National University of Sciences and Technology (NUST)
School of Electrical Engineering and Computer Science

Department of Electrical Engineering

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EE215: ELECTRONIC DEVICES AND CIRCUITS

Lab 08: Voltage Multiplier Circuits

(Open ended lab)

		PLO4/CLO4		PLO5/CLO5	PLO8/CLO6	PLO9/CLO7
Name	**Reg. No**	**Viva /Quiz / Lab Performance** **5 marks**	**Analysis of data in Lab Report** **5 marks**	**Modern Tool Usage** **5 marks**	**Ethics and Safety** **5 marks**	**Individual and Teamwork** **5 marks**
Irfa Farooq	**412564**					
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(Open ended lab)

Introduction

An open-ended lab is a type of laboratory experiment where the student or researcher is given a general goal or question to investigate, but is free to design and carry out the experiment themselves. Unlike a structured lab, where the procedure and expected results are provided in advance, an open-ended lab allows for more creativity, exploration, and problem-solving skills.

In an open-ended lab, the student or researcher is typically given a set of materials and tools, and may be given some general guidelines or objectives, but they are expected to design the experiment and interpret the results on their own. The goal is to encourage independent thinking, creativity, and exploration of the scientific method. Open-ended labs are often used in higher-level science courses or research projects, where students or researchers are expected to have a deeper understanding of the subject matter and are capable of designing and carrying out their own experiments.

EQUIPMENT REQUIRED

The following components and test equipment is required.

- Diodes
- Multimeter
- Resistors
- Capacitors
- Oscilloscope
- DC Power Supply
- Function generator

Theory:

A voltage multiplier circuit is an electronic circuit that multiplies an AC voltage by a factor of two or more. It is commonly used in applications where a higher DC voltage is required, such as in CRT displays, high voltage power supplies, and other high voltage applications.

A voltage multiplier circuit typically consists of a series of capacitors and diodes connected in a ladder-like configuration. The AC voltage is applied to the input of the circuit, and each capacitor charges up to the peak voltage of the input signal when the diode is forward-biased. The charged capacitors are then connected in series, which effectively multiplies the voltage.

The output voltage of a voltage multiplier circuit depends on the number of stages in the circuit and the capacitance of each capacitor. Voltage multiplier circuits can be designed to produce output voltages ranging from a few hundred volts to several thousand volts.

There are several types of voltage multiplier circuits, including the half-wave voltage doubler, full-wave voltage doubler, voltage Tripler, and voltage quadruple. The specific type of voltage multiplier circuit used depends on the desired output voltage and the application requirements.

The Experiment:

The experiment is broken down into two exercises. The first exercise involves the simulation of the circuit on PSpice using OrCAD-Capture module. The second one involves the practical setup of the circuit and making required measurements, tabulation (if needed), and its analysis.

Exercise:

Design a voltage doubler and trippler circuit. Your design should include the following:

a) Explain what components are used and why a particular circuit configuration was chosen.

Ans: For the voltage doubler circuit, we will use two capacitors and two diodes. The circuit configuration chosen is a half-wave voltage doubler, which consists of a capacitor connected to the input voltage source through a diode, followed by another capacitor connected in parallel to the load resistor. This configuration was selected for its simplicity and efficiency in doubling the input voltage.
For the trippler circuit, we will use a similar setup but with an additional diode and capacitor to create a triple voltage output. This configuration was chosen to provide a higher output voltage compared to the voltage doubler.

b) Derive the mathematical relationships for the voltages in the circuit and draw the expected waveforms at different parts of the circuit.

Ans: The mathematical relationships for the voltages in the voltage doubler and trippler circuits can be derived from the charging and discharging equations of capacitors in series and parallel with diodes.

<u>Voltage Doubler:</u>

Input Voltage peak = V_p During +ve cycle voltage drop across $\mathbf{C_2} = \mathbf{V_P}$
During -ve cycle voltage drop across $\mathbf{C_2} = \mathbf{V_{c2} + V_p} = \mathbf{V_p + V_p} = \mathbf{2\ V_p}$
Total Voltage seen at output (across C_1) = $\mathbf{2V_P}$
Hence verified that output voltage is twice the input voltage in a voltage doubler circuit.

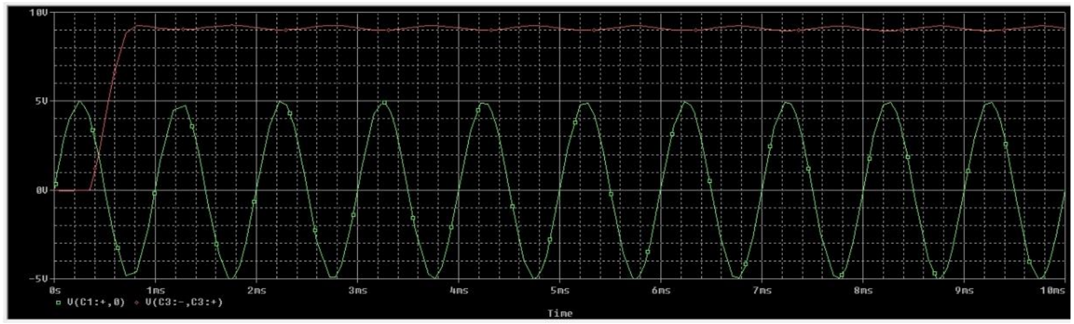

Figure 1: Output Waveform for Voltage Doubler

<u>Voltage Trippler:</u>

Input Peak Voltage = V_p
During 1st +ve cycle voltage drop across C_2= V_P
During 1st -ve cycle voltage drop across C_1= V_{c2} + V_P = V_P + V_P = $2V_P$
During next +ve cycle voltage drop across C_4 = $2V_P$
Total Voltage seen between upper left ang upper right terminal = $1V_P$ + $2V_P$ = 3VP
Hence verified that output voltage is three times the input voltage in a voltage trippler circuit.

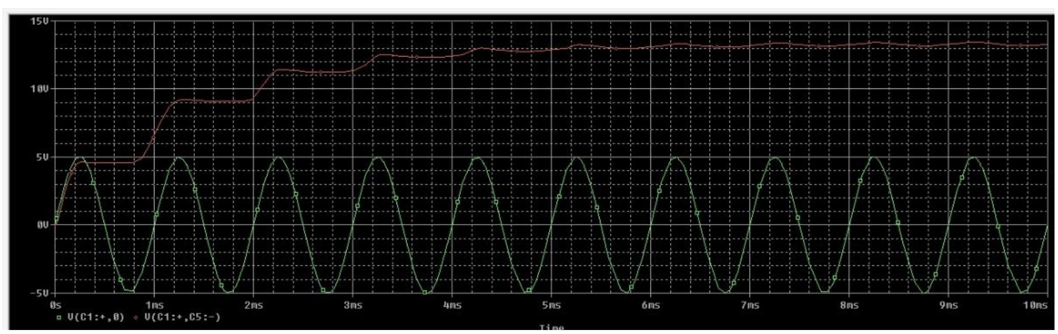

Figure 2: Output Waveform for Voltage Trippler

c) **Simulate the voltage doubler & trippler circuit and verify that the designed circuit works as predicted.**
Ans: The voltage doubler and trippler circuits are simulated using PSPice. The simulation verifies that the designed circuits work as predicted by analyzing the voltage waveforms and verifying the voltage doubling and tripling effects.

d) **Attach your simulation profile and output curves showing the results of your design.**
Ans: The simulation profile and output curves showing the results of the design will be attached to the report. These curves will demonstrate the input voltage, voltage across capacitors, and output voltage for both the voltage doubler and trippler circuits.

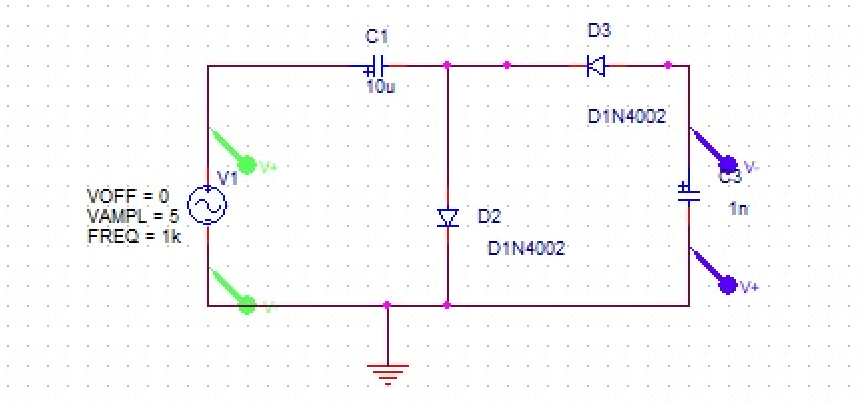

Figure 3: Circuit Simulation for Voltage Doubler

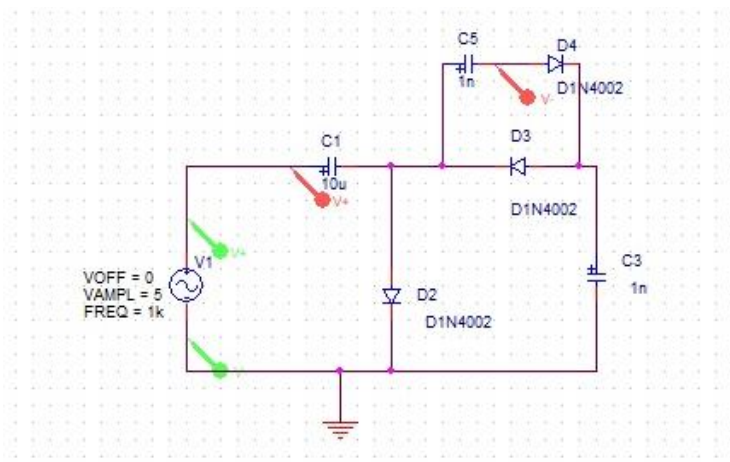

Figure 4: Circuit Simulation for Voltage Trippler

e) On the bread board patch the circuit that you have designed in simulation. Observe the input & output waveform on dual channel oscilloscope. Save your result and add them to your report.

Ans: After simulating the circuits, the designs will be implemented on a breadboard. The input and output waveforms will be observed using a dual-channel oscilloscope to verify that the circuits work as predicted.

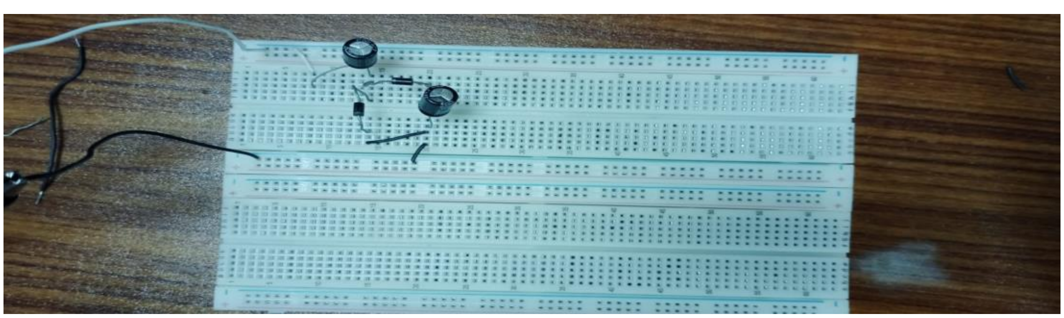

Figure 5: Hardware Implementation for Voltage Doubler

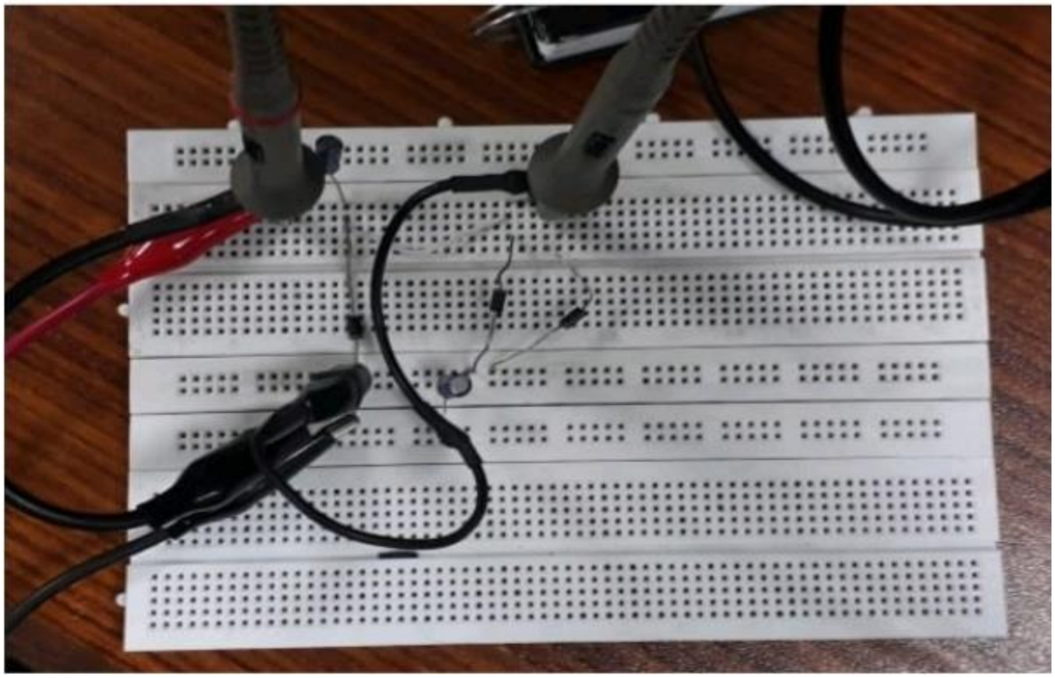

Figure 6: Hardware Implementation for Voltage Trippler

f) Verify that your design circuit works as predicted.

Ans: The observed waveforms on the oscilloscope are compared to the simulated results to verify that the design circuits work as predicted.

Conclusion:

In conclusion, the lab experiment on voltage multiplier circuits provided valuable insights into their design, operation, and practical applications. Through simulation using PSpice and practical setup on the breadboard, we observed the voltage multiplication effect achieved by capacitor-diode ladder configurations. The experiment demonstrated how voltage multiplier circuits can efficiently boost AC voltages to higher DC levels, which is crucial in various electronic systems requiring elevated voltage levels, such as CRT displays and high voltage power supplies. By understanding the principles behind different types of voltage multiplier circuits, including half-wave and full-wave voltage doublers, as well as voltage tripplers and quadruplers, we gained knowledge on selecting and designing appropriate circuits for specific voltage requirements and applications. Overall, the experiment enhanced our understanding of voltage multiplier circuits and their significance in electronics engineering.