EE 331 Project: DC-to-DC Voltage Multiplier

M. P. Anantram
Department of Electrical Engineering, University of Washington

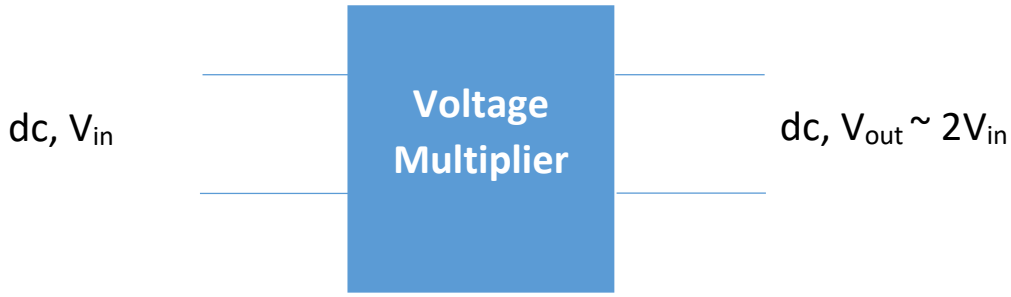
This project should be done by the student groups independently.

To complete the project, you will have to work beyond regular lab hours.

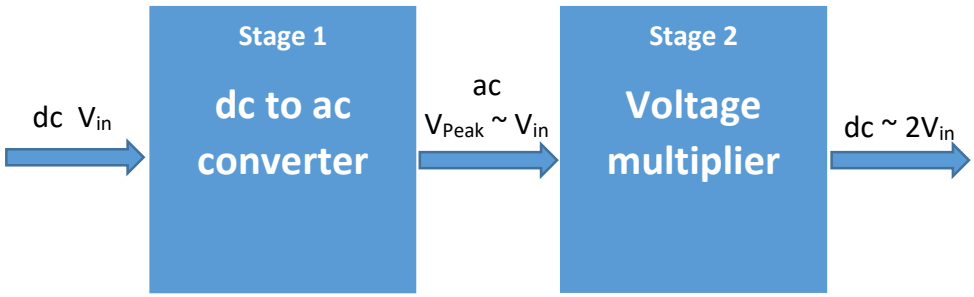
The project can use resistors, capacitors, inductors, diodes and transistors. Other chips and parts are not allowed. You can however purchase a transformer if you are not satisfied with the lab transformer.

Introduction

The DC-to-DC Voltage Multiplier is a device with many applications, hand-held electronics and beyond. A number of electronic devices have a fixed voltage source, the battery. However, subcircuits in the device may need more than one DC voltage source, including voltage values that are larger than the battery voltage.



DC-to-DC Voltage Multiplier circuits are usually based on taking the input DC voltage (V_{in}) and creating an AC voltage with amplitude of V_{in}. The AC voltage does not have to be sinusoidal. This AC voltage then serves as an input to an AC-to-DC voltage multiplier circuit, whose output is a rectified DC voltage with a magnitude of approximately $2V_{in}$.



Project Specifications

In this project, you will first use a transformer and a voltage rectifier to convert the AC voltage from a receptacle in the wall to a DC voltage of 10 V (This is not shown in the above figure). The ripple should be less than 1 % of 10 V. This 10 V source will serve as your DC input V_{in} (in lieu of a battery) to the voltage doubler.

Your project consists of three parts:

A) **Design:**

First design the circuit to take the AC from the wall-outlet and convert it to a DC voltage (V_{in}) of 10 V.

Then design a voltage multiplier circuit with these desired specifications:
- output voltage of 18.5-20 V (open circuit is enough)
- ripple voltage less than 1% of 20 volt

The tighter your design specs on top of the above specifications, the higher the grade you will receive.

In this stage, you need to clearly describe the structure of your circuit and illustrate its schematic. Your design should include a comprehensive description of how your circuit works, the rationale for the components used, and all the calculations or rule-of-thumbs used to pick the value of the components.

Note: A common way to design the DC to AC converter is using a commercial timer chip, like a 555 timer. You are not allowed to adopt this strategy. You should build all components from the fundamental devices learnt in this course.

B) **Simulation:**

Once you're done with your design, you need to simulate your circuit and verify that it will work as desired. Describe all the steps and settings of your simulation and include graphical and numerical results. Explain any difference observed between your theoretical analysis carried out in the design stage and the results of the simulation due to the approximations etc.

C) **Implementation:**

The final and the most important stage of the project would be the implementation part. Implement your designed and simulated circuit and assess its performance in practice.
- Without any load current, observe and record the output of your circuit.
- Now gradually increase the output current up to $2\ mA$ and observe the behavior of your circuit. Note any changes in your report. Provide a detailed analysis for the decrease in the output voltage from the multiplier circuit as the load draws more current. Discuss ways to minimize the decrease in output voltage as the load draws more current.
- Do any other experiment required and reflect on the empirical results.

Is your circuit working as it is supposed to? Explain any difference with the analysis and simulation.

Project Report

Minimum requirements for project report:

1) Purpose and function of circuit
2) Circuit topology and components chosen
3) Simulation and implementation results
4) Analysis of results (including any failures)

There will be bonus points awarded for exceptional projects. Only one project has been able to claim this in the last four years.

We will not be able to answer specific design questions.

PS: This project builds upon your knowledge of (a) transformers, (b) voltage rectifiers, (c) AC-to-DC voltage circuits, (d) transistors, (e) DC-to-AC converters and (f) labs.