Gazi University
Faculty of Engineering
Electrical-Electronics Engineering

EEE214 Analog Electronics I

Term Project: Power Supply Design

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July 4, 2024

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1 Summary

In this project, a DC power supply with three outputs is designed and built. These outputs are an adjustable 0-12V output with a maximum current of 2A, an adjustable 0 to -12V output with a maximum current of 2A, and a constant 5V output with a maximum current of 2A. The fundamental electronic components we used are Zener diodes, capacitors, potentiometers, and a transformer. All these parts are integrated into a breadboard. The designing process involved selecting Zener diodes for stable voltage regulation, capacitors for filtering and smoothing the DC output, and potentiometers for fine voltage adjustment. A transformer was used to step down the input voltage to a suitable level for the circuit.

The voltage from the transformer was then given to a rectifier. The output voltage from the rectifier was directly fed into the smoothing capacitors, which reduced any voltage ripple and provided a stable DC output. Zener diodes were used to regulate the output voltages, and potentiometers were wired into the circuit to provide adjustable resistance, allowing fine control over the output voltages.

After all components were connected to the breadboard, the power supply was tested to ensure it met the required specifications. Multimeters were used to measure the output voltages and currents, confirming that the adjustable positive voltage output provided a smooth and adjustable output from 0 to 12 volts with a maximum current of 2 amps, the adjustable negative voltage output provided a smooth and adjustable output from 0 to -12 volt, and the constant voltage output provided a stable 5V output. The DC power supply was successfully constructed and through testing, it was verified to meet the design requirements. This project demonstrated the practical application of fundamental electronic components and highlighted the importance of voltage regulation and current management in power supply design.

2 Introduction

Designing a DC power supply with multiple outputs is a fundamental yet an important project in the electronics field. A power supply like this is essential for a variety of applications and providing the necessary voltages to different electronic circuits and devices. The power supply described in this report features three distinct outputs: the first output is adjustable from 0 to 12V with a maximum current of 2A, the second output is adjustable from 0 to -12V with a maximum current of 2A, and the third output provides a constant 5V with a maximum current of 2A. This design does not include any special-purpose integrated circuits and microcontrollers, it consists of two general integrated circuits and Zener diodes for voltage regulation.

The requirements for this power supply design were determined by the need for variation and reliability in these various applications. This circuit has three different outputs: Adjustable positive voltage output of 0-12V with 2 amps maximum current, adjustable negative voltage output of 0-(-12V) with maximum current: 2 amps, constant voltage output (5V) with a maximum current of 2 amps. The inclusion of adjustable outputs allows for variety in providing the necessary power for different circuit requirements, while the constant 5V output is ideal for powering standard digital logic circuits.

This power supply can be used in a lot of areas such as educational laboratories, electronic testing, prototypes, DIY projects, etc. It is useful for engineers and technicians in testing and troubleshooting various electronic circuits and components. The adjustable outputs are beneficial for testing the voltage tolerance and performance of new designs. It provides an understanding of power regulation and the behavior of electronic components under different voltage levels.

We selected the components carefully according to our requirements without using special-purpose ICs or microcontrollers. We used Zener diodes and general integrated circuits to get stable voltage outputs. Ensuring precise voltage adjustments through potentiometers. This allows for fine-tuning of the output voltage, which is crucial for applications requiring specific voltage levels. Utilizing Zener diodes and general integrated circuits is for achieving stable voltage outputs. Zener diodes were specifically chosen for their ability to maintain a consistent voltage level, providing a simple yet effective method of voltage regulation. We made a careful selection of reliable components to ensure durability and performance while keeping the costs under the budget limit. Each component was chosen based on its specifications, reliability, and compatibility with the overall design.

This report explains the detailed design, simulation, and testing of the DC power supply, showing how the requirements were met using fundamental electronic components. We did not use any special-purpose ICs and microcontrollers. It provided an opportunity to explore and apply basic electronic principles and techniques.

3 Block diagram and circuit design

The block diagram is given below

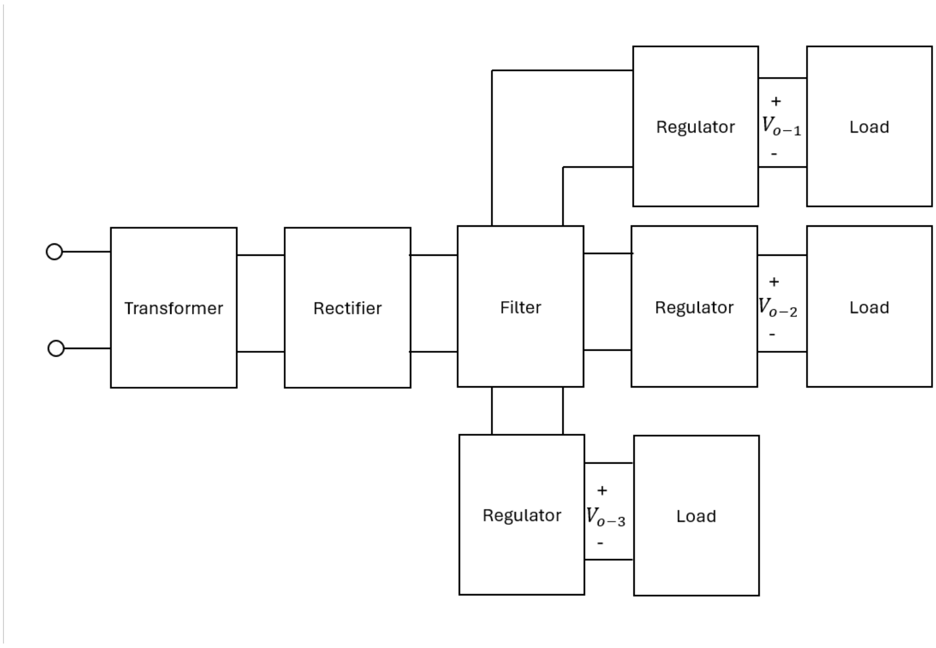

Figure 1: The block diagram

The circuit design is given below

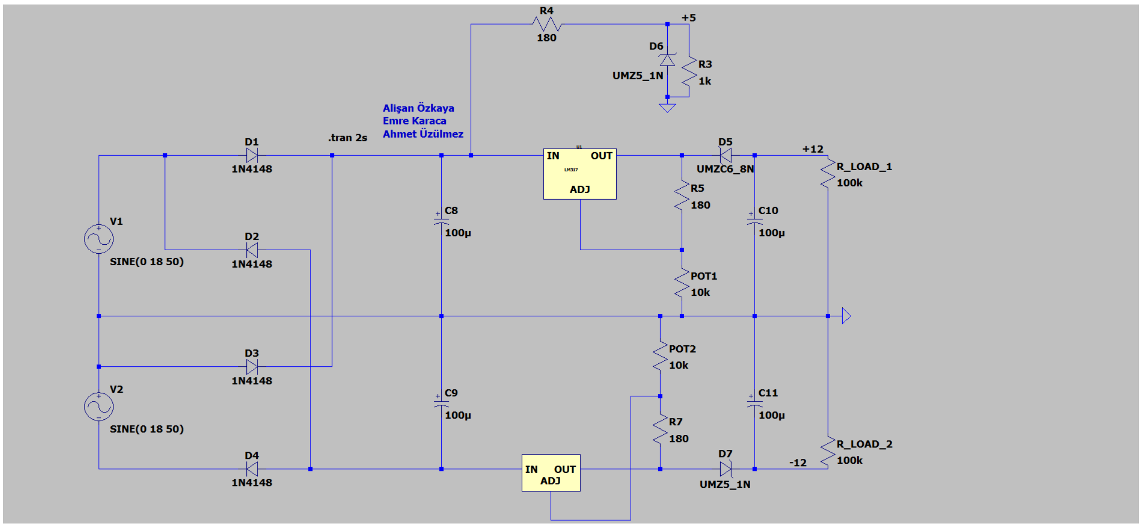

Figure 2: The circuit design

The circuit design and the block diagram are shown together below

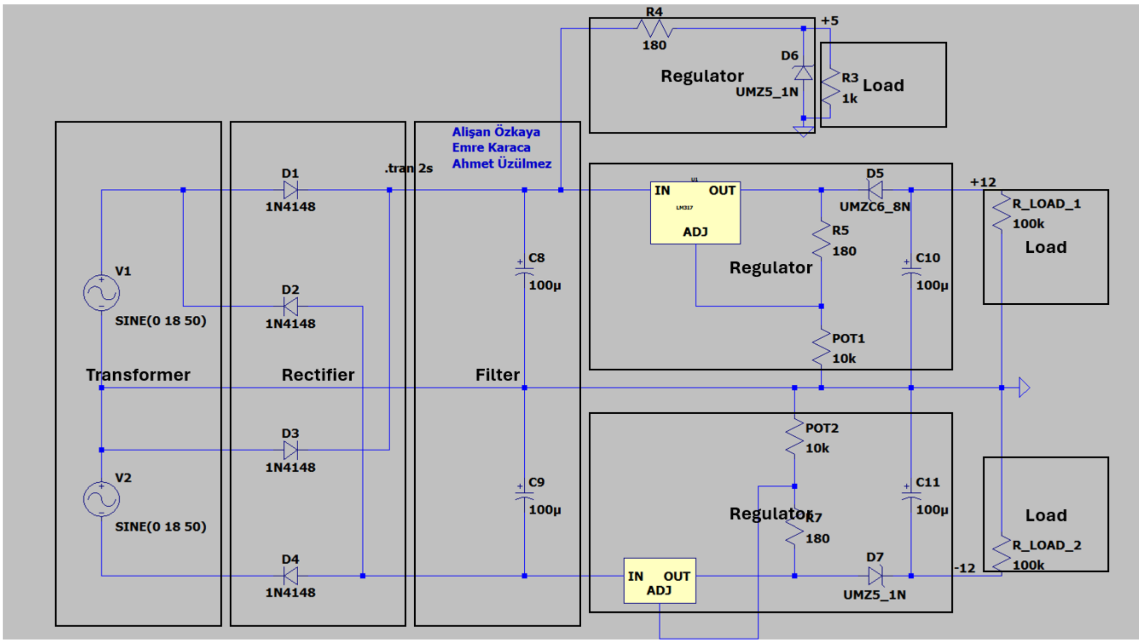

Figure 3: Block diagram and circuit design combined

4 Project working principles

Transformer: This block only has a transformer that is used to take the outlet voltage and change it to 18V and 4w. It uses electromagnetic induction with the usage of coils if we want to explain it as simply as possible.

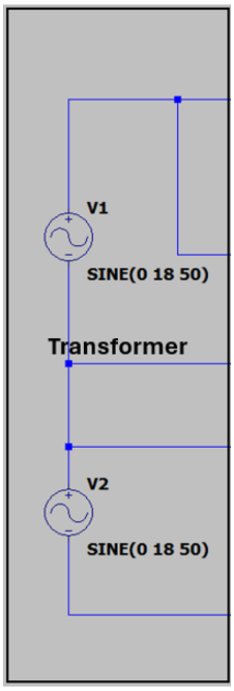

Figure 4: Transformer representation

Rectifier: This circuit has a full-wave rectifier that is constructed with four 1n4148 diodes. The purpose of this rectifier is to convert both halves of each waveform into positive pulses. These positive pulses from output can be named as 'pulsating DC signal'. Our rectifier has two outputs, one of them always gives positive the other one always gives negative half-waves.

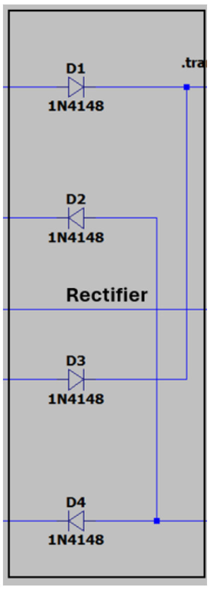

Figure 5: Rectifier representation

Filter: To smooth out these pulses, a capacitor is added for both outputs of the rectifier. Capacitors store energy and discharge it during the pulses. This results in a reduced ripple voltage that smooths the output.

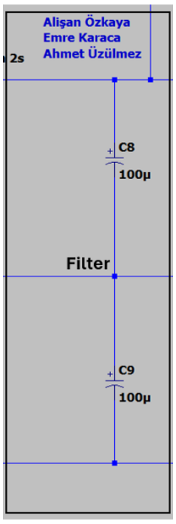

Figure 6: Filter representation

Regulator: The regulator for the +5 output is a Zener diode that limits the output voltage to 5.1V.

For the 0-12 adjustable output the regulation is mainly done by the LM317T adjustable voltage regulator. The adjusting is done by the potentiometer connected between the adjust leg of the LM317T and the ground. The datasheet suggests the usage of a 180-ohm resistor between the potentiometer and the output of the regulator. Then a Zener diode is used to limit the voltage passing to the output since the transformer gives 18V to the circuit. On top of that the regulator gives minimum of 1.2V contrary to requested minimum 0V. This resulted in us using a higher transformer than normally what we would choose and limiting the excess voltage with the Zener diode we have used. Then a capacitor was used to smooth out the regulator's output.

For the 0-(-12) adjustable output the same principles used as the 0-12 output but there were two main differences. Firstly we used LM337T instead of 317 and secondly, the Zener diode was connected reverse because the oncoming voltage from the regulator was negative.

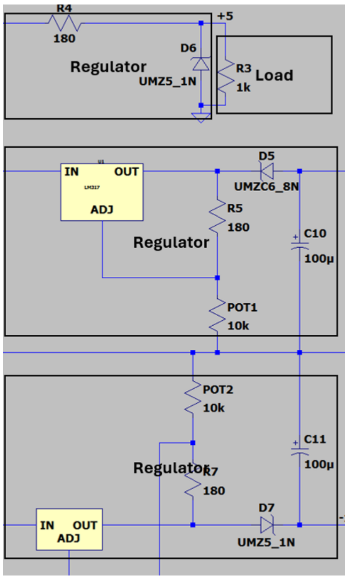

Figure 7: Regulator representation

Load: This part is just a resistor to give us a place to measure requested outputs. The Outputs are measured between the load and the regulator. We used a resistor with a very high resistance to be able to ignore the voltage loss from the resistor and have a very low current for not damaging the parts used such as diodes and capacitors.

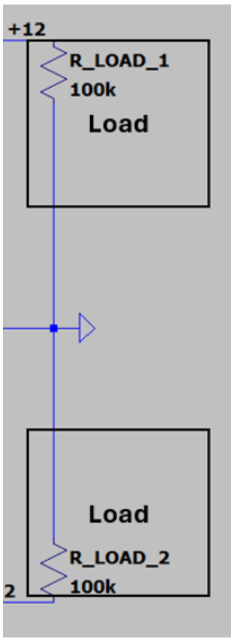

Figure 8: Load representation

5 Component list

As a precaution, we purchased every product with spares except the potentiometers, breadboards and the transformer. There was also a minimum purchase limit for resistors. The total cost is less than the given limit by a large proportion. The component list is given below.

Prize List				
Component	Manufacturer	Unit Price(TRY)	Quantity	Total(TRY)
18V / 4w Transformer	Nest	150	1	150
1n4148 Diode	MIC	0,33	12	3,96
100uF Capacitor	Koshin	0,81	12	9,72
180R Resistor	Yuetai	0,39	50	19,5
1K Resistor	Yuetai	0,12	50	6
100K Resistor	Yuetai	0,12	50	6
10K Potentiometer	Spike	5,68	2	11,36
6V8 1W Zener Diode	MIC	1,64	6	9,84
5V1 1W Zener Diode	Sentech	1,64	6	9,84
LM317T Adj. Positive Voltage Regulator	ST	9,85	2	19,7
LM337T Adj. Negative Voltage Regulator	Freescale	27,5	2	55
Breadboard 830 Point	Nest	34,48	2	68,96
Total cost				369,88

Table 1: Component list and their costs

LM317: LM317 is a adjustable 3-terminal positive voltage regulator capable of supplying 1.5A and more current between 1.2 to 37V range.

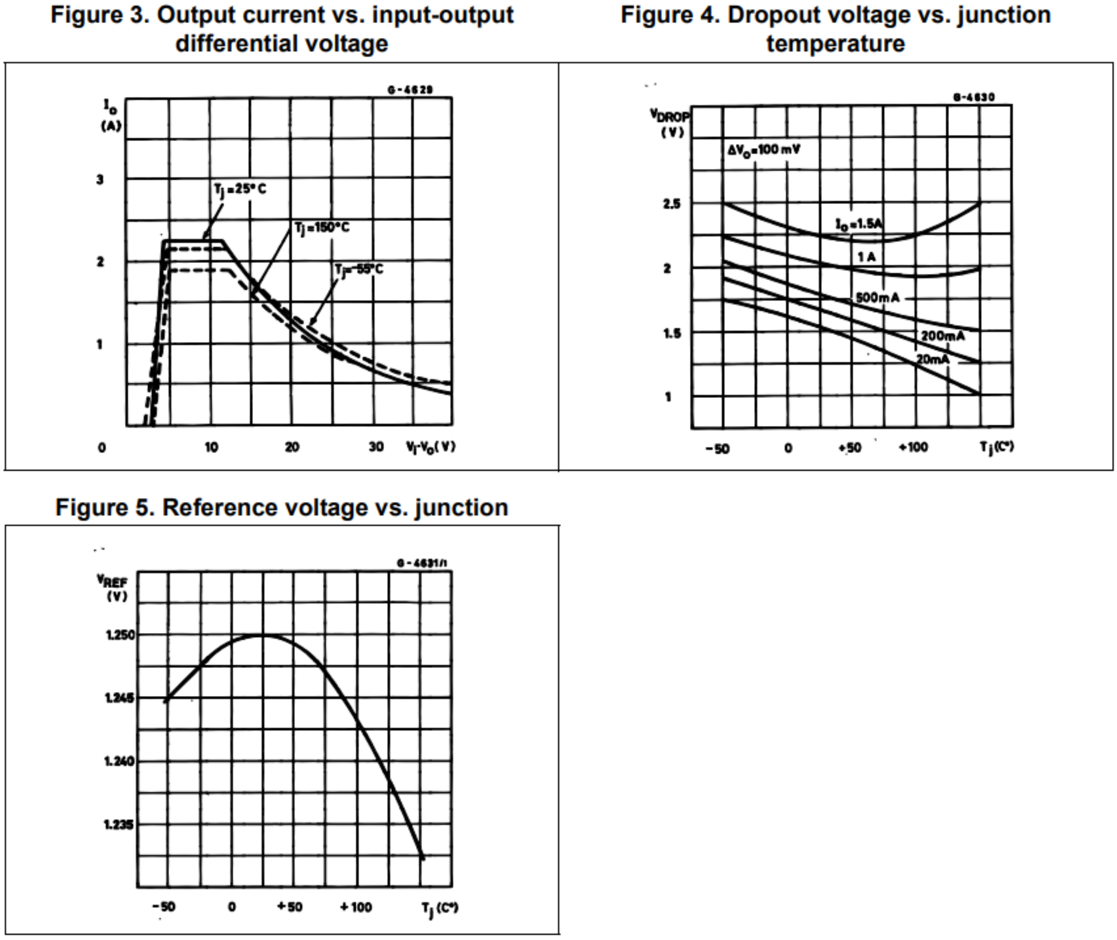

Figure 9: Important characteristics for LM317 acquired from it's datasheet

LM337T: LM337 is a adjustable 3-terminal negative voltage regulator capable of supplying -1.5A and more current between -1.2 to -37V range.

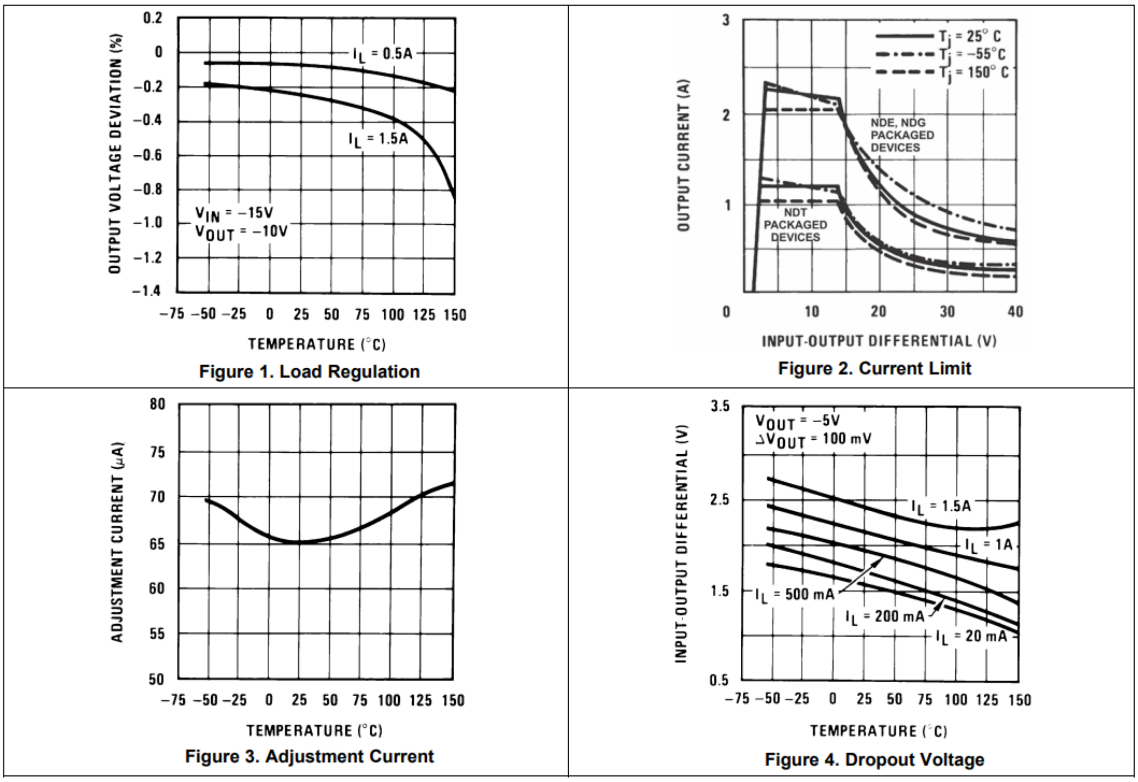

Figure 10: Important characteristics for LM337 acquired from it's datasheet

6 Simulation results

We tested six different situations to prove that outputs aren't dependent on each other. We changed the resistances of potentiometers to obtain these situations.

Here is a table below to summarize the simulation results

POT1 (ohm)	POT2 (ohm)	V(+12) (V)	V(-12) (V)	V(+5) (V)
10k	10k	11.78	-11.97	5.12
1.5k	10k	7.80	-11.97	5.12
0	10k	0.01	-11.97	5.12
10k	1k	11.78	-1.51	5.12
10k	0	11.78	0.00	5.12
0	0	0.01	0.00	5.12

Table 2: Simulation results

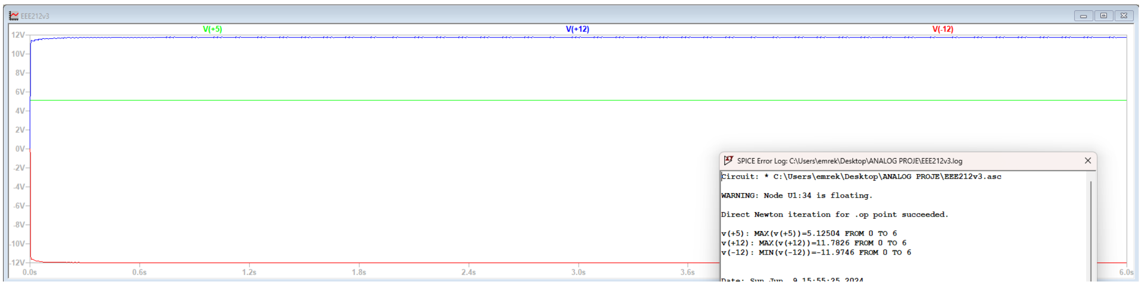

Figure 11: Simulation results for POT1=1.5k, POT2=10k

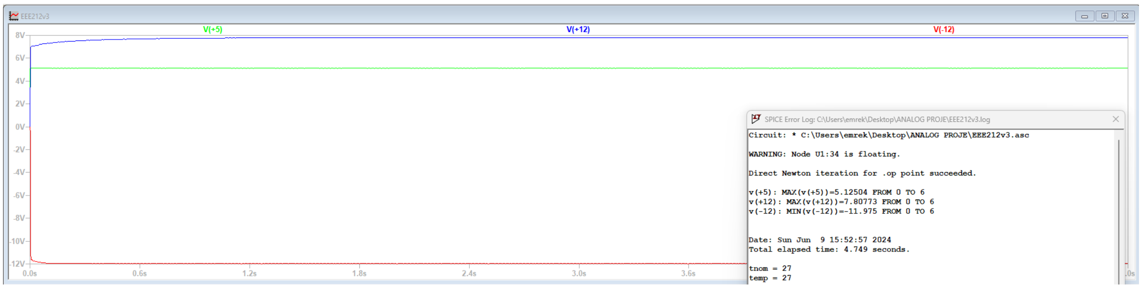

Figure 12: Simulation results for POT1=1.5k, POT2=10k

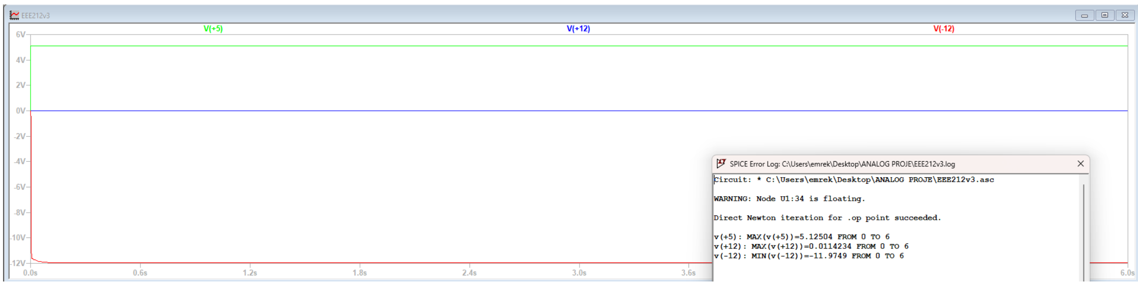

Figure 13: Simulation results for POT1=0, POT2=10

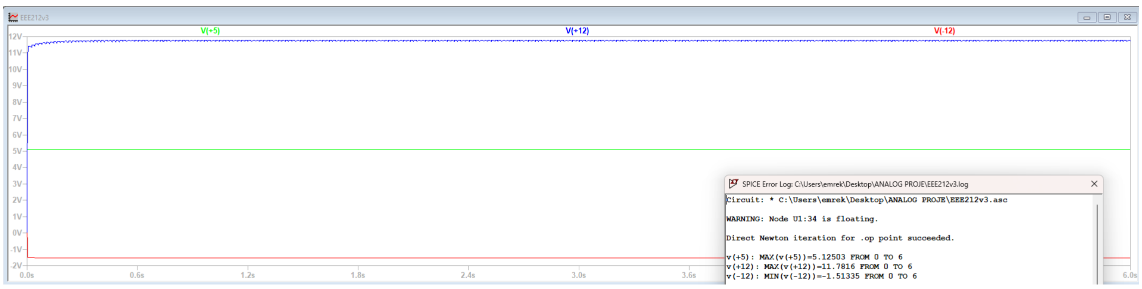

Figure 14: Simulation results for POT1=10k, POT2=1K

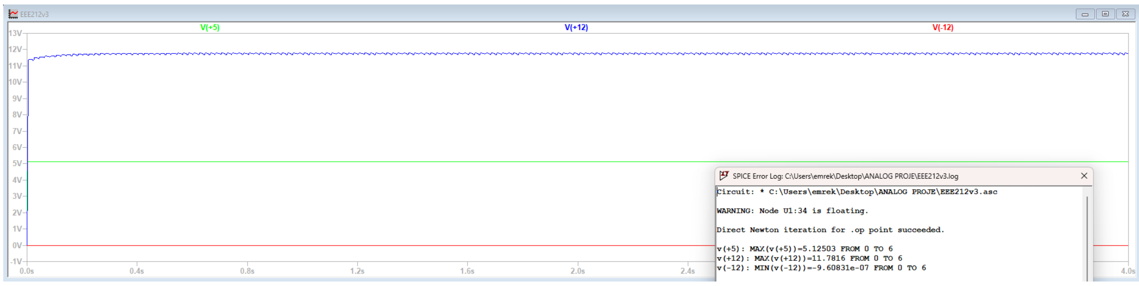

Figure 15: Simulation results for POT1=10k, POT2 = 0

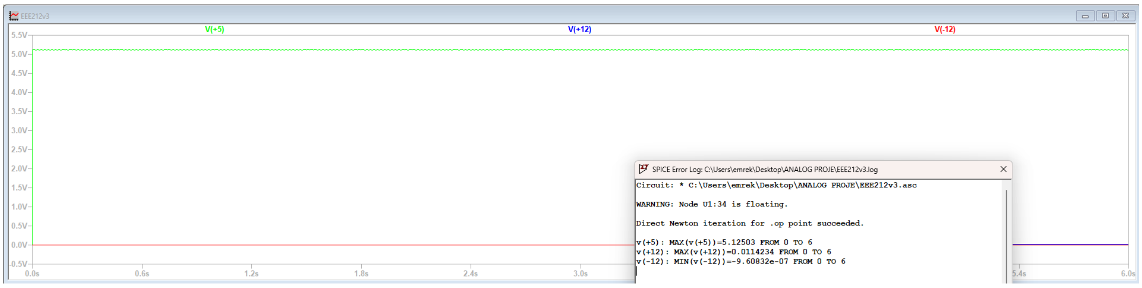

Figure 16: Simulation results for POT1=0, POT2 = 0

7 Experiment results

We tested seven different situations to prove that the outputs are independent. Except for the last three results, the only adjustments made were the potentiometers. The last three measurements are the outputs while cutting the other two outputs.

A table to summarize the results is given below

POT/+12	POT/+12	+5V output	V(+12) (V)	V(-12) (V)	V(+5) (V)
MAX	MAX	Active	12.1	-12.5	5.2
MAX	MIN	Active	12.1	-0.4	5.2
MIN	MAX	Active	0	-11.7	5.2
MIN	MIN	Active	0	-04	5.2
Disabled	Disabled	Active	Disabled	Disabled	5.2
MAX	Disabled	Disabled	0.00	Disabled	Disabled
Disabled	MAX	Disabled	0.00	5.-12.1	Disabled

Table 3: Simulation results

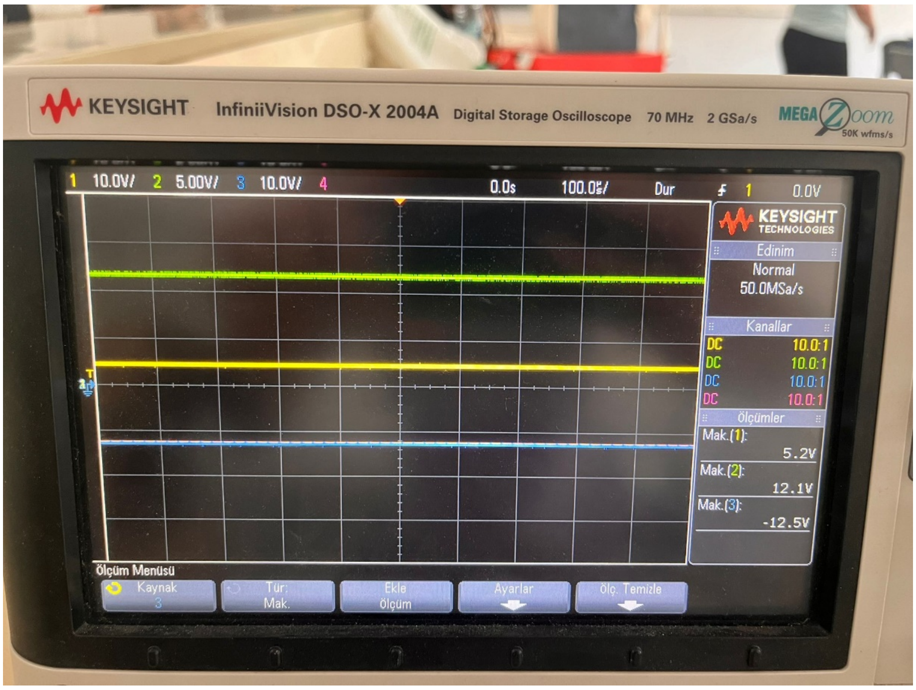

Figure 17: Experimental results when both potentiometers are adjusted to the maximum resistance

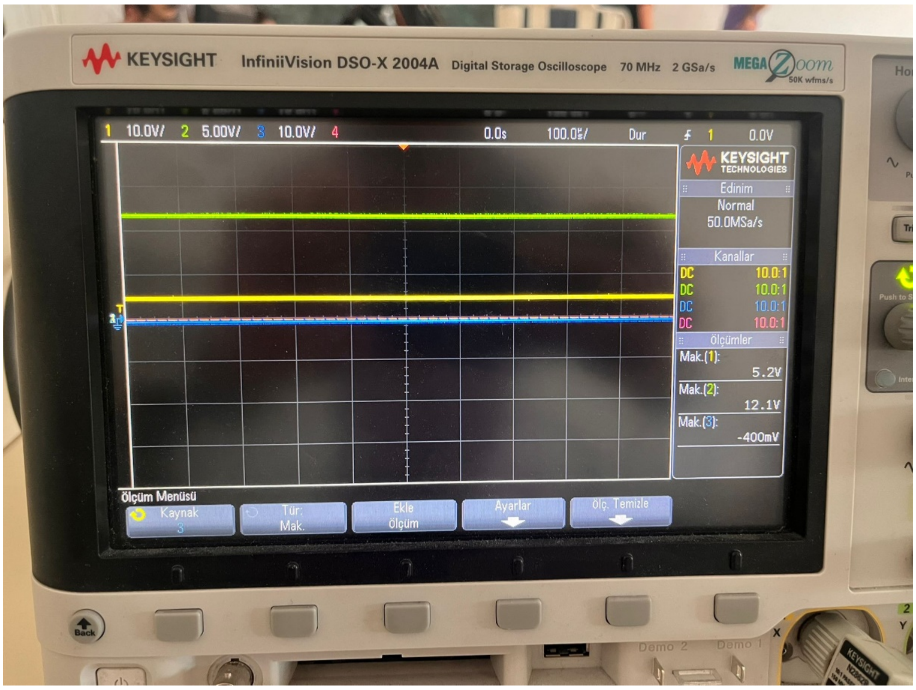

Figure 18: Experimental results when the potentiometer of '-12' output is adjusted to minimum resistance

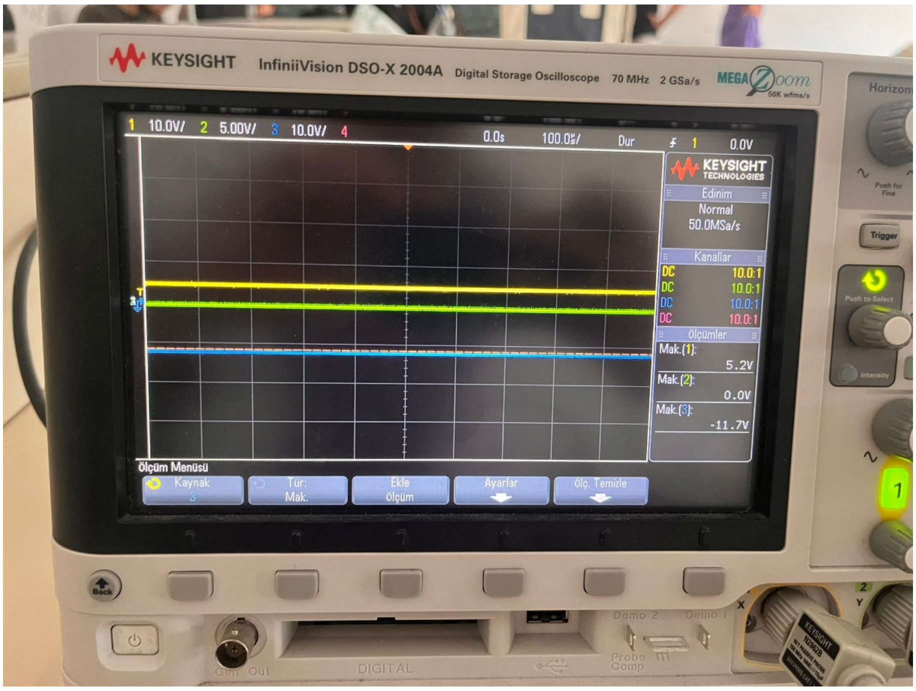

Figure 19: Experimental results when the potentiometer of +12 output is adjusted to minimum

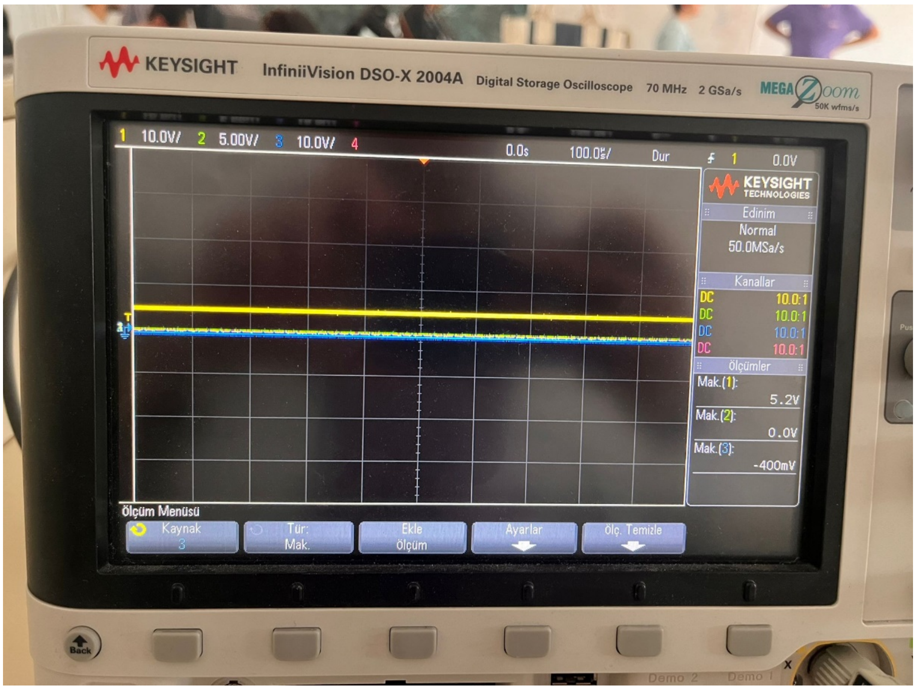

Figure 20: Experimental results when the both potentiometers are adjusted to minimum

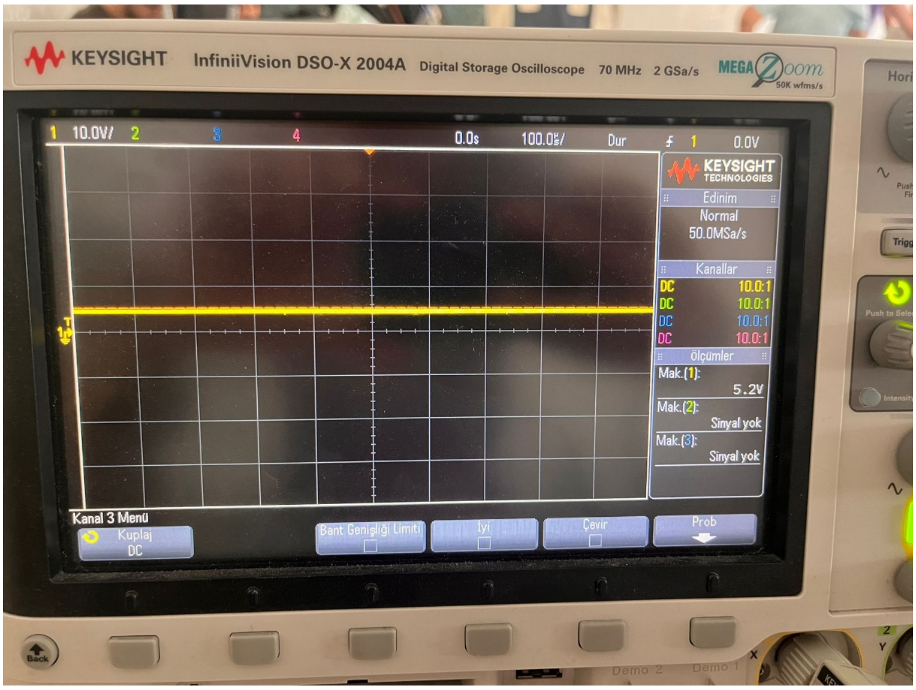

Figure 21: Experimental results when the -12V and +12V outputs are disabled, only +5V output is active

Figure 22: Experimental results when the -12V and +5V outputs are disabled and only +12V output is active

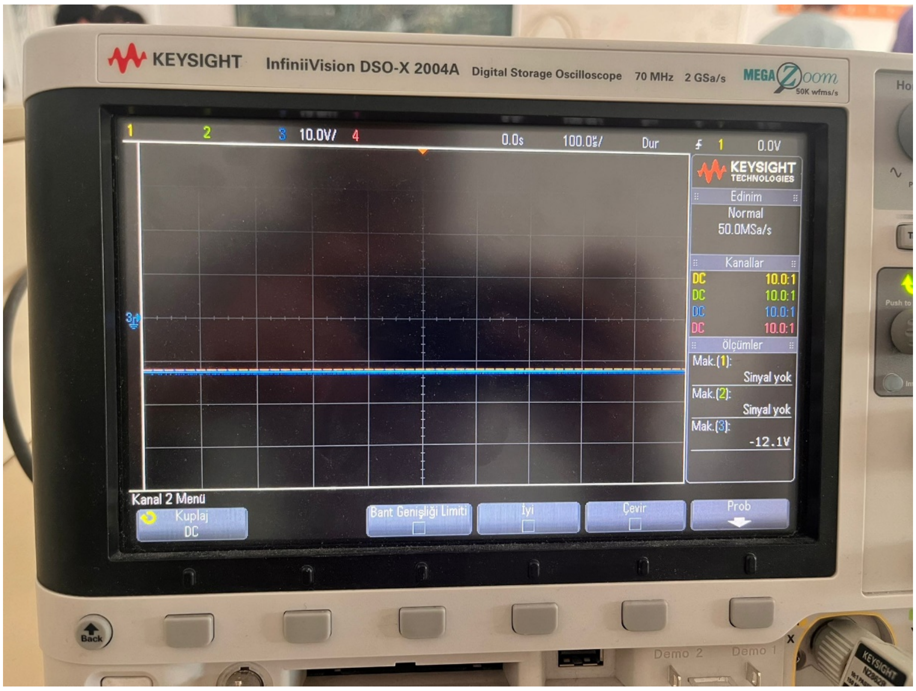

Figure 23: Experimental results when the +12V and +5V outputs are disabled and only -12V output is active

8 Conclusions

The design of the DC power supply with three outputs that are adjustable 0-12V, adjustable 0-(-12)V, and constant 5V successfully met the design requirements.

Firstly the simulation results confirmed the independence of the outputs. Adjusting one output did not significantly affect the others, shown in the table.1. For example, changing POT1 while keeping POT2 constant yielded expected variations in the positive voltage without impacting the negative or 5V outputs. This process also made deciding and acquiring parts easier since we could try out different variations to get the desired results for the experiment. Furthermore, these results confirmed that the circuit we planned to build is suitable to meet the output requirements of this project. These results made us start the process of obtaining the required parts, building the circuit and experimenting with it.

Secondly, the experimental results validated the simulation results, showing expected behavior. We mainly wanted to confirm that outputs are independent and added these results to table.2. To summarize these results, the maximum outputs were approximately 12.1V, -12.5V, and 5.2V. Even when specific outputs were changed or disabled, the active outputs remained stable. It shows that the circuit we have built works to meet the output requirements just like our simulation results. Even though there were some differences compared to the simulation results, it is most likely due to the heat and the error rate of the parts. This difference does not affect the results meeting the output requirements.

Overall, the project effectively utilized fundamental electronic components to achieve stable and adjustable outputs that are independent of each other. The successful implementation underscored the importance of voltage regulation and current management. In conclusion, the DC power supply project achieved its objectives, showing reliable performance and teaching us the critical aspects of power supply design, including output independence and stability. The experience we gained from this project will be useful for planning, building and documenting more advanced projects.