GEBZE TEKNİK ÜNİVERSİTESİ

MÜHENDİSLİK FAKÜLTESİ

ELEKTRONİK MÜHENDİSLİĞİ BÖLÜMÜ

ELM 237

Project Assignment

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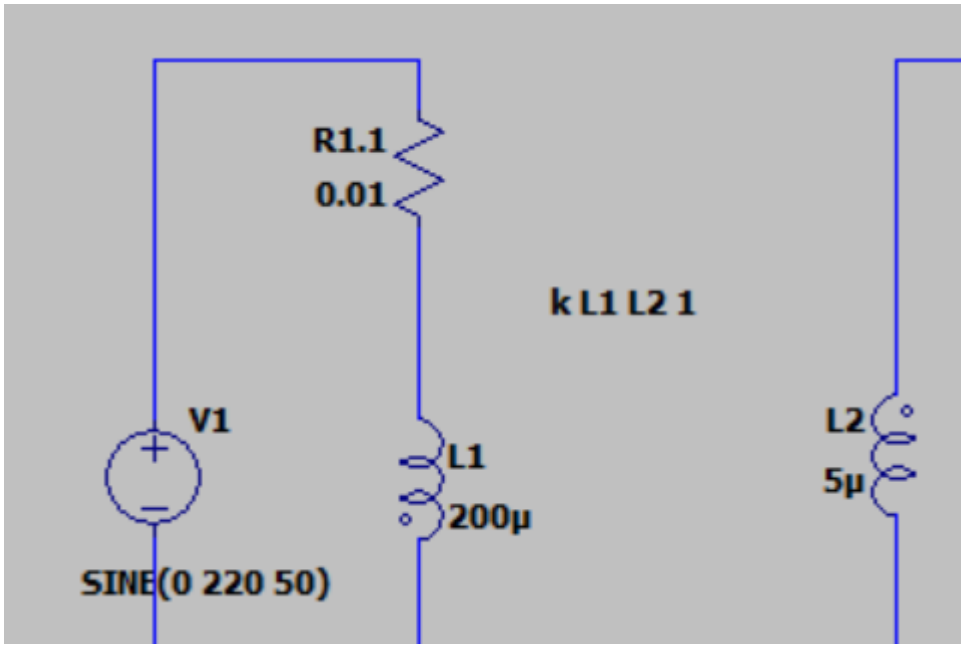
12-18V Adjustable DC Power Supply Design on LTSPICE:

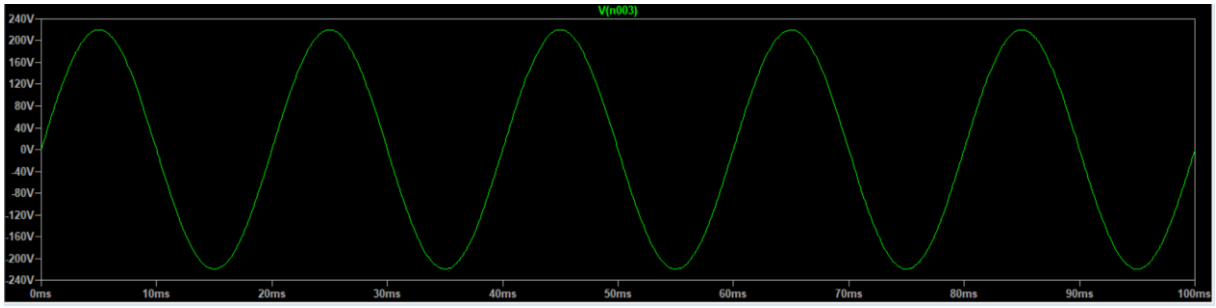
In this project assignment, the goal is to design an adjustable DC power supply in LTspice that provides an output of 12-18V when 220V AC is applied at the input. Additionally, the design should ensure stability, efficiency, and incorporate protection features. Stability refers to maintaining a constant DC voltage output when 220V AC is applied at the input. Efficiency aims to achieve minimal power loss, which necessitates the use of high-efficiency switching regulators. Protection is intended to prevent damage to the circuit in the event of changes, which implies the need for diodes.

In this report, the circuit will be examined part by part, and the complete version will be shown at the end. Necessary components, graphs, and analyses will be reviewed section by section.

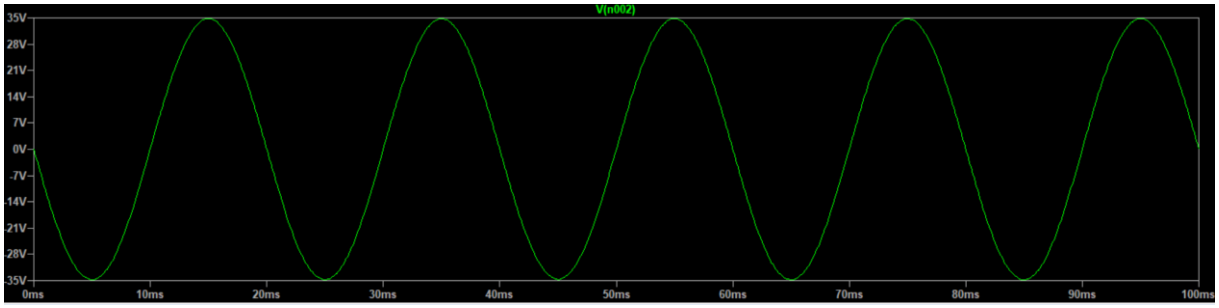
1-) In the first part of the circuit: A 220V amplitude and 50Hz frequency input is applied, and it is aimed to obtain an AC voltage of approximately 40V amplitude from the secondary side of the transformer. For this purpose, the transformer is set to a 40:1 ratio, and the graphs are shown below .



Input voltage :



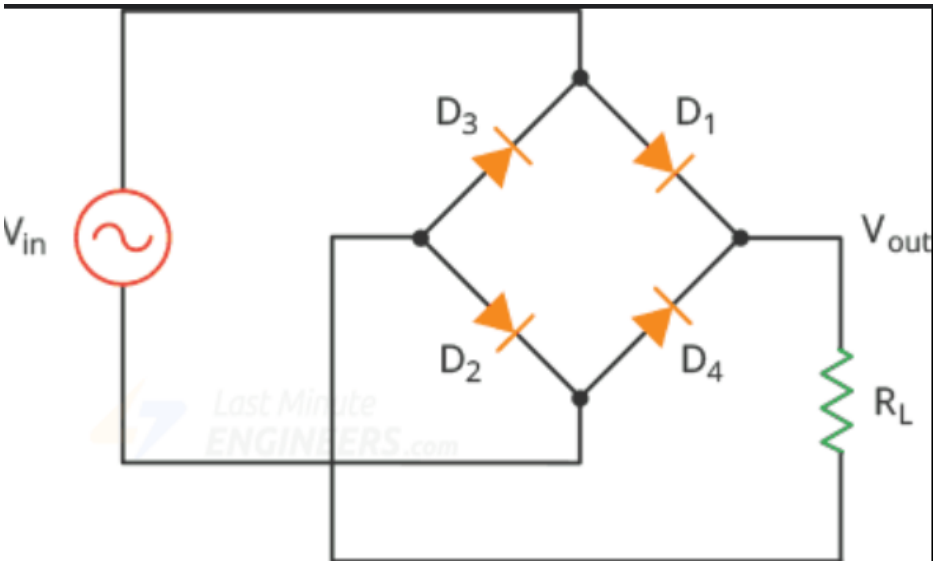
Output voltage :

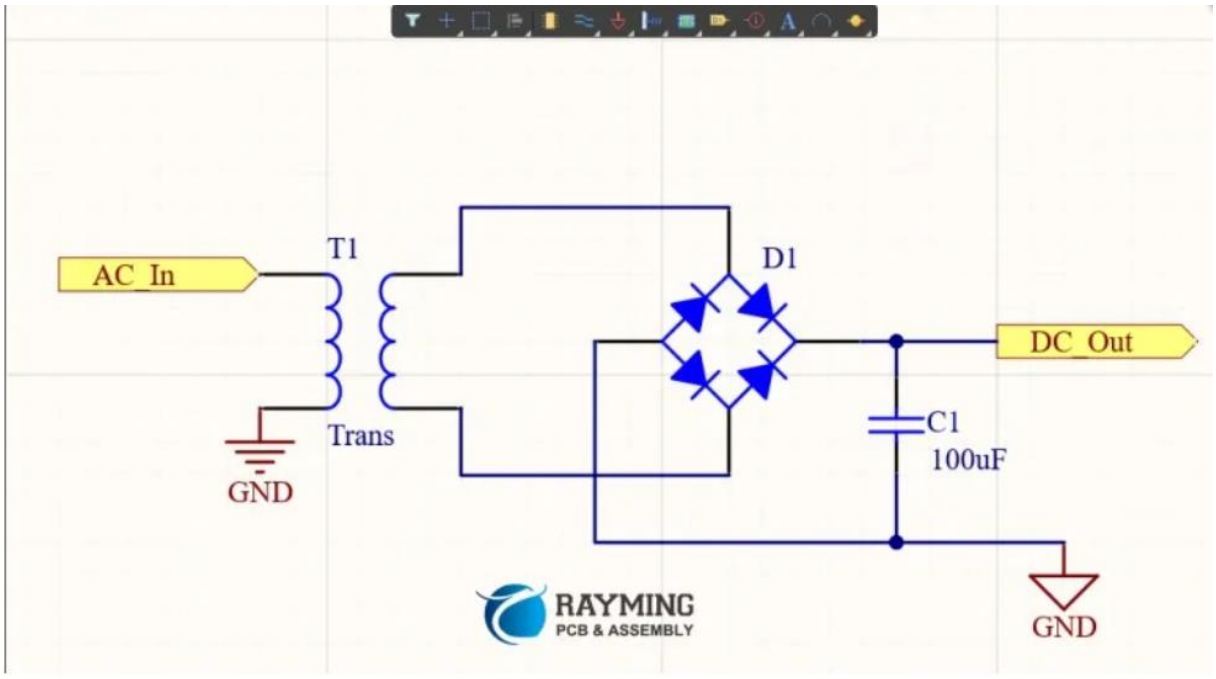


Thus, the first part has been completed.

2-) The 40V amplitude AC voltage is converted to DC using a full rectifier. The full rectifier shifts both positive and negative half-waves onto the axis. For this purpose, a 1N914 diode is used, and below are the specifications of this diode.

Full wave rectifier :





1N914 features :

Peak Reverse Voltage: 100V

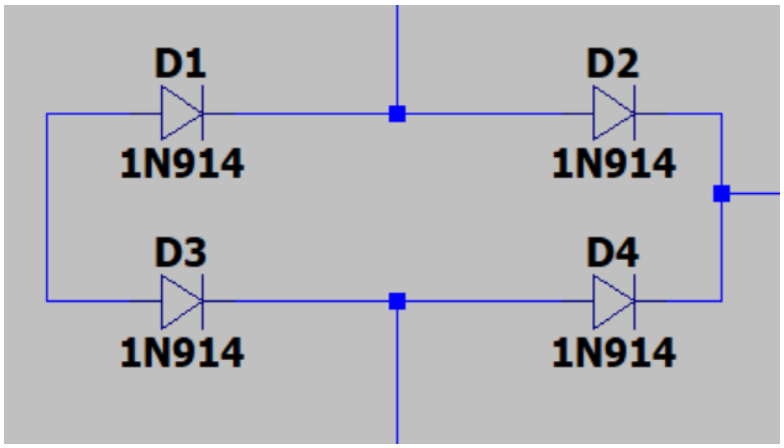
Average Rectified Forward Current: 75mA

Peak Forward Surge Current: 2A (for 1 second)

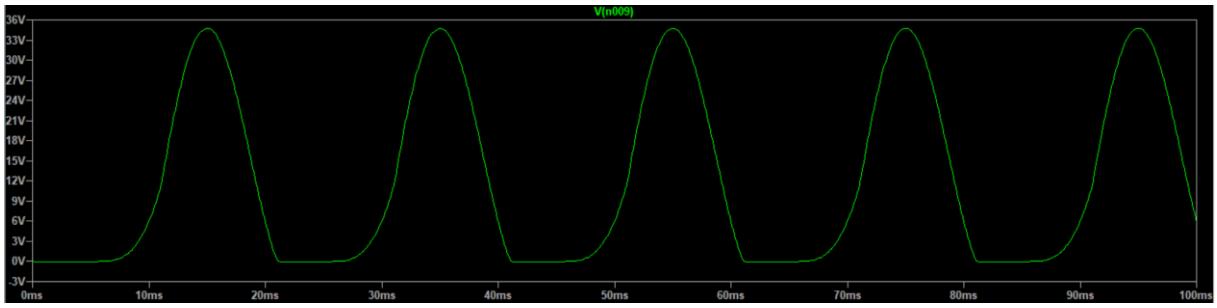
Forward Voltage Drop: Approximately 1V

Operating Temperature Range: -65°C to +175°C

On ltspice :



Wave after this application :

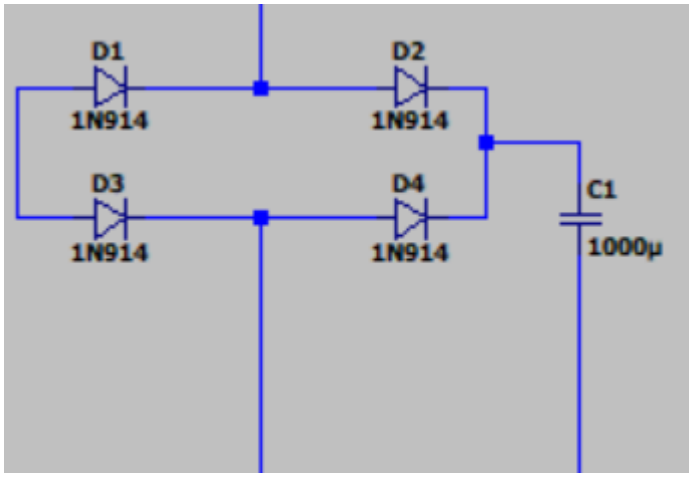


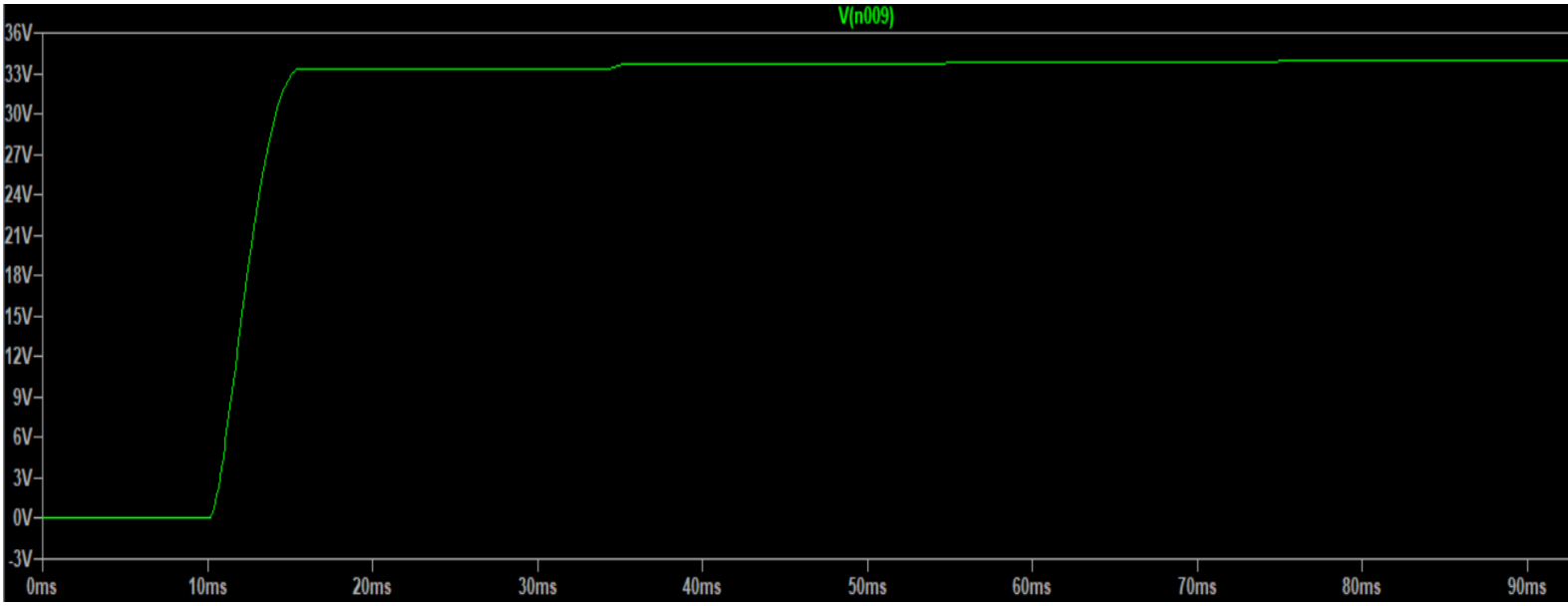
Thus, full wave rectification has been successfully achieved.

Filtering :

After this, the obtained rectified waveform needs to be smooth and flat; for this purpose, a filtering process will be conducted. A capacitor will be used for this.

On ltspice :





As seen, the filtering process has been successfully completed.

3-) Part of Voltage Regulator :

The circuit currently outputs 33 volts, and using a voltage regulator aims to achieve a more protected and stable output.

What is the voltage regulator and LM317 :

Voltage regulator is an electronic circuit used to maintain or regulate a specific voltage level. These circuits typically convert variable input voltages to a steady output voltage. Their key features include:

Dropout Voltage: The minimum voltage difference required for the regulator to operate. The lower this value, the more efficiently the regulator operates.

Output Voltage: The fixed output voltage that the regulator can provide. This value may vary depending on the specific regulator model.

Maximum Current: The maximum amount of current the regulator can supply at its output.

Thermal Protection: The protection feature the regulator has to prevent overheating.

LM317 is a popular voltage regulator chip with a wide range of applications.

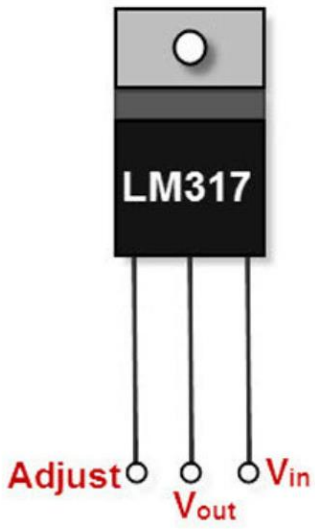
LM317 Voltage Regulator Features:

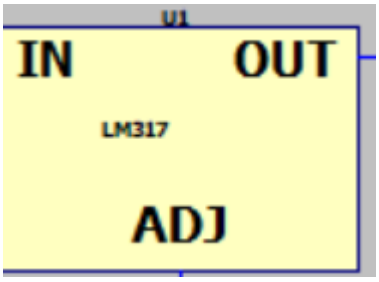
Dropout Voltage: Typically between 2V to 2.5V.

Output Voltage: Adjustable between 1.25V to 37V.

Maximum Current: Can supply up to 1.5A of current.

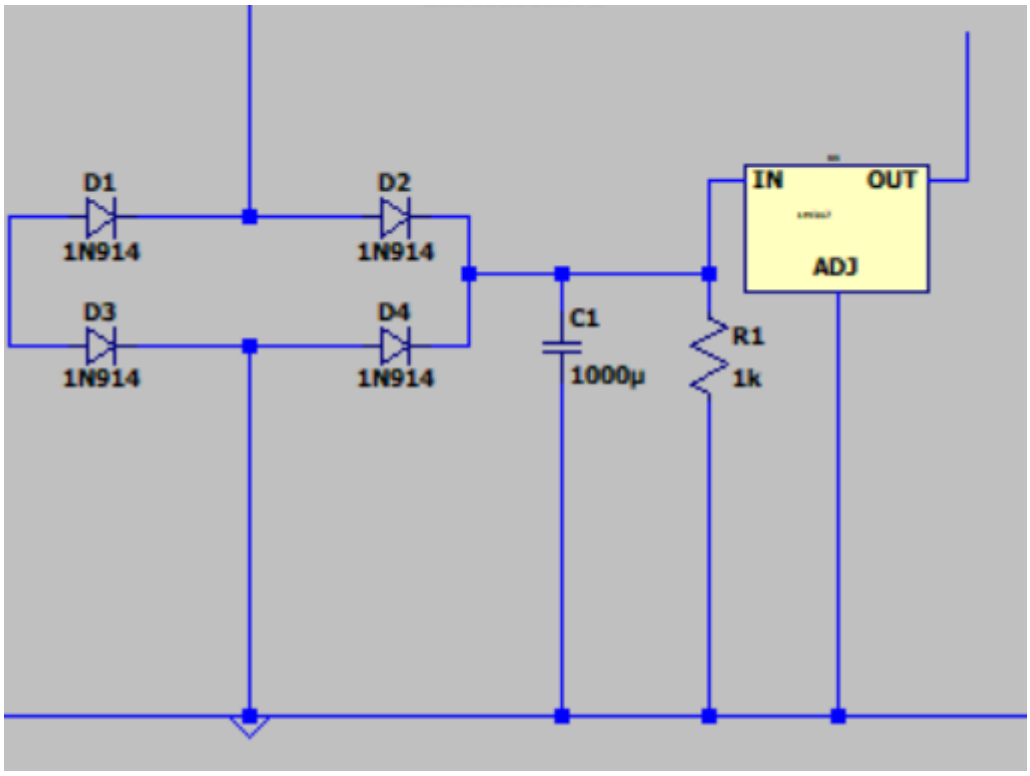
Thermal Protection: Includes a thermal cut-off to prevent overheating.



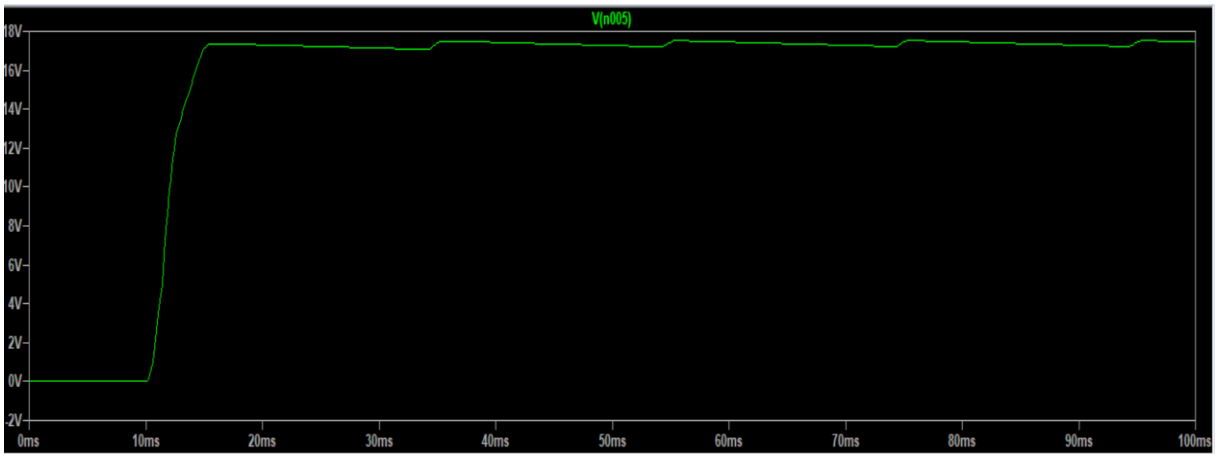


After obtaining 33 volts, when connected to the voltage regulator, 18 volts were obtained. Below is the formula for the voltage regulator, but despite extensive work with this formula, it did not work, and the 18 volts were achieved through trial and error by reverting back to the circuit.

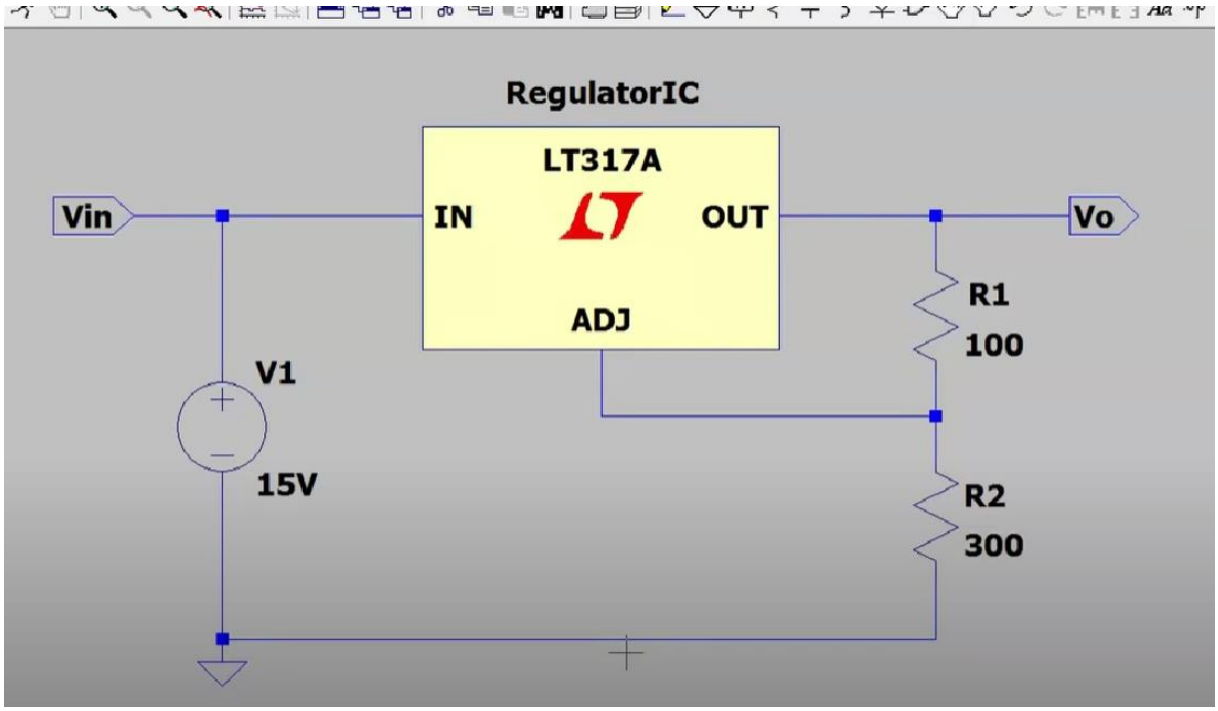
$$V_{out} = (V_{ref} \approx 1{,}25) \times \left(1 + \frac{R_2}{R_1}\right) \times I_{adj} \times R_2$$



Vout : 18v(----)



Everything up to this point has been shown step by step, and now we have reached the value of 18V. To adjust this between 12V and 18V, a combination of a zener diode, an adjustable potentiometer, and resistors is required. Various sources from the internet have been utilized, and these have been added to the reference sections.

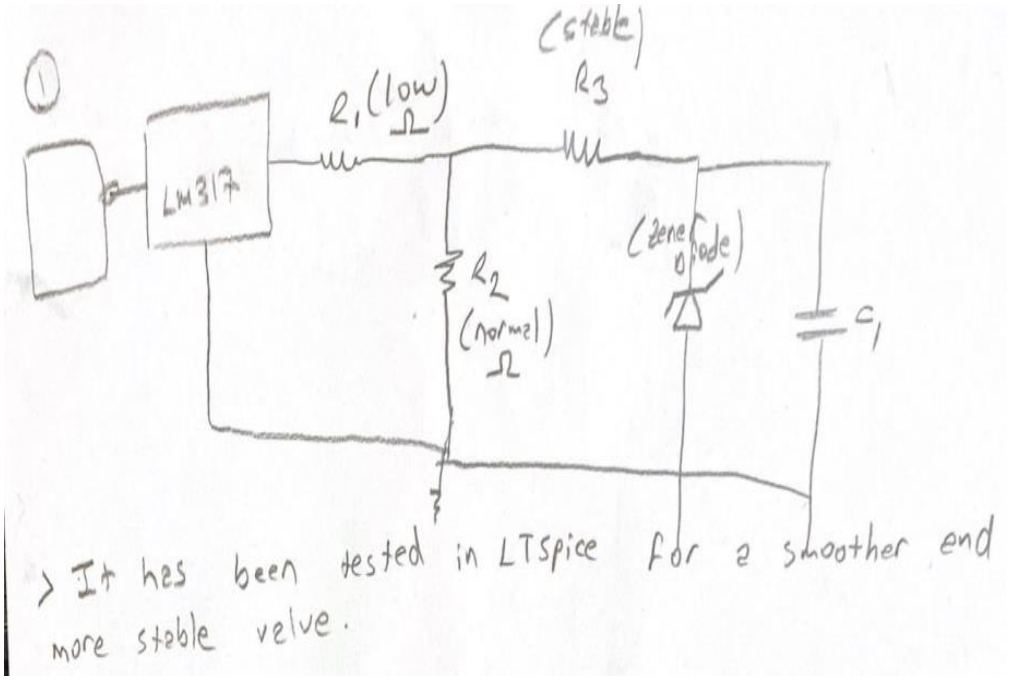


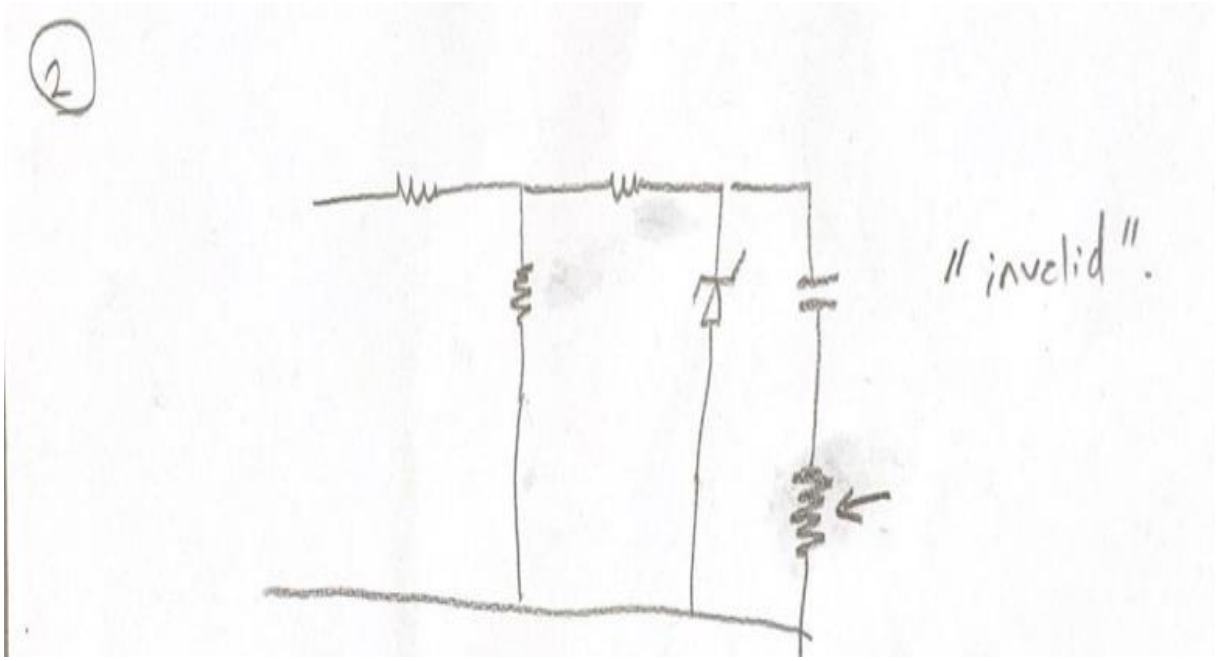
4-) part of voltage regulator and zener , potentiometer combination :

Overvoltage Protection: Overvoltage protection safeguards the circuit from high voltages resulting from various reasons such as voltage spikes and sudden voltage increases. Zener Diode (D5): A Zener diode is used to reduce the voltage to a certain safe level and is connected in parallel with the load. It cuts off or limits a portion of the voltage, thus keeping the voltage at a certain level before reaching the components of the circuit. For example, in a specific application, the Zener diode may be selected to stabilize at 12V. In this case, when the diode reaches a certain voltage, the excess voltage does not reach the circuit and does not damage the sensitive components. Therefore, the Zener diode prevents damage from overvoltage by ensuring that the circuit operates within a certain voltage range.

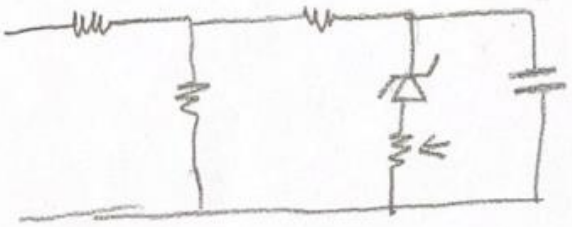
A YouTube video demonstrating circuit combinations after a regulator was found above, and inspiration was drawn from there. However, there are no zener diode and potentiometer here. Later, these were

added, and relevant circuit combinations were tried. Some of these works are shown below.



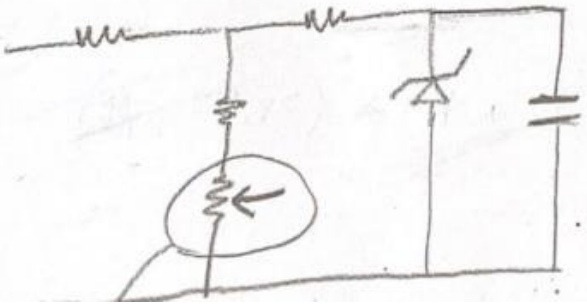


(3)



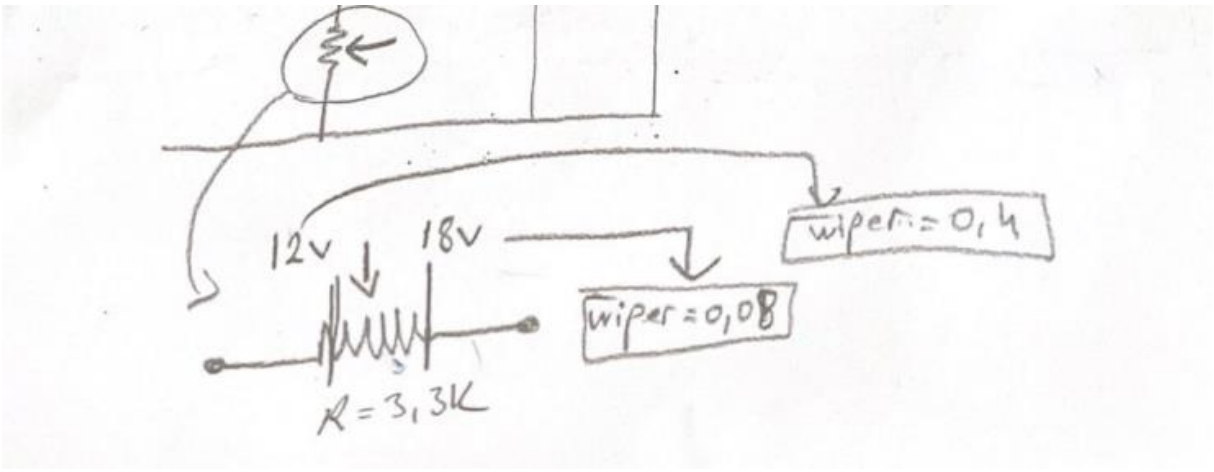
" invalid "

(4)

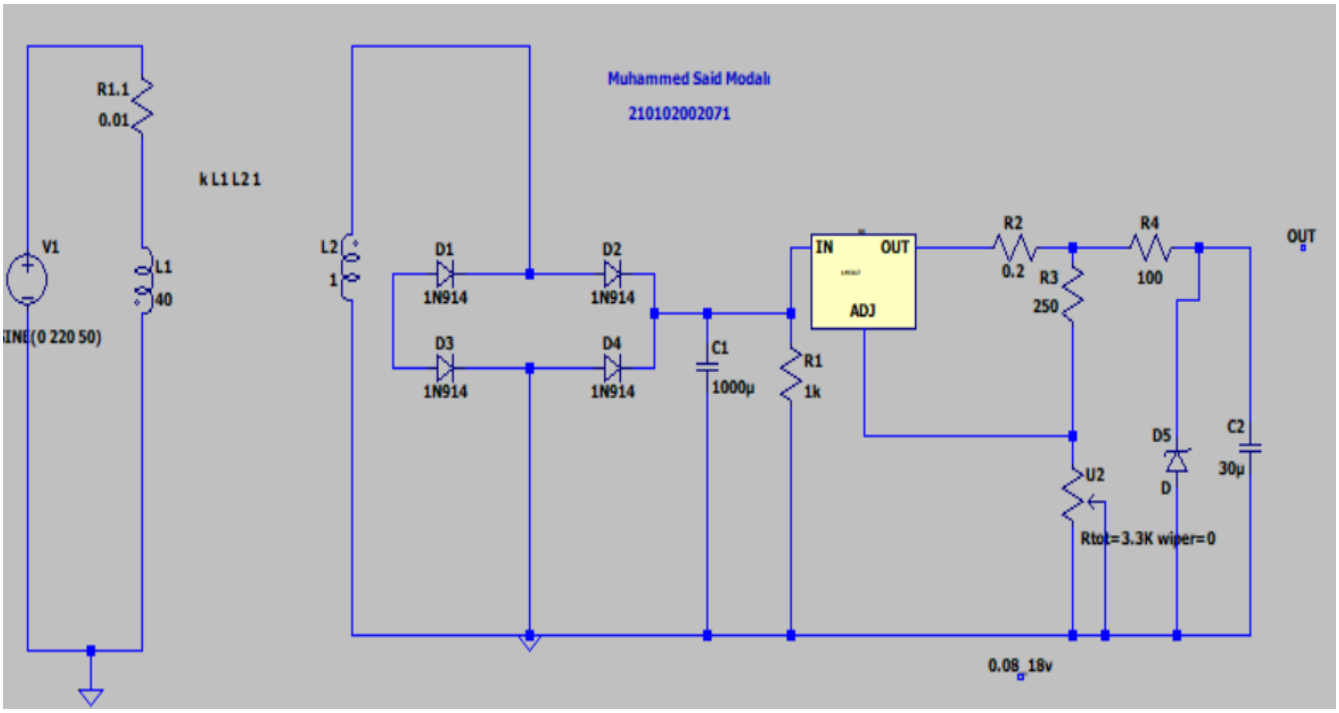


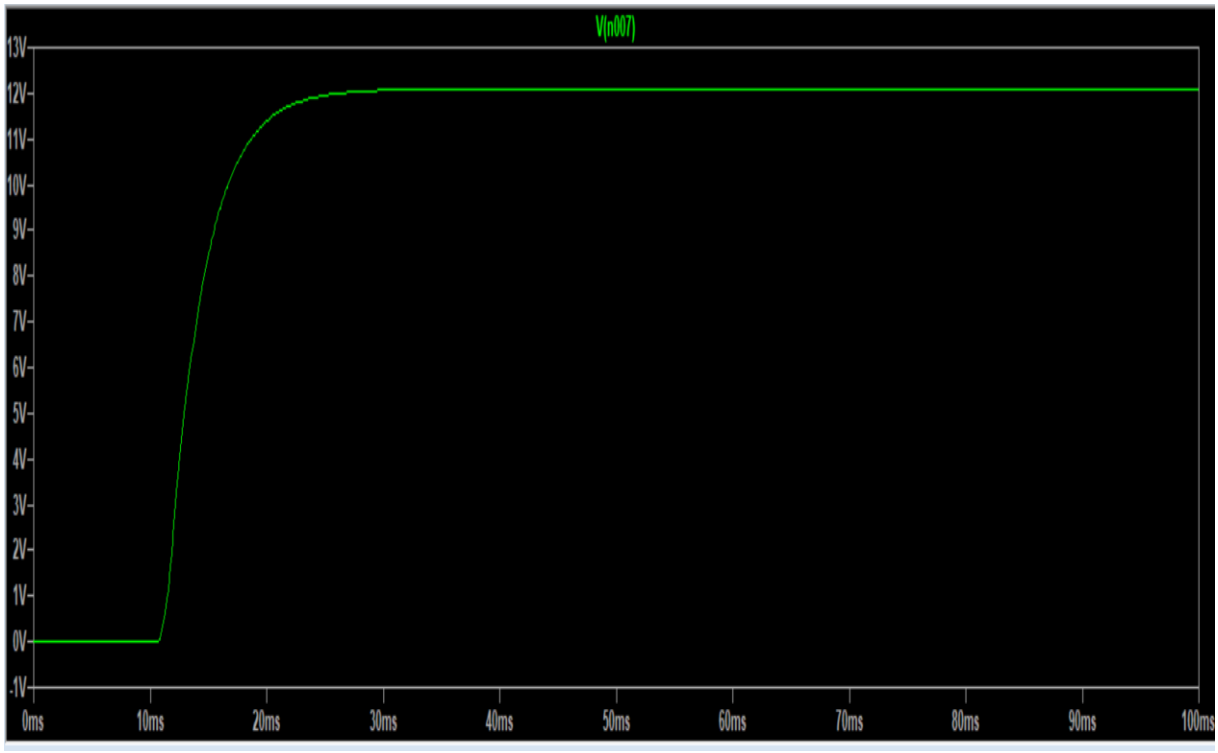
" valid "

Up to this point, it has been analyzed analytically and tested with LTspice. Then, it was verified which values of the adjustable resistor provide a stable DC source between 12V and 18 volts, and it has been written.

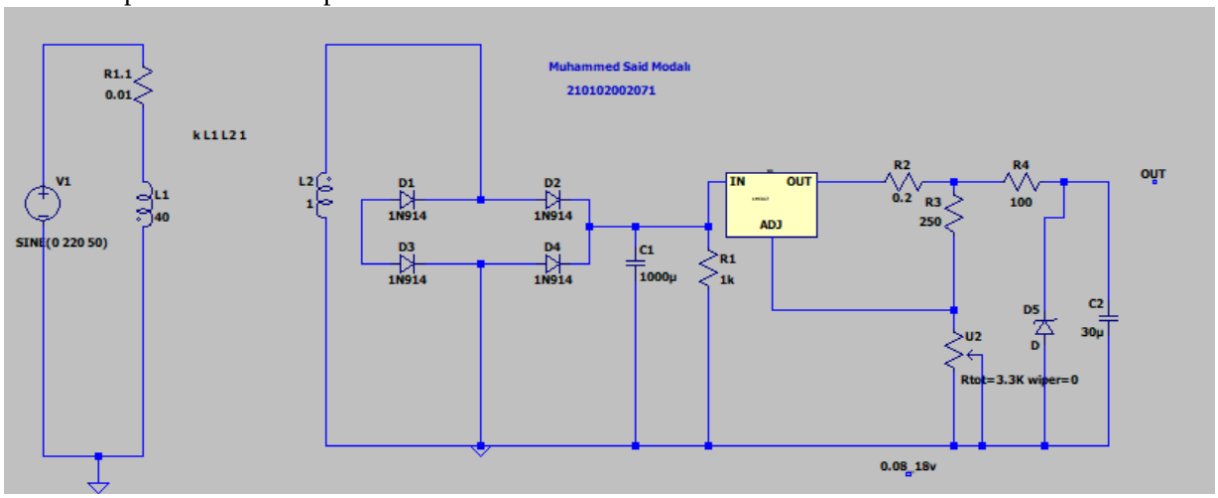


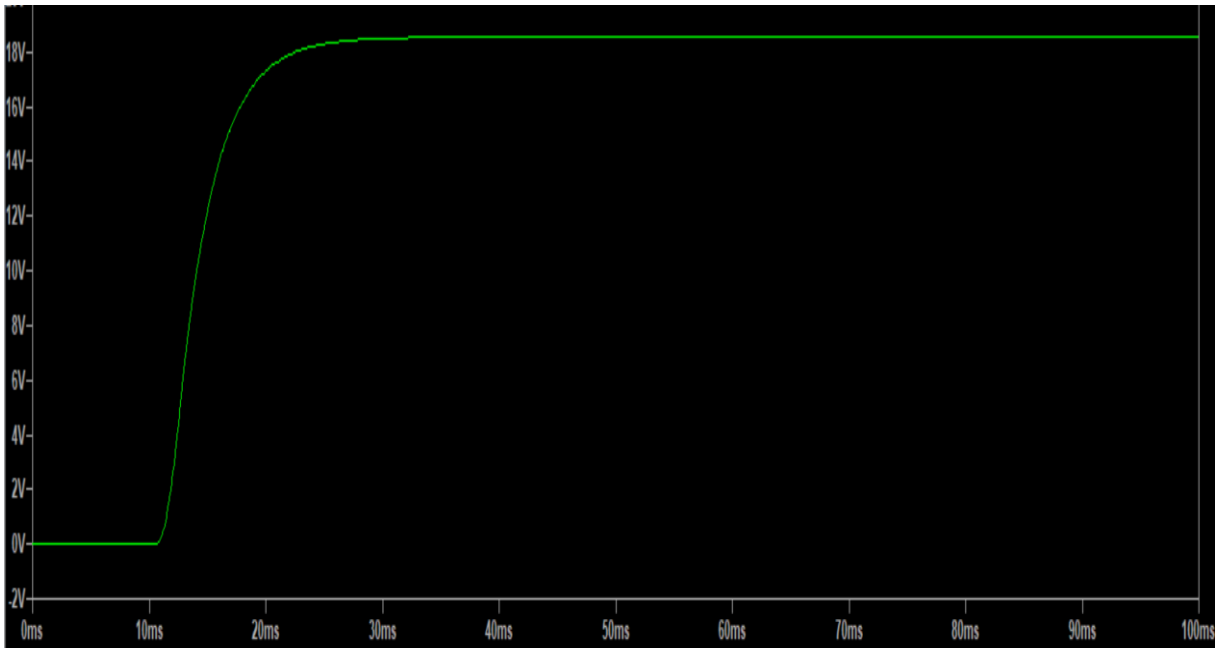
When the potentiometer wiper is set to 0.4 for a stable 12V DC :





When the potentiometer wiper is set to 0 for a stable 18V DC :





CONCLUSION :

As seen, the circuit has been meticulously set up from the beginning to achieve the desired 12V-18V DC output. This experiment encountered many challenges, such as adding the libraries of components not available in LTspice, determining suitable potentiometer values, appropriate diodes, suitable resistor values, etc. Additionally, through trial and error, the circuit was fully established with the relevant values shown. The graphical outputs came out accurately. The references used in the experiment are as follows:

REFERENCES :

[1] : https://medium.com/@raymingpcb/how-to-design-an-ac-to-dc-converter-circuit-891d64d3c4ad

[1] : https://www.slideshare.net/slideshow/rectifier-and-filter-circuits-chapter14/247103074

[1] : https://www.youtube.com/watch?v=A77HpJBRUaA

[1] : https://www.youtube.com/watch?v=euX9KndZmtc

[1] : https://www.youtube.com/watch?v=B9OHGXLQCKE

[1] : https://www.youtube.com/watch?v=AyDtVjeG5I8