# Electronic Devices and Circuits 1 2EI4
# Project 1
# Building a DC Power Supply

Instructor: Dr. Haddara
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As a future member of the engineering profession, the student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University and the Code of Conduct of the Professional Engineers of Ontario. Submitted by **[Ahmad Molhim, molhima, 400440228]**

## *Summary:*

I have been tasked with designing a DC supply that outputs 3V within +/- 0.1V and 10mA from an AC source that is 120V(rms) & has a frequency of a 1000 Hz. At a basic level, my DC power supply will require a Step-Down Transformer, Bridge Rectifier, Capacitive Filter & possibly a Zener Diode behaving as a regulator.


## *Design:*

### *Transformer:*

I chose the Input voltage of my circuit to be 4.4V. The reason I chose this input is because there will be voltage drop across the diodes of the rectifier which leaves me with a voltage greater than 3V, the expected output voltage.

I calculated the turns ratio of my transformer to be 38.6:1 using the following method:

Input Peak Voltage = 120V * sqrt (2) = 169.7V → Turns ratio = 169.7/4.4 = 38.6

### *Rectifier:*

A non-centred tapped transformer and a bridge rectifier were used for my rectifier topology. I decided to use this topology as it utilizes both halves of the AC waveform leading to a higher efficiency compared to other topologies, this means more power is extracted from the AC source, resulting in a smoother DC output. Two diodes out of four are conducting at each cycle, the positive and negative. The voltage drop across the two diodes will be 1.4V.

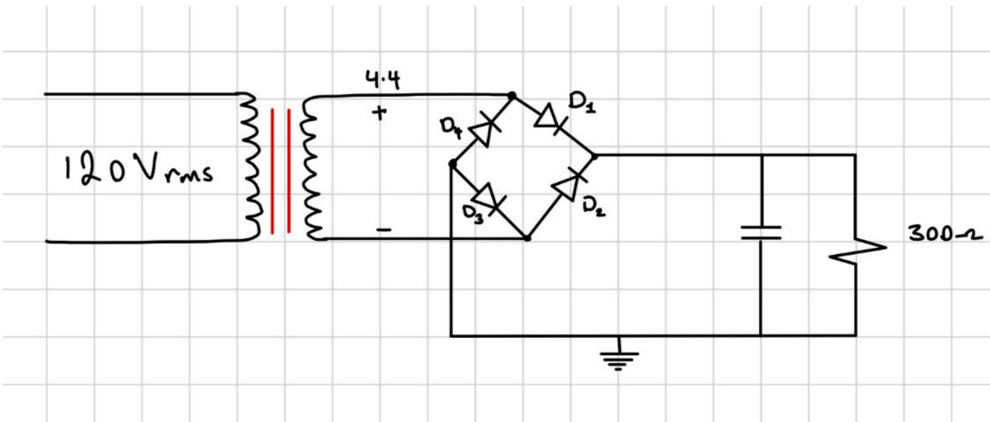
### *Filter:*

A filter is used to eliminate undesired noise that is present on AC input lines. I will use a 100uF capacitor from TDK(CM107) to act as my filter. The larger the capacitance, the lower the ripple voltage will be. My capacitor can take a voltage up to 6.3V.

### *Regulator:*

If a significant, specified voltage ripple continues, a regulator can smooth out peak-to-peak voltage ripple; however, I will not be using a regulator in my design.

## ***Schematic:***




## ***Calculations:***

### ***Diodes:***

Voltage drop across each 1N4148 Diode = 0.7V

### ***Resistor:***

$R_L$ = 3V / 10mA = 300Ω

### ***Capacitor:***

$Vrpp = I_{out} / f * C$

$Vrpp = 0.1$ V

$I_{out} = 10$mA

$f = 1$KHz

$C = 0.01/(2000*0.1) = 5x10\text{-}5$ F = 50μF

### ***Voltage Input :***

I calculated the Voltage Input using the Voltage output and the voltage drop across the diodes, since the voltage drop across the diodes at each cycle is 1.4V my Voltage Input should be 4.4V.

### ***Turns Ratio:***

Input Peak Voltage = 120V * sqrt (2) = 169.7V → Turns ratio = 169.7/4.4 ≈ 38

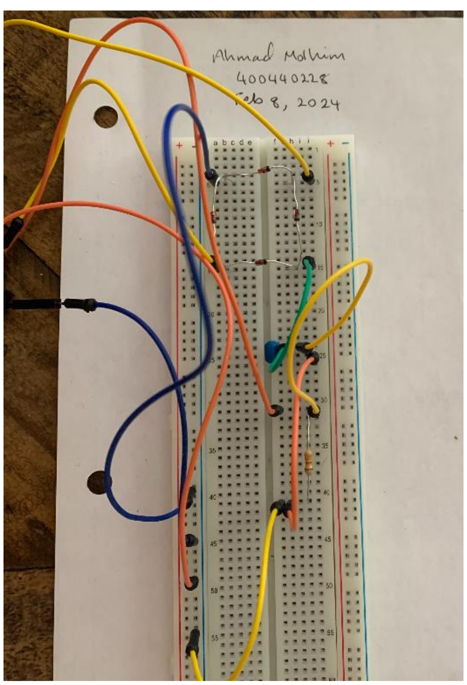
## ***Expected Performance:***

From my theoretical calculations I expect a DC Voltage output of 3V ± 0.1V on the Load Resistor and a direct current of 10mA.

## ***Tradeoffs:***

The capacitor I used is designed to handle a voltage of up to 6.3V, heavily surpassing the extremes of my circuit, which operates at an input level of merely 4.4V. Additionally, the diodes chosen can withstand a rise in current in case of a load resistor short or a capacitor surge. Based on my calculations, I can claim with confidence that the diodes would not be adversely affected if the load resistor were to short, as the increased current stays well within their operational limits. With respect to the capacitor surge, the current flowing through the DC supply is substantially lower than the forward continuous current of the 1N4148 diodes, ensuring that the diodes can handle this current configuration without any issues.

## ***Measurement and analysis:***



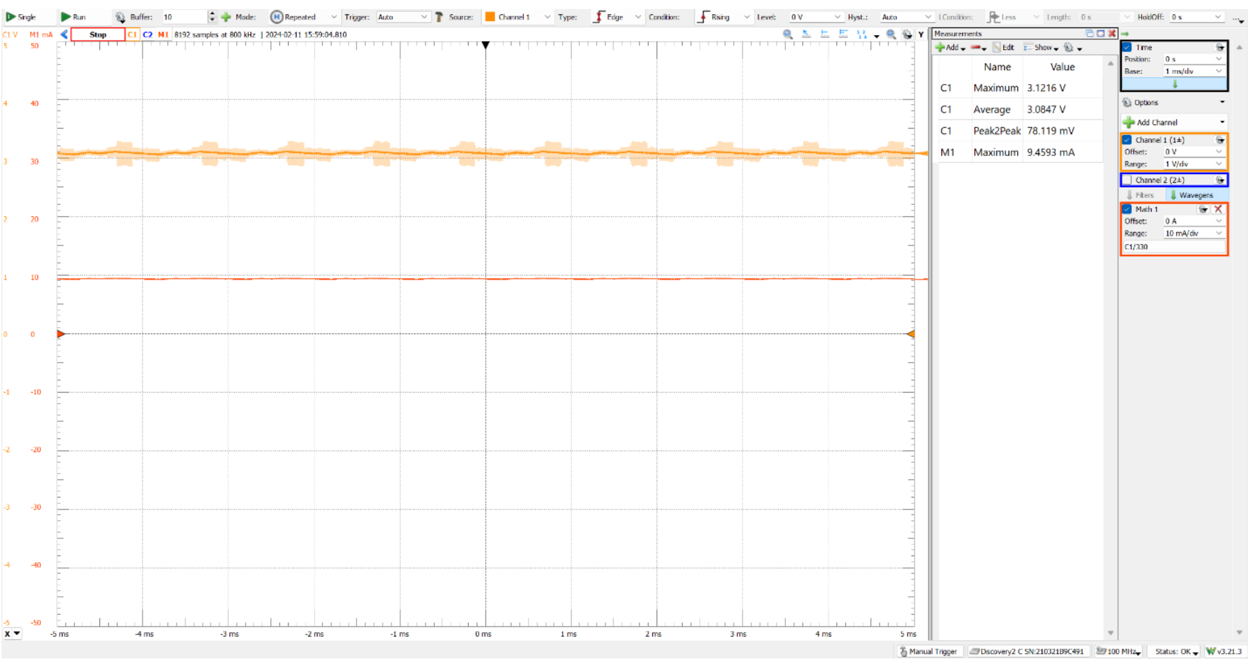
*Picture of Built Circuit*

## ***Measurement procedure:***

I connected the AD2's Wavegen channels to the diodes to supply voltage of 4.4V at a frequency of 1KHz to my circuit then connected the 1+ channel to measure the output voltage and display it on the waveforms scope. I also used the built in maximum and average measurements from waveforms to show the voltage and current output, and the peak2peak measurement to show the ripple voltage.

## ***Key Measurements:***

| | |
|---|---|
| DC Voltage output | 3.08V |
| Current output | 9.45mA |
| Ripple Voltage | 78.1mV |

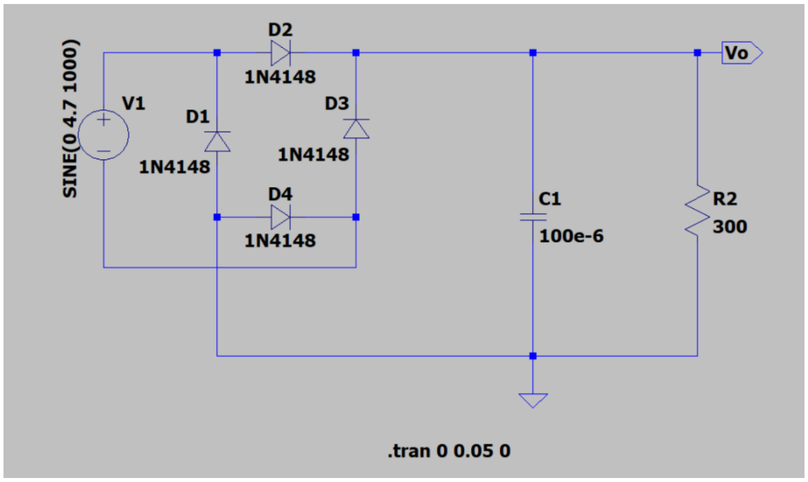



*Picture of Oscilloscope Output.*

*Channel 1 (Orange line) shows the voltage output

*Math 1 (Red line) shows the current output

## Simulation:



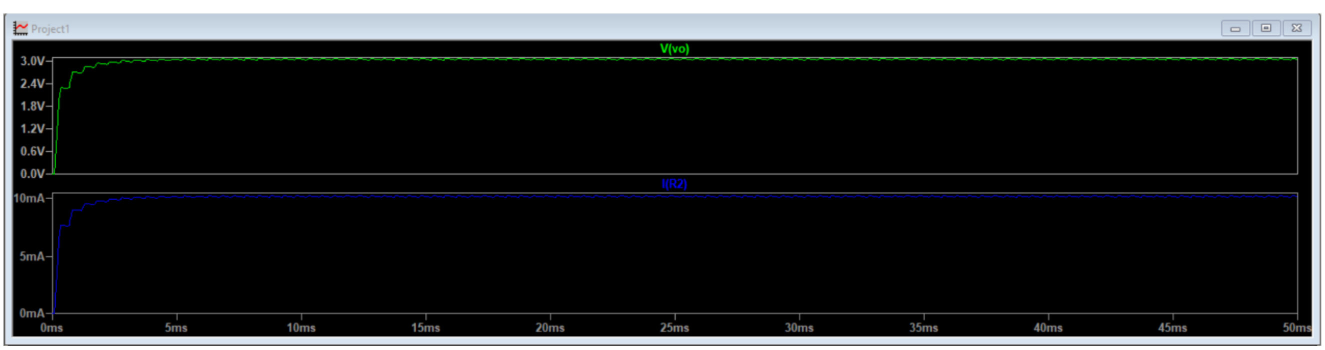

*Picture of Schematic*

## Netlist:

```
* C:\Users\ahmad\OneDrive\EE2EI4\Project1.asc
V1 N001 N002 SINE(0 4.7 1000)
D1 0 N001 1N4148
D2 N001 Vo 1N4148
D3 N002 Vo 1N4148
D4 0 N002 1N4148
C1 Vo 0 100e-6
R2 Vo 0 300
.model D D
.lib C:\Users\ahmad\AppData\Local\LTspice\lib\cmp\standard.dio
.tran 0 0.05 0
.backanno
.end
```

## Simulation Conditions:

- Transient Function: Stop time = 0.05, time to start saving data = 0
- Outputs: V+(Vo) & I(R2)



# Discussion:

## Comparison of Results:

My physical circuit measurements and theoretical calculations correlate with one another. However, I used a higher voltage than my theoretical voltage for my simulation since the simulation utilizes the factory values indicated in the data sheet whereas the theoretical calculations use the ideal voltage drop of 0.7V. This difference in voltage drop at each diode results in a need of a greater supply of voltage.

## Discrepancies:

My physical measurements had a slightly lower output voltage and current and the reason for this was because my physical components were not in their ideal conditions, while in the simulation they were.

## Limitations:

The lack of components for this project imposed a limit on my design; I used a 100µF capacitor as I didn't have a capacitor with the same calculated value, therefore I had to experiment a lot to find the best setup by experimenting with different resistor, input level, and capacitor combinations. My method involved repeated testing rather than computing and deriving theoretical component values. One further limitation was the fluctuation in Waveform Average and Peak-2-Peak values, which made it difficult to find the most accurate and stable values for these characteristics.

## Problems Encountered:

I faced a problem with my initial design as I designed my circuit to have a resistor after my rectifier. However, after many simulations and trials, I failed to achieve an output voltage of 3V on my load resistor. Consequently, I decided to alter my design and remove the resistor after the rectifier and found out that using only the load resistor was sufficient for my design.

# *References*


Rectifiers selection guide: Types, features, applications | GlobalSpec, https://www.globalspec.com/learnmore/semiconductors/discrete/diodes/rectifier_diodes (accessed Feb. 13, 2024).

"Explained," Filter Capacitor, https://www.learningaboutelectronics.com/Articles/Filter-capacitor.php (accessed Feb. 12, 2024).