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EEE 419 – 01

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EEE 419 Homework Assignment 1 – High Efficiency DC Power Supply

Introduction

The aim of this assignment is to design a high efficiency DC power supply which can deliver a variable voltage between 3.3 to 5V with maximum current of 0.5A and 25mV ripple.

Methodology

In this design, LT3080 is used as LDO Adjustable Linear Voltage Regulator. It has max 1.1A output current, wide input voltage rate (1.2V to 36V), low output noise (40µV_{RMS}) and low dropout voltage(350mV).

In this assignment, input voltage fluctuates between 195.5Vrms to 264.5Vrms which is 230Vrms±15%. Hence, "the worst-case scenario" is 195.5Vrms, so the turns-ratio of the transformer is calculated for this voltage value.

$$195.5\ \text{Vrms} \approx 276.5\ \text{V}$$

$$\frac{V_{\text{primary}}}{V_{\text{secondary}}} = \frac{276.5\ \text{V}}{10\ \text{V}} = 27.65 = n$$

$$L_2 = \left(\frac{1}{n}\right)^2 (12\ \text{H}) - \left(\frac{1}{27.65}\right)^2 (12) \approx 0.016$$

With the given specifications and the result obtained, the primary part and transformer is formed as shown in figure 1.

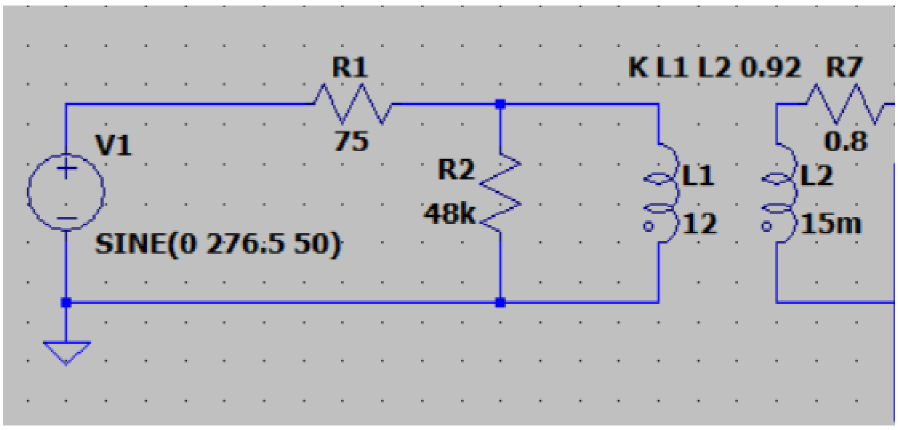

Figure 1: Primary Part of the Circuit

The first component of the secondary part is a full-bridge rectifier. Once the AC signal from the input is lowered by transformer, the signal needs to be converted to DC signal with pulse. The rectifier allows current to flow in only one direction. For this purpose, 1N5819 Schottky Diodes are used for low voltage drop.

Then the circuit is directly connected to LDO Linear Voltage Regulator, and the result is observed. This kind of connection caused at least 2V ripple. Hence a bulk capacitor is connected to the output of the rectifier. This solution did not efficiently reduce the ripple, so instead of using very high valued capacitors, an inductor is added to form a LC low pass filter.

While adjusting the voltage regulator, the direction in its datasheet is considered. The resistor value of setting resistor is determined by using following formula:

$V_{\mathrm{OUT}} = R_{\mathrm{SET}} \cdot 10\,\mu\mathrm{A}$

Since the required outputs are 5V and 3.3V, the resistor value is changed to 500k for 5V and 330k for 3.3V.

Also, $V_{control}$ pin requires adjustment for required output. $V_{control}$ needs to be 2V greater than Vout.

The overall circuit is shown in Figure 2.

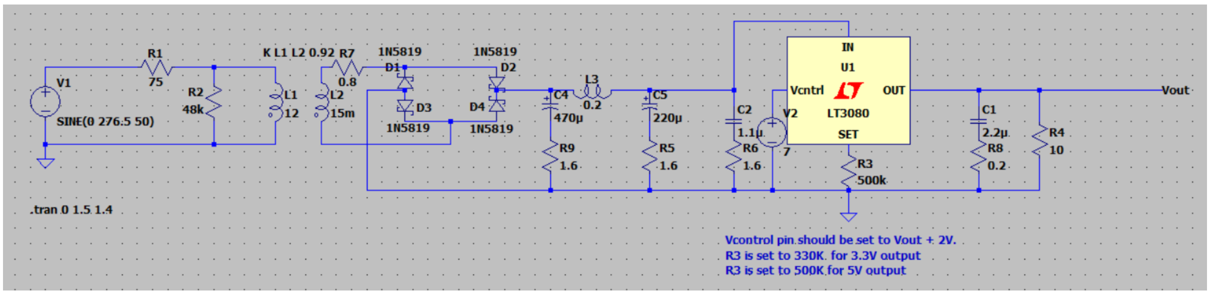

Figure 2: DC Power Supply Circuit

The values of C2 and C1 is advised in the datasheet of LT3080. The values of the other capacitors and the inductor are determined by observation. When the ripple reduction is satisfied with highest efficiency, the circuit is completed.

Results:

The output voltage graph of DC power supply while the AC input voltage is at its minimum is shown in Figure 3.

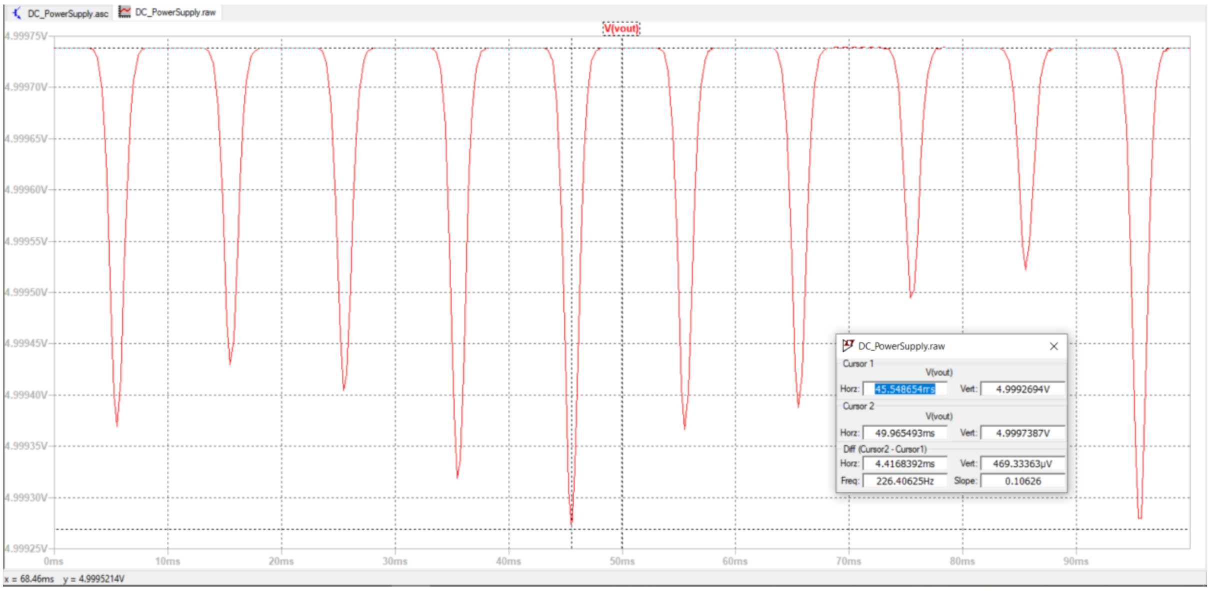

Figure 3: The Output Voltage when Input is 195.5 Vrms

The ripple is 469.33µV which is also shown in Figure 3. This is less than 25mV. The instantaneous power of input source is shown in Figure 4.

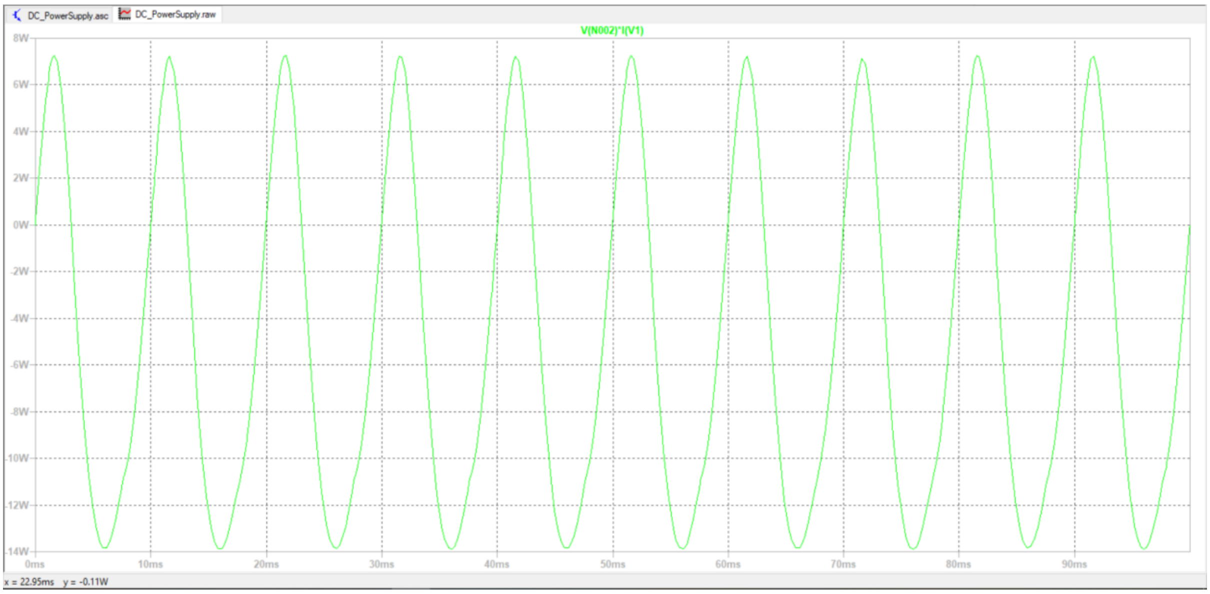

Figure 4: Instantaneous Power of the Input Source

The efficiency is calculated as 50.9% by proportioning the average input and output powers.

The output voltage graph of DC power supply while the AC input voltage is at its maximum is shown in Figure 5.

For this observation, $V_{control}$ is change to 5V and the setting resistance is changed to 500KΩ.

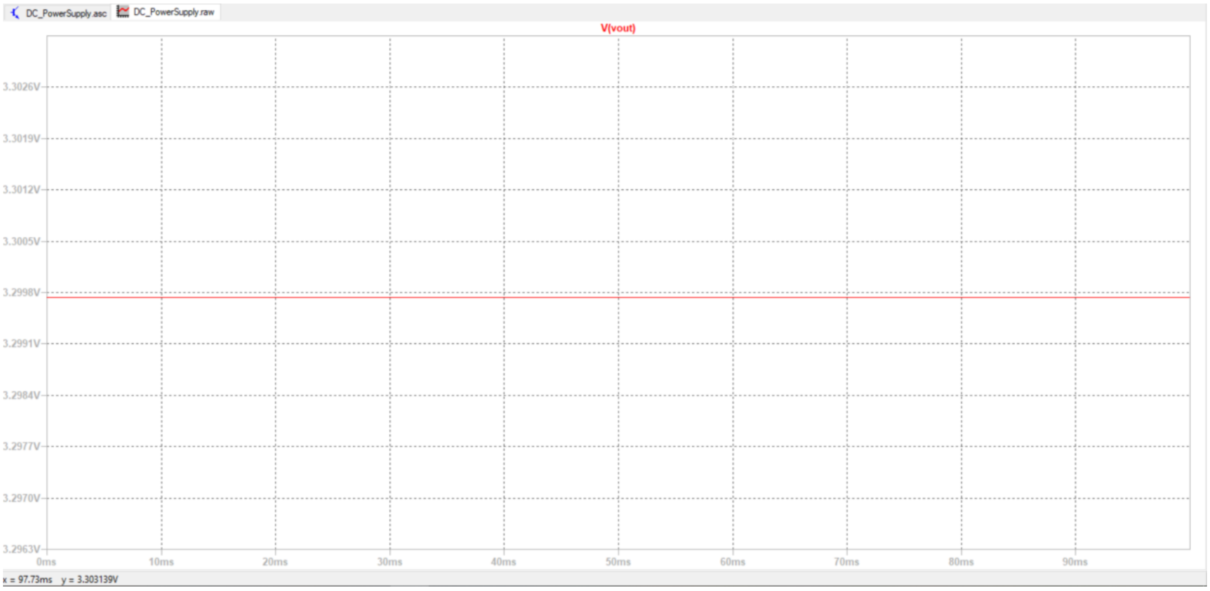

Figure 5: The Output Voltage When Input is 264.5 Vrms

The ripple is completely gone and not observable anymore. The instantaneous power of input source is shown in Figure 6.

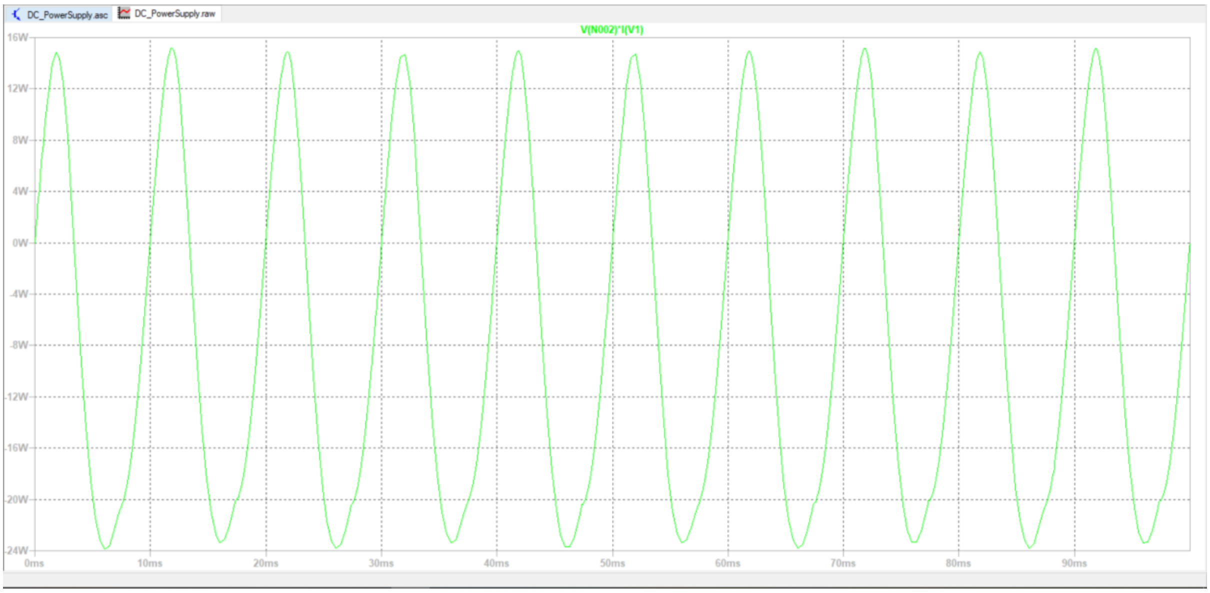

Figure 6: Instantaneous Power of the Input Source

The efficiency is calculated as 22.75% by proportioning the average input and output powers. This is expected because the required voltage output is decreased while the input voltage is at its maximum.

The output voltage graph of DC power supply when input voltage is in 230 Vrms is shown in figure 7.

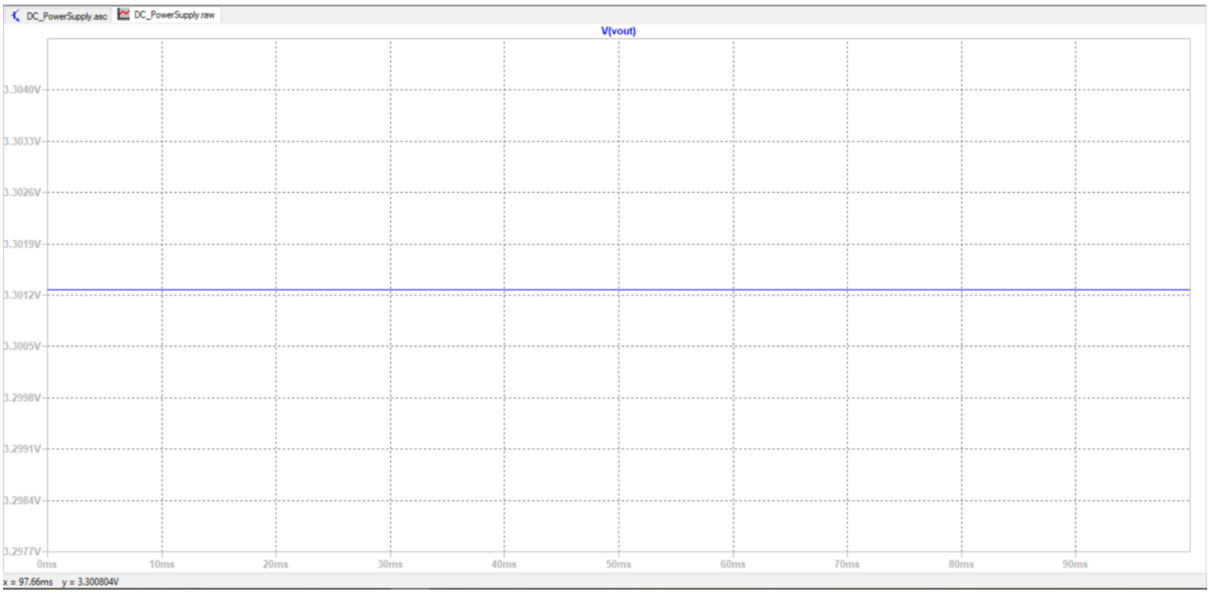

Figure 7: The Output Voltage when Input Voltage is in 230 Vrms

As shown in the figure, the ripple is not visible. Hence it is quite low.

The instantaneous input power graph is shown in Figure 8.

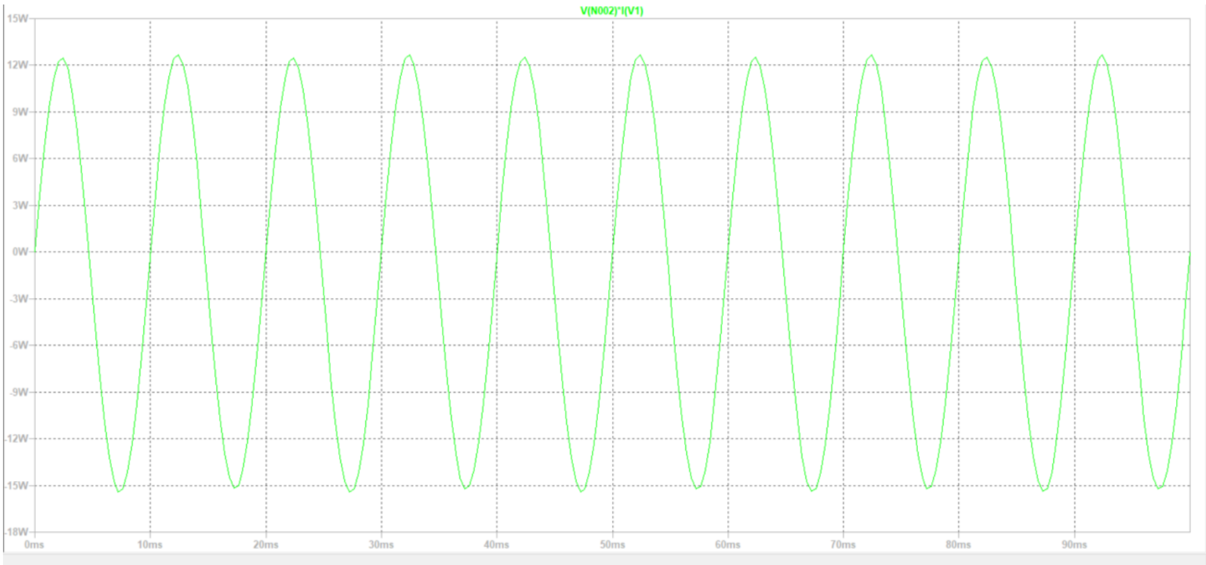

Figure 8: Instantaneous Power of the Input Source

Also, the average input power is shown in Figure 9.

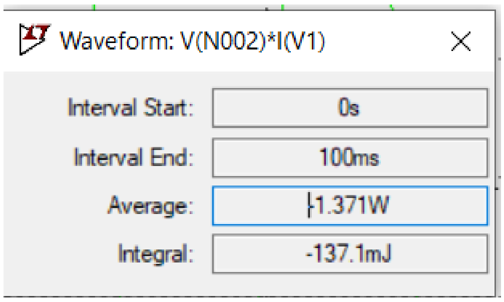

Figure 9: Average Input Power

This average is lower than the two input voltages.

Conclusion

In this assignment, we successfully designed a high-efficiency DC power supply using an adjustable linear regulator. The design allows for a variable output voltage between 3.3V and 5V, meeting the required ripple specifications. By adjusting the transformer's secondary inductance (L2) and implementing a full-wave rectifier, we were able to filter and regulate the AC input voltage efficiently. The use of Schottky diodes helped minimize power dissipation, improving overall efficiency.

Simulation results demonstrated that under varying input voltage conditions (195.5Vrms to 264.5Vrms), the regulator maintained stable output voltages of 3.3V and 5V with minimal ripple and acceptable efficiency. Power dissipation in the system was carefully managed with appropriate capacitor selection and realistic ESR values, leading to improved performance.