SEMI-CONDUCTOR DEVICES LAB:

Final Project:

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Section C

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Variable Power Supply

0 Volts to 30V

1-1.5A DC output

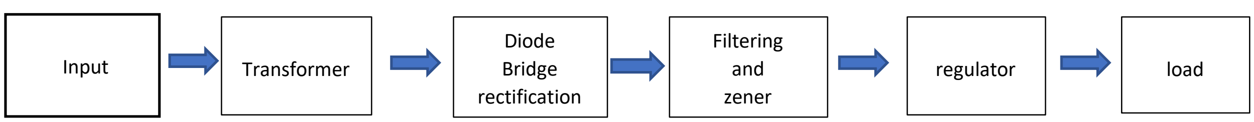
Problem Statement:
Design and simulate a variable power supply which takes an AC input of 230V rms at 50 Hz and gives a DC output that can vary in the range of 0-30V and maximum output load current should be 1-1.5A.

Software Used:

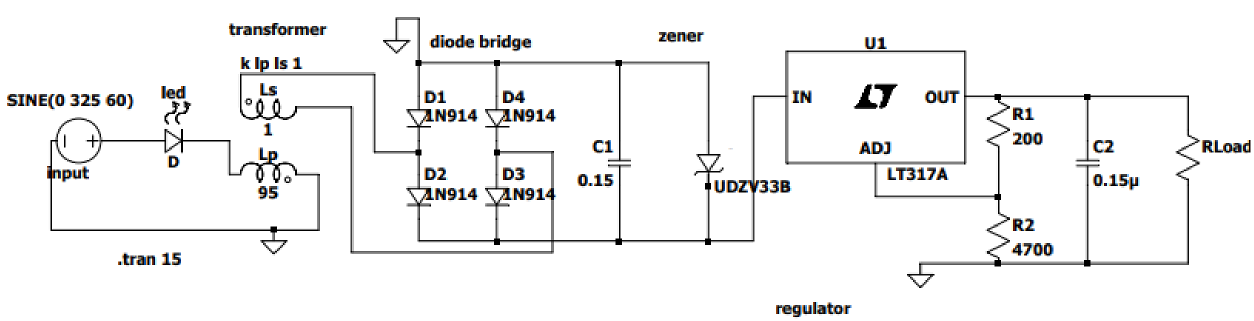
I have used LTSPICE XVII software for simulation.

Circuit Design:

Block Diagram:



Schematic diagram:



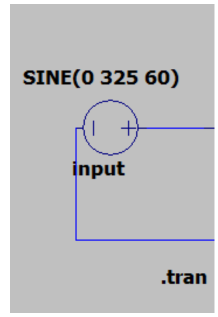
Circuit Explanation:

Input:

We have used 240V rms that calculates to nearly 325V peak value as we know that:

$V_{rms} = V_{peak} / \sqrt{2}$

So, in the circuit we have attached various components to make this AC input convert into DC with the required specifications.



LED:

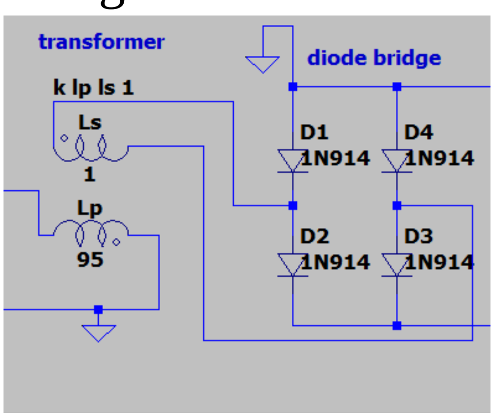
A LED is a semiconductor light source that emits light when current flows through it. Here, just after the input, we have used an LED. This LED enables transformer to be placed. Because in LTSPICE, when input is directly connected to transformer, it gives error and desired output is not achieved.

Transformer:

A transformer is defined as a passive electrical device that transfers electrical energy from one circuit to another through the process of electromagnetic induction.

Here, we have to use a step down transformer, so that we can step down our 325 V_{peak} input to nearly 30V. I have used the ratio of 95:1. Ideally the ratios may be different from this but according to the output variations and output requirements, this ratio gives the perfect result.

Bridge rectifier:



A diode bridge is an arrangement of four diodes in a bridge circuit configuration that provides the same polarity of output for either polarity of input. When used in its most common application, for conversion of an alternating-current input into a direct-current output, it is known as a bridge rectifier.

Here, we have achieved full wave rectification using diode bridge. As a result, we get a pulsating DC after the rectification part and the voltage we are getting after it is 31.6V.

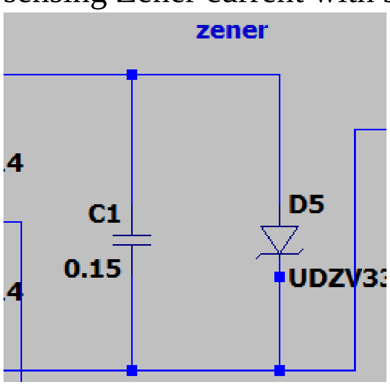
Filtering and smoothing:

We have used 0.05F capacitor for smoothing of the waveform. It gives a clear waveform and ripple is kind of negligible.

We can use whatever capacitance we want making sure that, it doesn't affect our circuit output (and it doesn't affect output at all, it often makes ripple voltage larger or smaller.)

Zener diode:

A Zener diode permits Zener current, Iz, to flow when the voltage is above the specified Zener voltage. Thus, a Zener diode can be used for voltage detection by sensing Zener current with some other device.

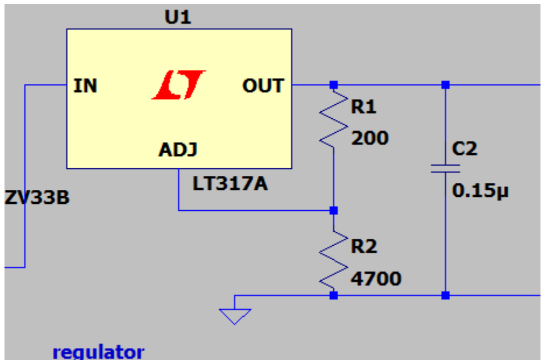


Now, after patching the whole circuit, we found that voltage is somewhat exceeding the limit at some scenarios. Although, Zener is not necessary here, we have added it just for the safe side. So, we came to conclusion, that we should add a Zener diode, which limits our voltage. So, here using a 33V Zener diode with appropriate settings makes the circuit output according to the requirement.

LT317A Regulation:

LT317A is a 3-terminal adjustable voltage regulator which provides output efficiently and correctly.

Here, the output from Zener is entering into it as its input. Here, two resistors R1 and R2 are deciding the ratio and hence the output voltage and current. This regulator limits max current to 1.5A which is desirable to us.



Load:

Load is the part of the circuit, where we are testing the current and voltage values.

Calculations:

- ## Transformer ratio selection:

$$Vp^2 /Vs^2 = L1/ L2$$

Using the above formula, we can easily calculate the inductances . In LTSpice, we put the 'squared values of inductances'.

We have chosen the values as 95:1. Technically, the value should be somewhat different , but we use them to get output as 33V keeping value at L1 as 1.

$325^2/33^2 = L1 /L2$

$325^2/33^2 = L1 /1$

Above equation gives, L1 as 96.99, so, we chose inductance close to it as 95H.

- ## Smoothing waveform:

Also, we have chosen first capacitor of 0.15F which is quite a large value, just to bring smoothness to the waveform and it quite worked well. And we found very little ripple.

- ## Regulator calculations:

We are using the formula which is generally used for LT317A regulator device and it tells that:

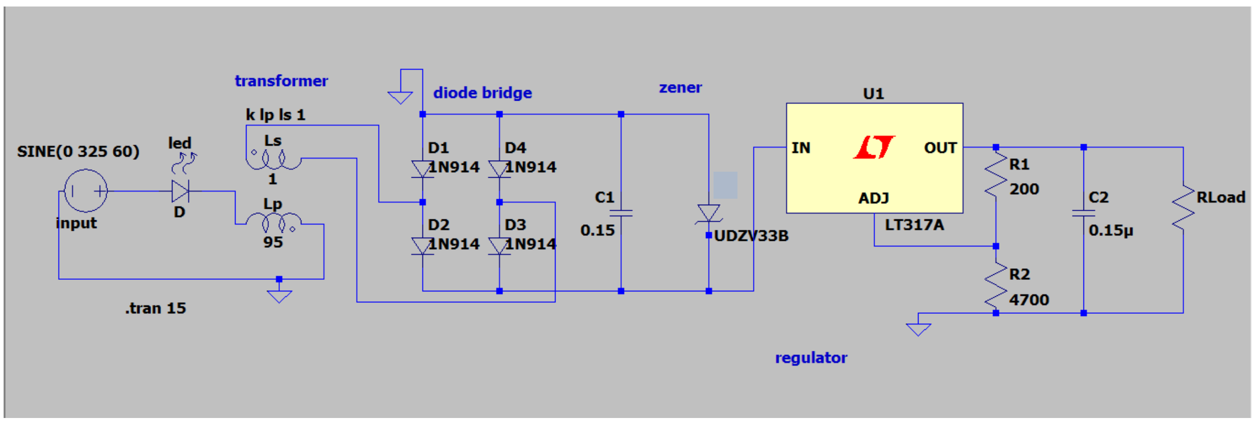
$Vout = 1.25\ (1 + R2/R1)$

Here, 1.25 is the Vref value and we are ignoring the error areas just for the sake of ideal calculations, we so, according to this we have used R2 as 4700 instead of 4800 (which was more accurate) because, 4700 was standard value of resistance.

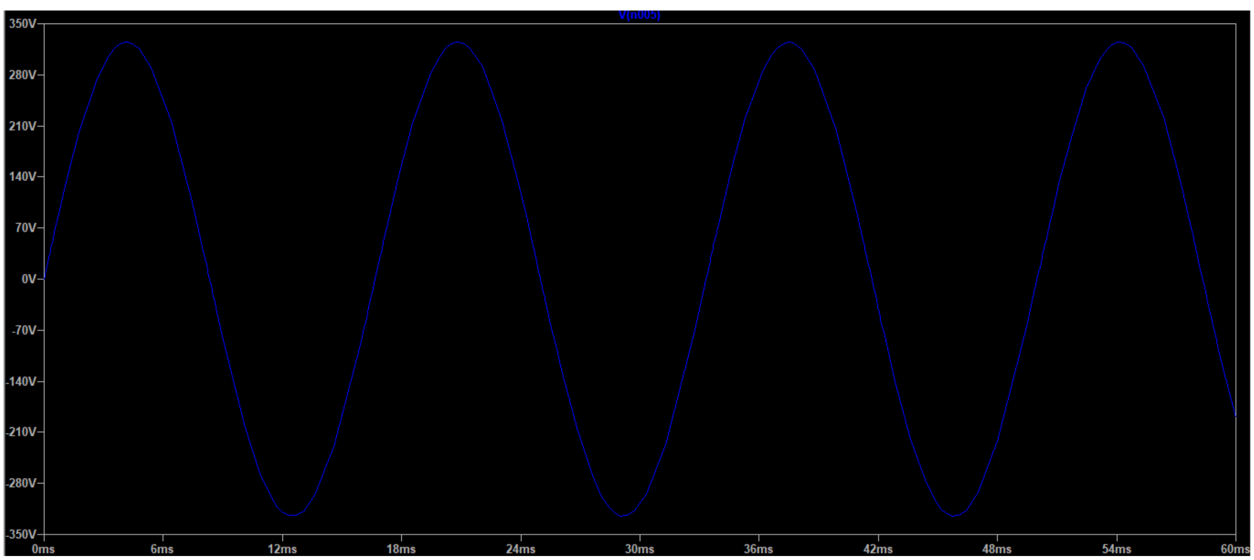
Sr.No	V-(in)$_{RMS}$	R$_{LOAD}$	Vout	I$_{Load}$ - A
1	230	1	0.802V	0.804
2	230	100	27.714	0.277
3	230	1k	29.563	0.029
4	230	10k	29.928	0.003

Circuit simulation:

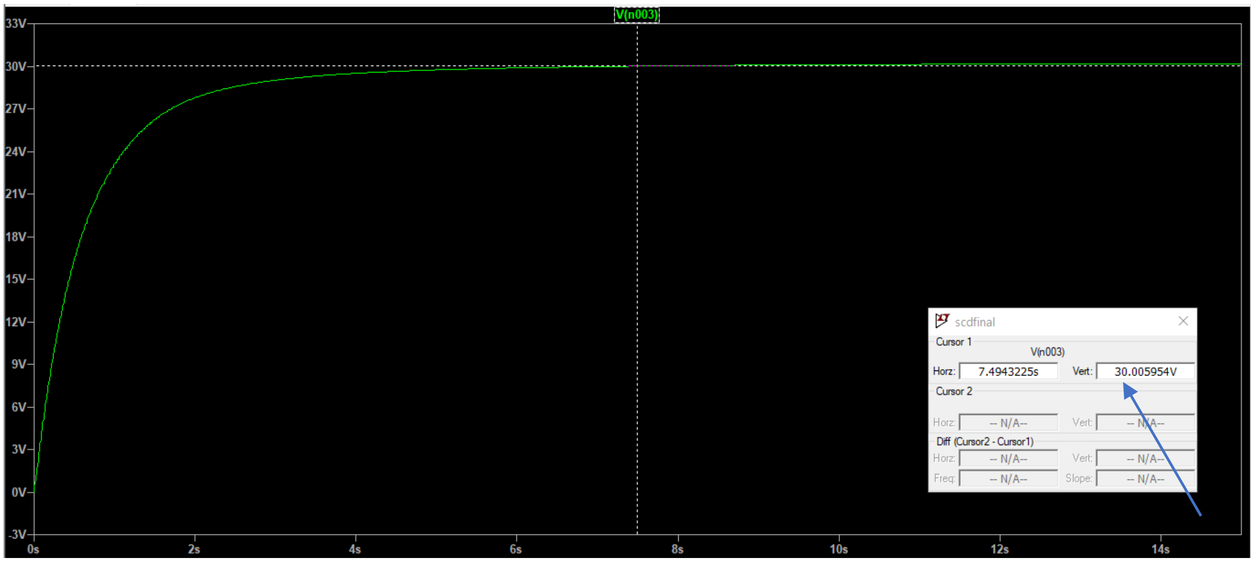
Circuit simulated:



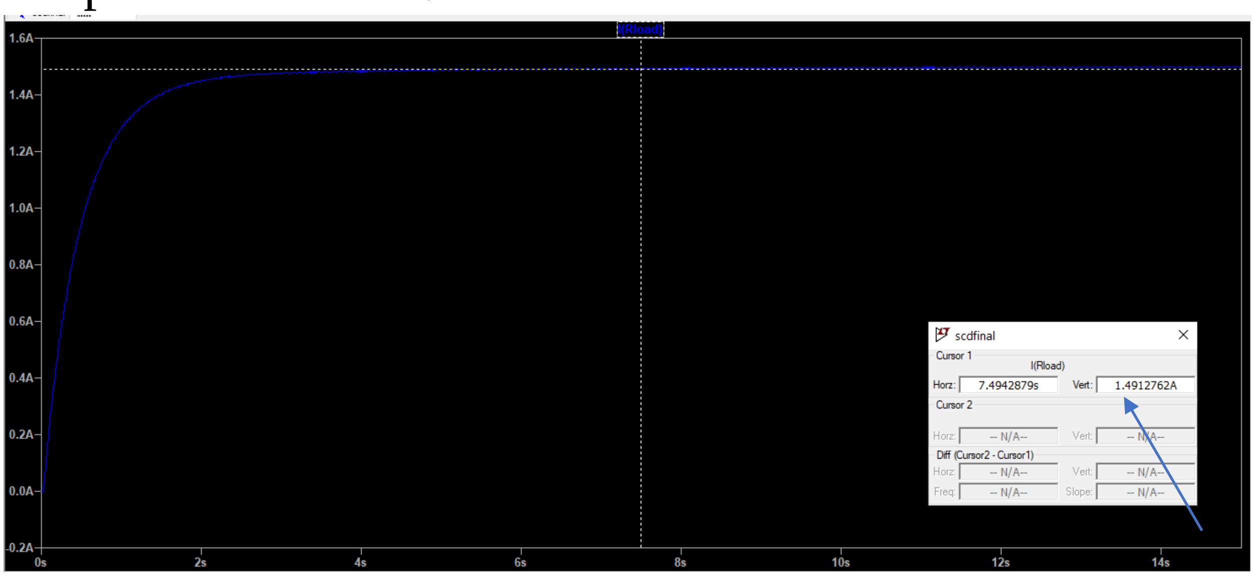
Input waveform:



Output max voltage:

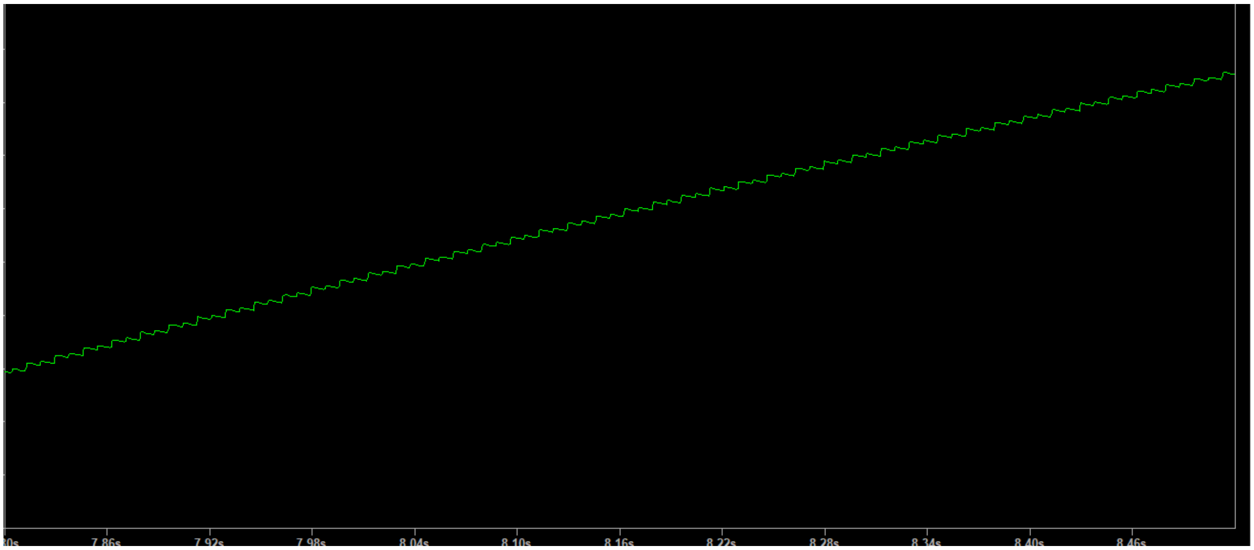


Output max current:



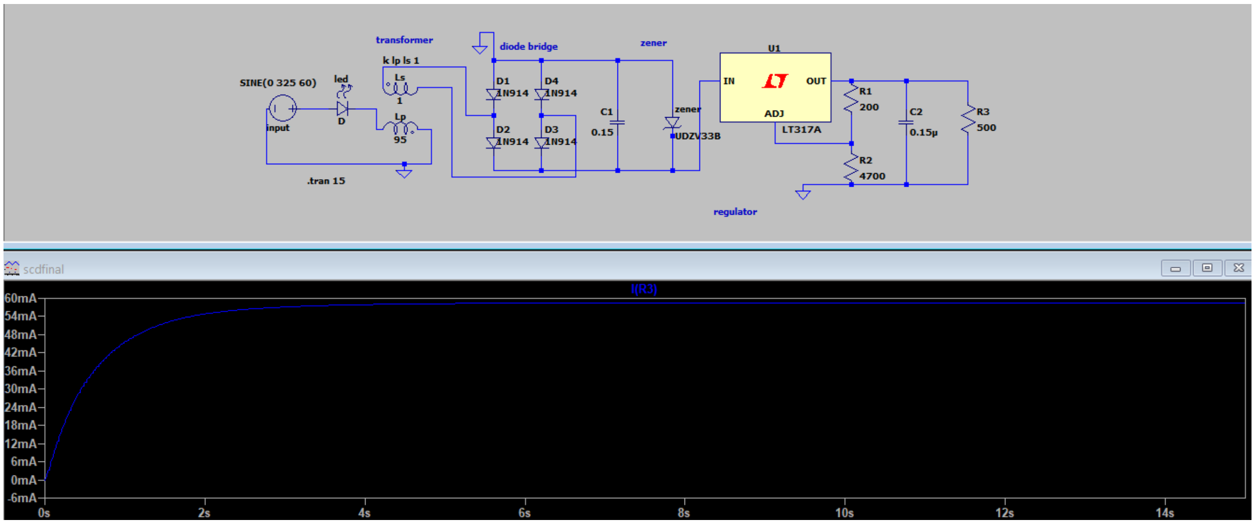
Output Ripple:

On zooming out, I found this ripple. Due to wise usage of capacitances, there is very small ripple and it is quite clear from this image.

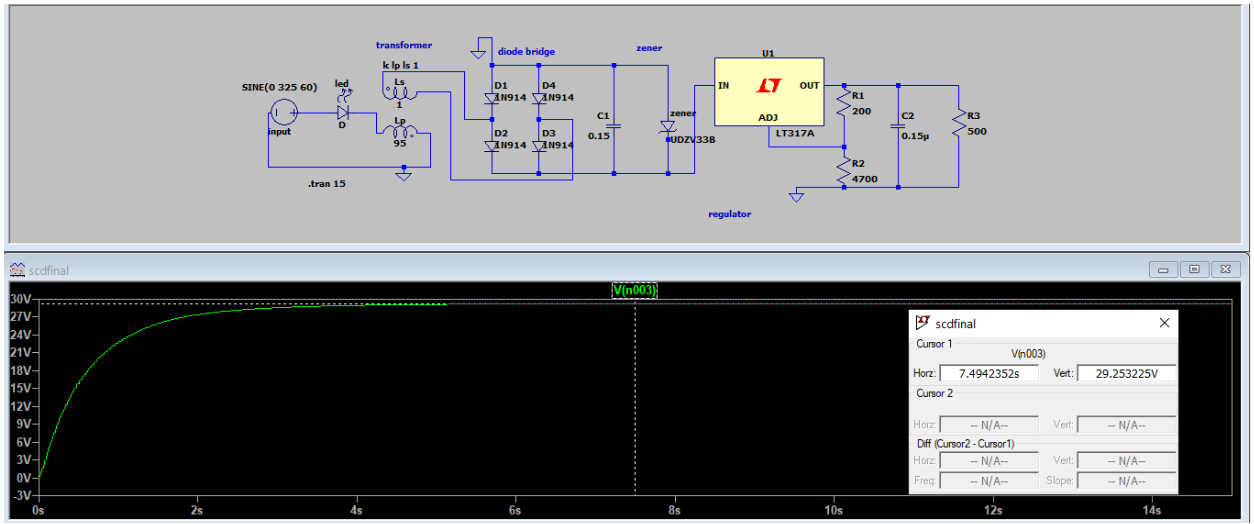


At load resistor 500 Ohm:

- Current value:



- Voltage value:



Assumptions:

Upon hit and trial basis, I found that in my simulated circuit when we put load resistor near to 16 or 15 Ohm, we get a perfect max current output, which is 1.5A in this case. So, on the whole, we assume this design to be quite okay, neglecting a few limitations. Load can be tested at 0 Ohm and any higher value of resistance.

Also, here I have used silicon diodes, assuming their ideal voltage as 0.7V.
Also, transformers are ideal and here, we have used 33V Zener because of voltage limitations and other problems but it gives perfect 30V at least resistance.

Conclusion and comments:

In a nutshell, we have used, various components and models in LTspice to make the output correct and achieve the desired results.

Also, because of quite user-friendly features of LTspice, it has made our usage of circuit components and manipulation of devices more and more easy.
We have used LED in circuit after the input, to make the circuit work properly, and it can be a limitation of our software.

So, we have found the results of simulation quite synchronizing with the calculated ones and so, what we can say is that this variable supply (0-30V and variable 1.5V limited) is according to every demand mentioned.