2 W resistor.

$E_{R2} = 88V \quad \rightarrow P_{max} = \frac{(88V)^2}{1000} = 7{,}744\ W \rightarrow$ ✗ It cannot be used in our circuit.

It is decided to calculate with a 100 kΩ / 0.25 W resistor.

$E_{R2} = 88V \quad \rightarrow P_{max} = \frac{(88V)^2}{100000} = 0{,}077\ W \rightarrow$ ✔ It can be used in our circuit.

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

Conclusion

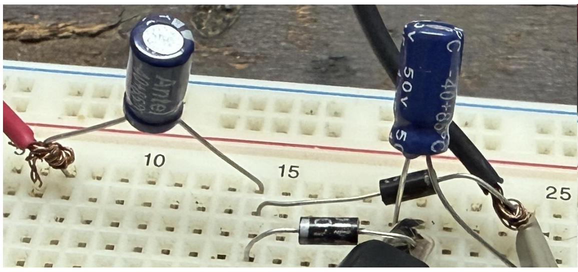
Through this lab, it was possible to build, measure, and analyze a voltage doubler and a voltage quintuplicator using rectifier diodes and capacitors on a breadboard. It was verified that, through the sequential charging of the capacitors, it is possible to obtain a DC output voltage higher than the input voltage.

In the case of the doubler, a no-load output voltage close to twice the input peak value was obtained, while under load a drop was observed due to capacitor discharge and the current limitation of the diodes.

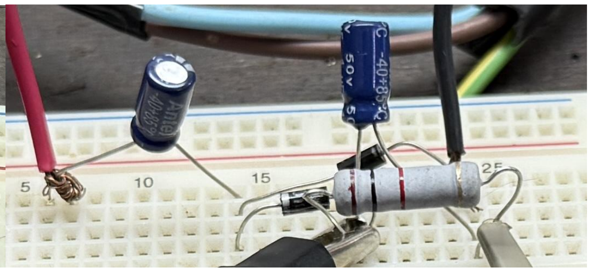
This drop was more noticeable in the case of the quintuplicator, where the number of stages increases the output impedance and losses, so the real output value is considerably lower than the theoretical one.

These results allow the conclusion that, although voltage multipliers are useful for low-current, high-voltage applications, their performance is strongly affected by the presence of load.

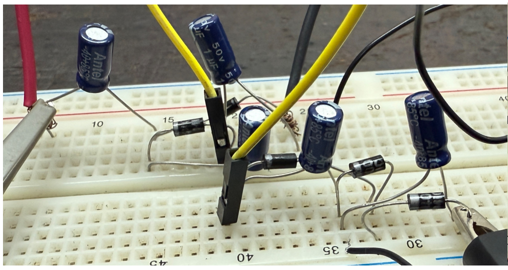
Annex



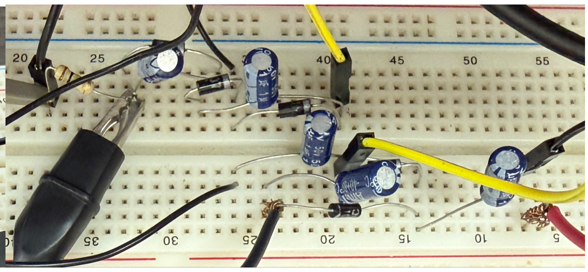
Circuit1



Circuit2



Circuit3



Circuit4

References

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