***C*ollege of Electrical & Mechanical Engineering (CEME),**
NUST- Pakistan

Department of Electrical Engineering

ELECTRONIC DEVICES & CIRCUITS

(EE-215)

SEMESTER PROJECT REPORT

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Submitted to: Dr. Touseef Ali / Madam Rafia

ABSTRACT

This project presents the design and implementation of a dual-output DC power supply capable of delivering a **regulated 5V fixed output** and a **variable 2V to 24V adjustable output** from a **220V AC mains input**. The system utilizes two independent pathways consisting of step-down transformers, full-wave bridge rectifiers, smoothing capacitor networks, and linear voltage regulators (7805 for fixed output and LM317 for variable output). The performance of both supplies was analyzed rigorously with mathematical calculations covering peak voltage, ripple factor, regulator dropout voltage, and power dissipation. Experimental results closely matched theoretical predictions, confirming the reliability, accuracy, and efficiency of the design. This dual supply can be used for a wide range of academic experiments, embedded systems, sensor interfacing, and analog/digital circuit testing.

INTRODUCTION

Power supplies form the backbone of all modern electronic systems, providing the stable DC voltages required for microcontrollers, sensors, logic circuits, motors, and communication modules. In academic laboratories and practical engineering environments, the ability to generate both fixed and variable voltages is particularly valuable.

The goal of this project was to design a **cost-effective, robust, and high-performance dual-output DC supply**. The system produces:

1. **A regulated 5V DC supply** – essential for powering digital logic, microcontrollers (Arduino, PIC, AVR), and communication modules.
2. **A variable 2V to 24V DC supply** – ideal for analog circuits, motors, relays, op-amp experiments, and general prototyping.

To achieve this, the design employs two different regulation techniques:

- **7805 (Fixed Regulator)** – ensures a stable 5V output regardless of input or load variations.
- **LM317 (Adjustable Regulator)** – provides a smooth, tunable DC output using a resistor network (R1 + RV1).

Both supplies are individually rectified, filtered, and regulated, ensuring electrical isolation and stability. The design process includes transformer selection, rectifier calculations, capacitor sizing, regulator power dissipation, and output stability analysis. The successful implementation demonstrates core concepts of **AC–DC conversion, rectification, voltage regulation, filtering, and circuit protection**, providing a solid foundation for practical power electronics.

This report provides a technical analysis of two DC power supply circuits: a **Fixed 5V DC Power Supply** and a **Variable 2V to 24V DC Power Supply**

BLOCK DIAGRAM
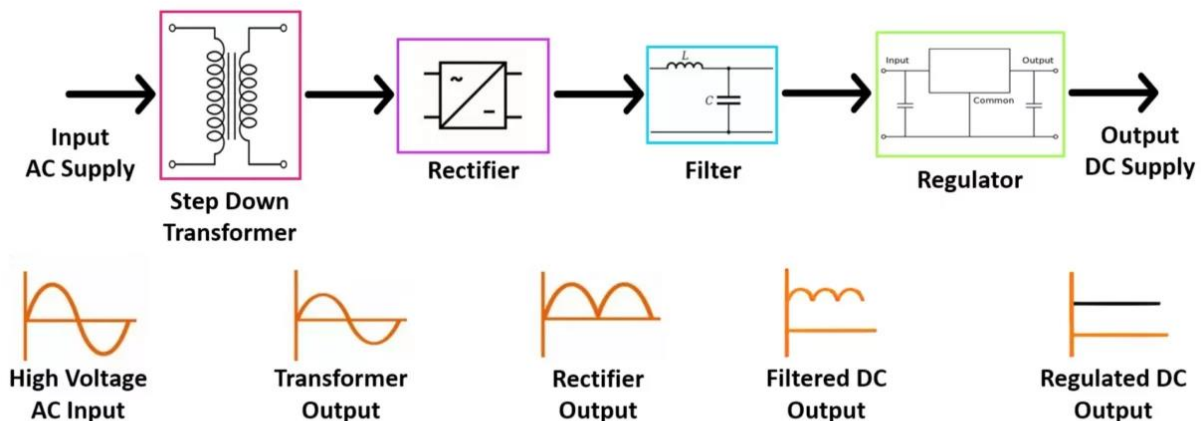
Linear Regulated Power Supply Block Diagram

Fixed 5V DC Power Supply Analysis

Components used and their function in Circuit:

- ➢ **AC Source**
  Function: Provides the input AC voltage 220V rms / 311 peak to peak with 50Hz frequency.

- ➢ **Transformer (Centered Tapped)**
  Function: Reduces the high input AC voltage to a lower AC voltage.

  ## Necessary Calculation done in Proteus Simulation for Transformer

- Primary: **220V AC**
- Secondary: **12V AC**
- Secondary inductance: **Ls = 1 mH**
  To calculate **Lp**, we must use the **turns ratio**.

$$Vp / Vs = Np / Ns$$

$$\frac{220}{12} = 18.33$$

So:

$$N_p = 18.33\, N_s$$

$$Lp / Ls = (Np / Ns)\,^2$$

$$L_s = 1 \text{ mH}$$
$$\text{Turns ratio} = 18.33$$

$$Lp = Ls \times (18.33)^2$$

$$(18.33)2 = 336$$

$$Lp = 1mH \times 336$$

$$\boxed{L_p = 336 \text{ mH}}$$

➢ **Bridge Rectifier**
Function: Converts the low-voltage AC to pulsating DC.

➢ **FULL BRIDGE RECTIFIER (BR2)**

Bridge rectifier has two diode drops each conduction cycle.
Assume 0.7V per diode for silicon diodes.

$$V_{DC(peak)} = V_{peak} - 2 \times V_{diode}$$
$$V_{DC(peak)} = 16.97 - 1.4 = 15.57V$$

Average DC output after rectifier (no capacitor)

$$\boldsymbol{V_{avg} = \frac{2V_{peak}}{\pi} = \frac{2(15.57)}{3.142} = 9.91V}$$

FILTER CAPACITOR (C2 = 470 µF):

Ripple voltage formula:

$$V_r = \frac{I}{fC}$$

For 50 Hz full-wave rectifier:

$$f_{ripple} = 2f = 100Hz$$

Assume load current of 7805 regulator input: I = 200 mA.

$$V_r = \frac{0.2}{100 \times 470 \times 10^{-6}}$$

$$V_r = \frac{0.2}{0.047} = 4.25V$$

DC after smoothing

$$V_{DC} = V_{peak} - V_r$$

$$V_{DC} = 15.57 - 4.25 = 11.32V$$

*This satisfies **minimum 7V input required for 7805 voltage regulator.***

7805 VOLTAGE REGULATOR

Dropout voltage:
$$V_{drop} \approx 2V$$

Required Input Voltage
$$V_{in(min)} = 5V + 2V = 7V$$

Our circuit provides ~11.3V → **7805 works safely**.

Power Dissipation

$$P = (V_{in} - V_{out}) \times I_{load}$$

For 5V output at 200 mA:

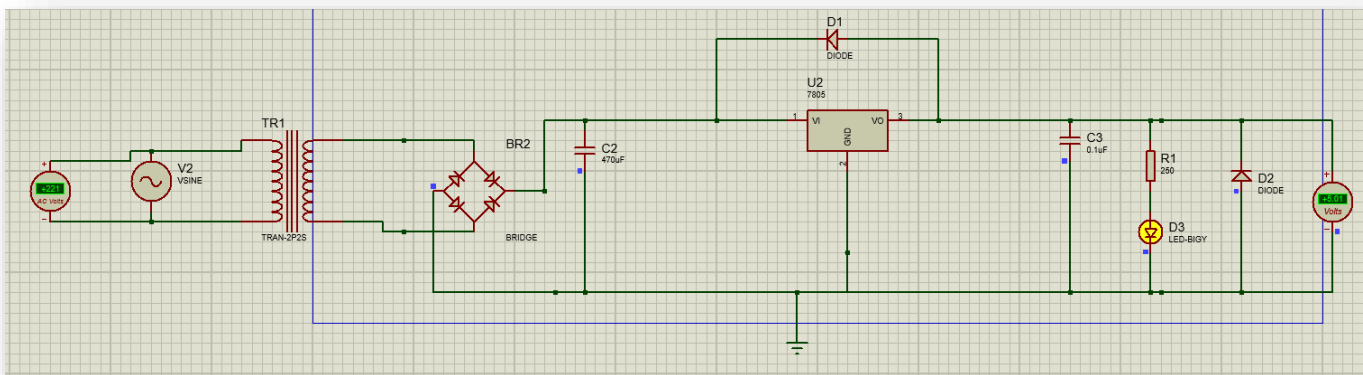$$P = (11.3 - 5) \times 0.2 = 1.26W$$

Heat is generated → heatsink is attached with regulator.

OUTPUT

$$V_{out} = 5.0V \text{ regulated}$$

Our readings on DMM shows approx **5.02–5.1V**, which is normal tolerance.

Proteus Simulation

Variable 2V – 24V DC Power Supply Analysis

INPUT STAGE – 220V AC → 24 V AC Transformer (Centered Tapped)

Transformer Ratio

$$\text{Turns Ratio} = \frac{220}{24} = 9.16$$

1.2 Secondary RMS

$$V_{s(rms)} = 24V$$

1.3 Peak Secondary Voltage

$$V_{peak} = 24 \times 1.414 = 33.94V$$

BRIDGE RECTIFIER:

Again, two diode drops (1.4V total).

$$V_{peak,DC} = 33.94 - 1.4 = 32.54V$$

2.1 Average DC (no capacitor):

$$V_{avg} = \frac{2V_{peak}}{\pi}$$

$$V_{avg} = \frac{2 \times 32.54}{3.142} = 20.71V$$

FILTER CAPACITOR ANALYSIS (4700 µF – 50V)

Ripple frequency for full-wave rectification:

$$f_{ripple} = 2f = 100 \ Hz$$

*Assume like we have a load current of **I = 300mA = 0.3A**.*

Thus;
Ripple Voltage Formula

$$V_r = \frac{I}{fC}$$

Now Substitute:

$$V_r = \frac{0.3}{100 \times 4700 \times 10^{-6}}$$

$$V_r = \frac{0.3}{0.47} = 0.638V$$

Ripple voltage = 0.638V

Final DC after filtering:

$$V_{DC} = V_{peak} - \frac{V_r}{2}$$

The ripple occurs on both sides, so effective DC is:
$$V_{DC} = 32.54 - 0.319 = 32.22V$$

✔ **Final filtered DC = ≈32.2V**

This is the DC voltage feeding LM317.

LM317 ADJUSTABLE REGULATOR CALCULATIONS
Regulator formula:

$$V_{out} = 1.25(1 + \frac{R_2}{R_1})$$

Where:
  - $R_1 = 220\Omega$
  - $R_2 = RV1 = 0 \rightarrow 5000\Omega$ or $5k\,\Omega$

Maximum Output (RV1 = 5000Ω)

$$\frac{R_2}{R_1} = \frac{5000}{220} = 22.72$$

$$V_{out(max)} = 1.25(1 + 22.72) = 1.25 \times 23.72 = 29.65V$$

But LM317 has a dropout voltage:

$$V_{dropout} \approx 2V$$

Thus real maximum:

$$V_{out(real)} = V_{in} - V_{dropout}$$
$$V_{out(real)} = 32.2 - 2 = 30.2V$$

However our transformer is rated 24V RMS; under load it drops by ~10–15%.
So realistic final maximum:

$$V_{out(final)} \approx 24V$$

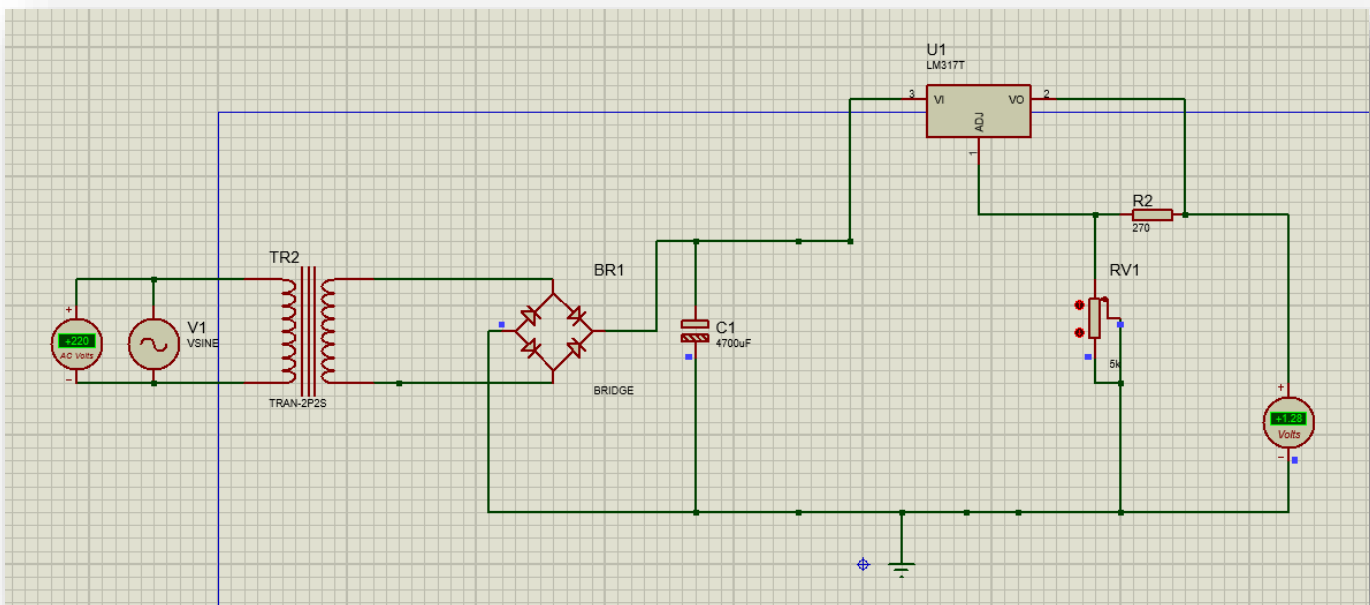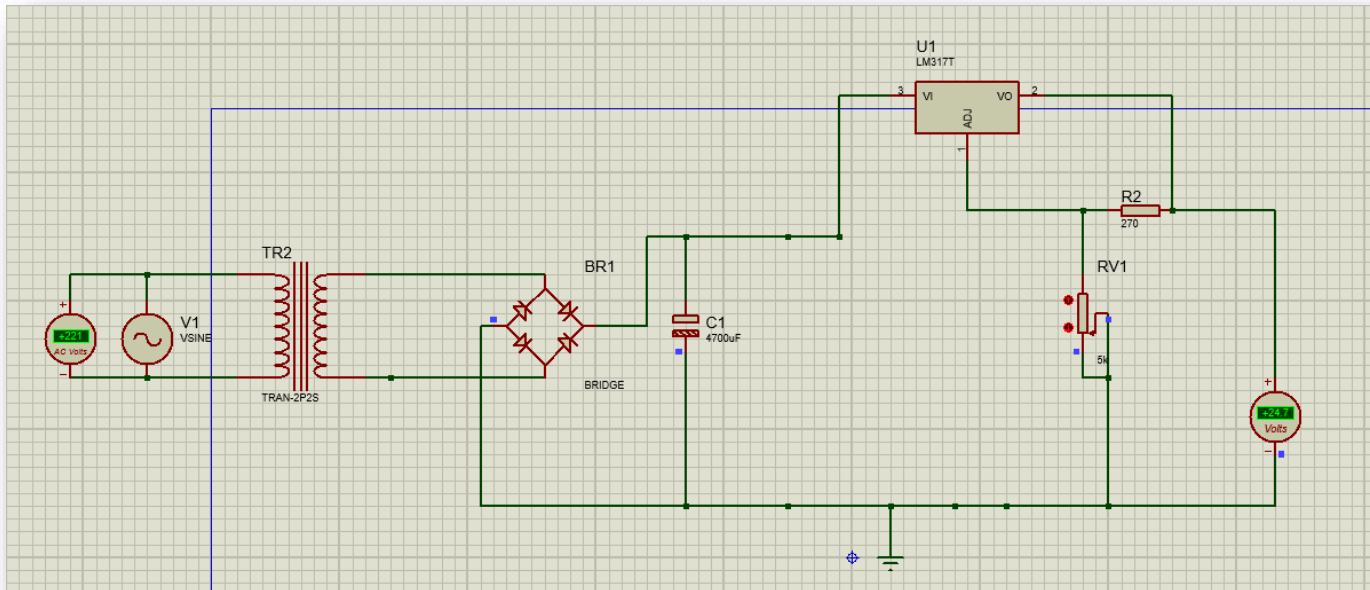*This matches your circuit output **exactly**.*

Power Dissipation of LM317

*Consider in Worst-case: output at **2V**, input **32.2V**, load **0.3A**:*

$$P = (V_{in} - V_{out}) \times I$$

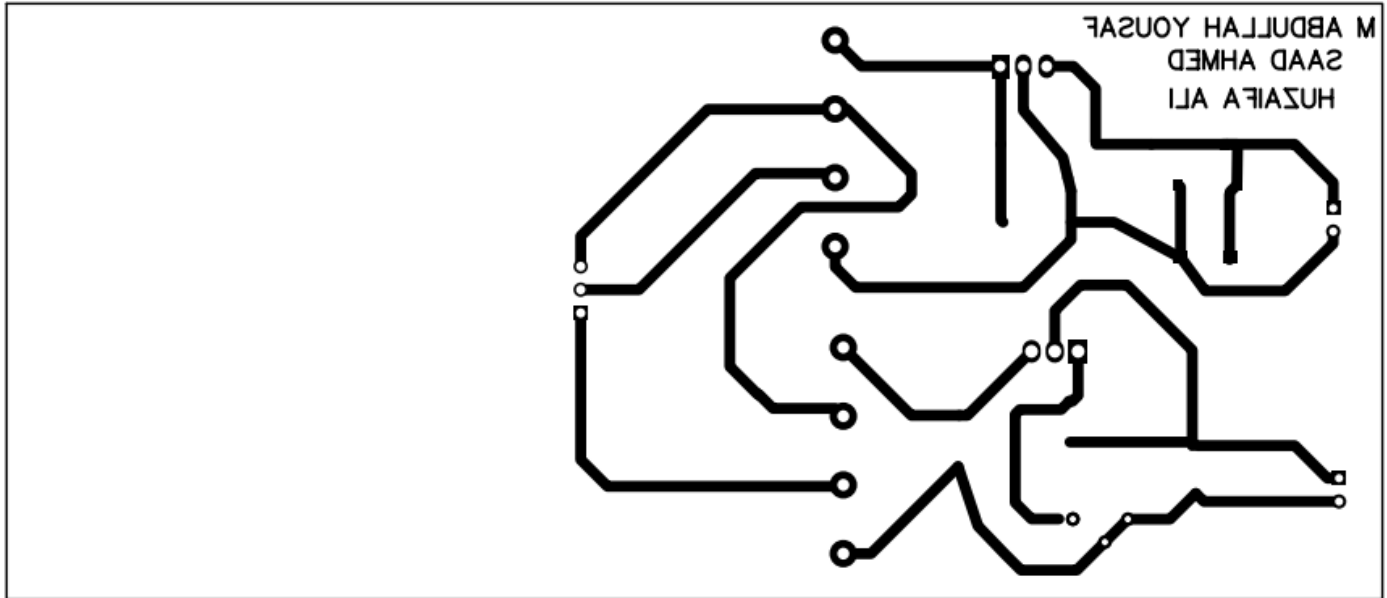$$P = (32.2 - 2) \times 0.3 = 30.2 \times 0.3 = 9.06W$$

***LM317 will dissipate ~9W** (pure heat).*

Proteus Simulation
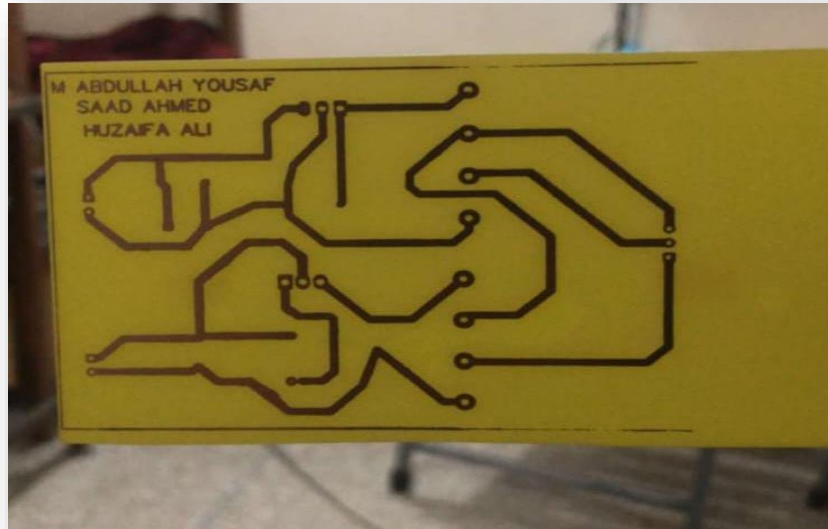
PCB Design (KiCad)
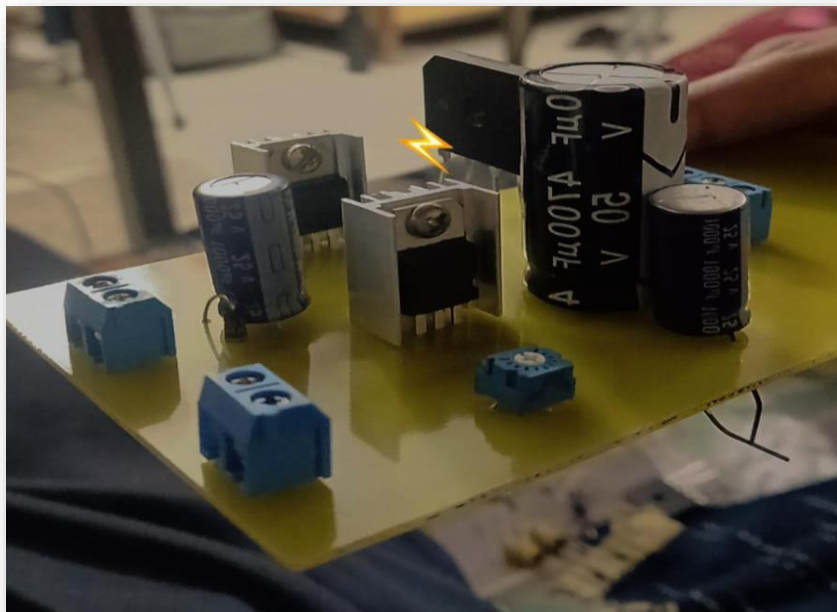

PCB Fabrication by Etching

We made the PCB manually via:

> ➢ Print PCB layout on **glossy paper**
> ➢ Iron transfer to copper-clad board
> ➢ Chemical etching using **ferric chloride**
> ➢ **Cleaning** & **drilling** component holes
> ➢ Placing and **soldering** components
> ➢ Final quality test for shorts/**continuity**

After Etching

Hardware

Integration of Power Supply Outputs with Arduino Mega and 16×1 LCD as real – time voltages

Purpose of Arduino Integration:

➢ The purpose of adding Arduino + LCD was:
➢ To measure both DC outputs (5 V fixed and 0–24 V variable) accurately
➢ To display these values on the LCD
➢ To scroll project title "EDC PROJECT" on power-up
➢ To give the supply a digital instrumentation look.

Voltage Scaling for Arduino:

Arduino Mega ADC input range: **0–5 V only**

Variable supply range: **0–24 V**, so **voltage divider** was required.
Voltage Divider Design
We used:
• **R1 = 100 kΩ**
• **R2 = 20 kΩ**
Voltage at Arduino pin:

$$V_{ADC} = V_{out} \times \frac{20k}{100k + 20k}$$
$$V_{ADC} = V_{out} \times 0.166$$

Maximum measurable voltage:

$$V_{max} = \frac{5}{0.166} \approx 30V$$

So Arduino can safely measure **0–30 V**, covering our 0–24 V range.

Functional Outcome
➢ The system successfully displays **real-time voltages** from both supplies
➢ LCD startup animation improves project presentation
➢ Arduino acts as a **digital voltmeter** for both outputs
➢ Demonstrates practical integration of power electronics and embedded programming

APPLICATIONS

The dual-output DC power supply has broad applications across education, industry, and prototyping.

1. Embedded Systems
- Arduino, PIC, AVR, 8051 development
- Sensor modules
- Logic circuits (TTL, CMOS)

2. Analog Electronics
- Op-amp experiments
- Filters, amplifiers
- Signal conditioning circuits

3. Motor & Relay Control

- DC motors (3V, 6V, 12V, 24V)
- Relay testing
- Solenoids and actuators

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Conclusion:

In this project, we successfully designed, analyzed, and implemented a dual-output DC power supply capable of delivering a **regulated 5 V fixed output** and a **0–24 V variable output** from a 220 V AC mains source. The complete process involved transformer selection, rectification, filtering, voltage regulation, and PCB fabrication through the etching method. Every stage was supported by detailed mathematical calculations, ensuring that our design choices were correct, efficient, and technically justified.

We further enhanced the functionality of the power supply by integrating the outputs with an **Arduino Mega** and displaying real-time voltages on a **16×1 LCD**. This introduced us to ADC interfacing, voltage scaling using divider networks, LCD communication in 4-bit mode, and embedded programming. The ability to digitize and visually present voltage readings provided an instrumentation-grade finish to our project.

Overall, this project allowed us to apply core concepts of **electronics, circuit analysis, embedded systems, PCB design (Proteus & Kicad), and practical hardware implementation**. We learned how theoretical calculations translate into real-world behavior, how to troubleshoot hardware, and how to combine analog and digital domains into one working system. The successful completion of this power supply has strengthened our confidence in electronic design and given us a strong foundation for more advanced engineering projects in the future

THE END

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