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EN2091 - Analog Voltmeter
Group Wired Wizards

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Contents

1 Introduction

An analog voltmeter is a fundamental instrument used to measure electrical potential difference, or voltage, in a circuit. It displays measurements using a needle that moves across a calibrated scale. These devices work based on the principle of converting electrical signals into mechanical motion, allowing for a visual representation of the voltage being measured. Analog voltmeters are crucial for various applications, from basic troubleshooting in electronics to sophisticated scientific experiments.

2 Working Principle

Analog voltmeters use a magnetic field to measure voltage, turning it into a visible pointer movement.

2.1 Key Findings

- Coil Movement - A current flows through the coil, creating a magnetic field that interacts with a permanent magnet.
- Pointer Deflection - The coil's movement rotates the pointer, which indicates the voltage on a calibrated scale.
- Voltage Measurement - The scale is calibrated to directly show the voltage level measured by the instrument.

3 System Model

Analog voltmeters work by converting electrical signals into mechanical movements.

- Signal Conversion - Analog voltmeters convert electrical signals into mechanical movements.
- Amplification - Amplifiers boost the signal strength for accurate reading.
- Meter Movement - Meter movements provide a visual display of the measured voltage.

3.1 Design Parameters

- Analog voltmeters are designed with specific parameters to achieve desired accuracy, sensitivity, and response time.
- Accuracy refers to how closely the measured voltage matches the actual voltage. Sensitivity determines the smallest voltage change detectable by the meter.
- Response time is the speed at which the meter reacts to changes in the input voltage. These parameters are influenced by the type of meter movement, amplifier, and other components used.
- Designers carefully select components and optimize circuit configurations to meet the specific requirements of the intended application.

4 Schematics

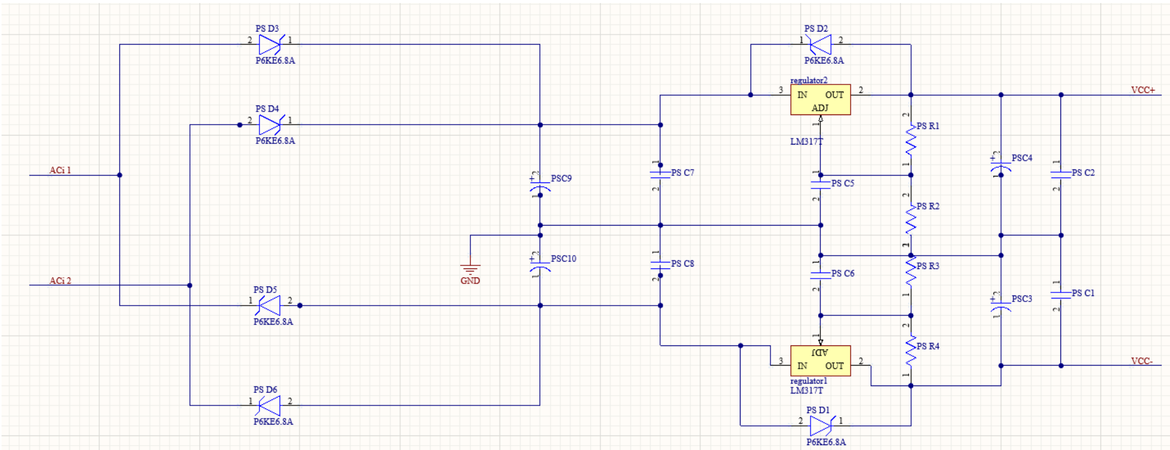

Figure 1: Power Supply

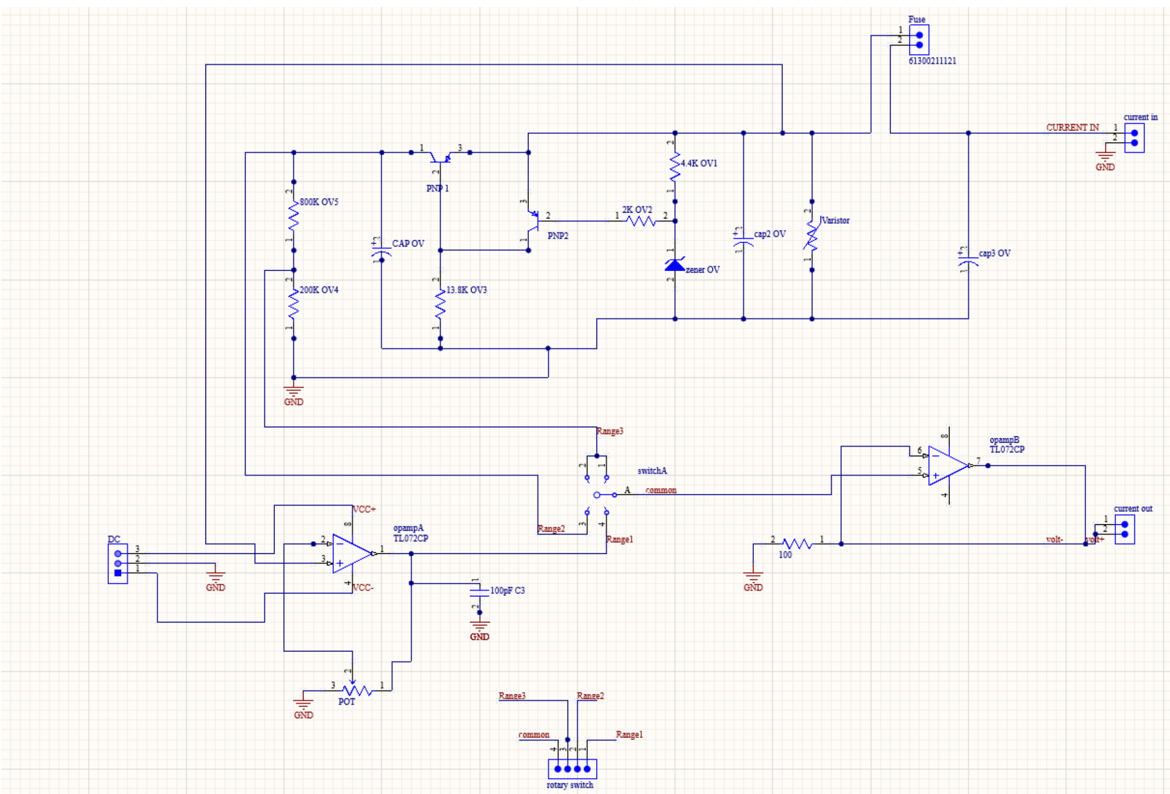

Figure 2: Over voltage and amplifier

5 PCB design

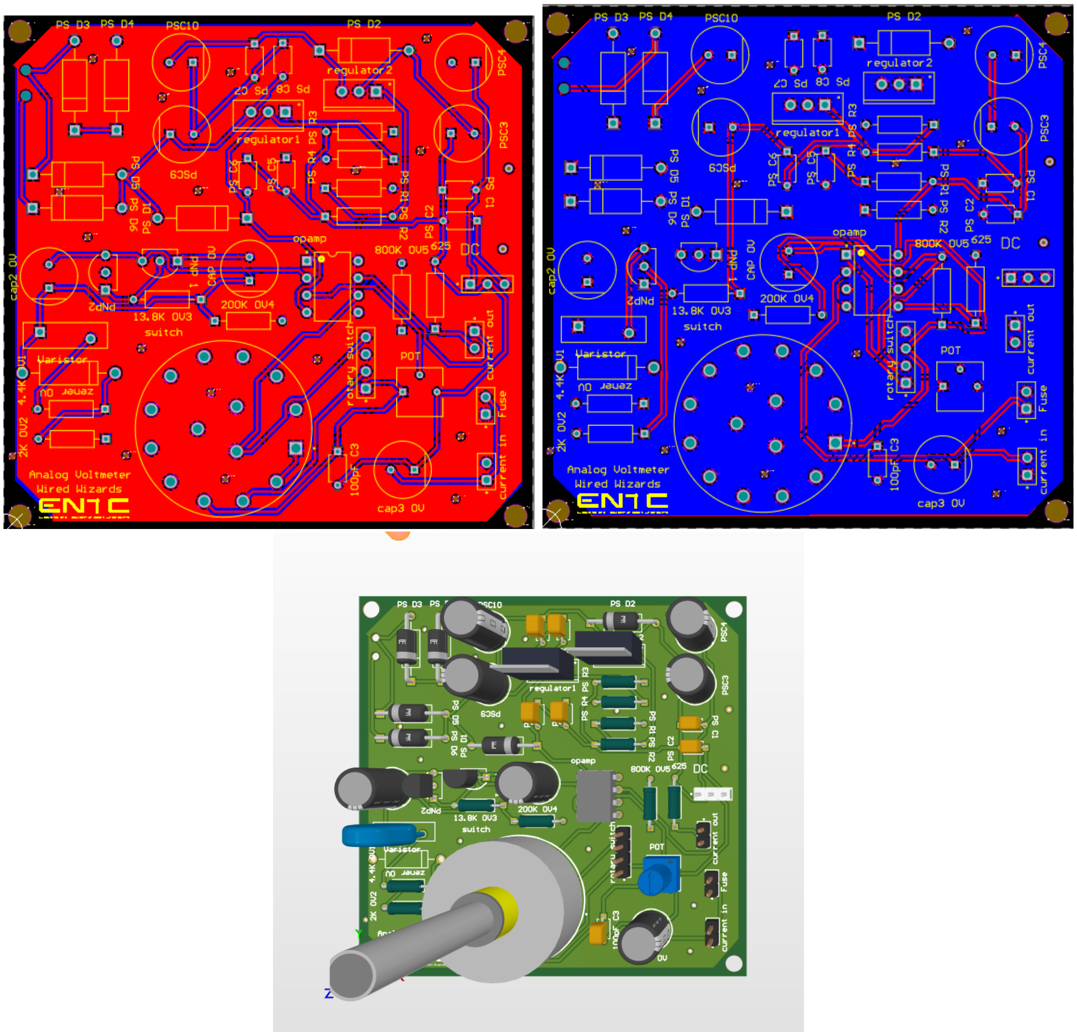

Figure 3: PCB Design

- This is a two layer PCB
- The layout is organized, with grouped components (e.g., regulators, op-amp sections, and input/output connections).
- Component names (e.g., resistors, caps, POT, switch) are clear and well-placed.
- Vias has been placed to input AC current

6 Enclosure Design

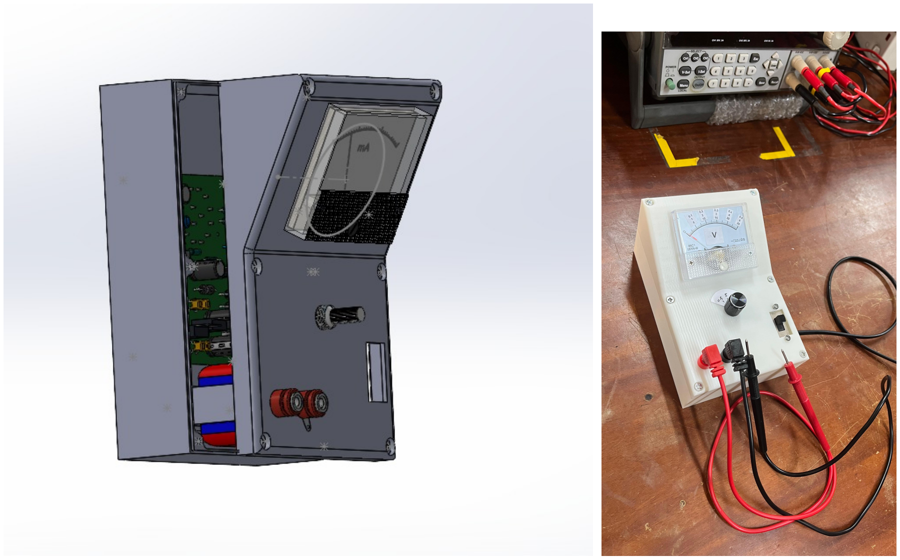

Figure 4: Enclosure Design

- Compact Design - The enclosure has a clean, well-structured look with a sloped front panel for the analog meter, which is ergonomically efficient for reading values.
- Clear Display - The placement of the analog meter at an angle makes it easily visible for users.
- Good Component Layout - Internal components, including the PCB, appear neatly arranged, which enhances accessibility for maintenance or repairs.
- The toggle switch and terminals are logically positioned for ease of use.
- The screw placements allow for easy opening and closing of the enclosure
- We added labels near the rotor switch to improve user-friendliness.

7 simulation results

- We used proteus software for simulation
- We ensure that the switching mechanism is robust, and clearly document the ranges for usability and accuracy
- Tested the ripple voltage at the output of C7 and C8 to confirm stability, as filtering capacitors (470µF) should provide smooth DC voltage.

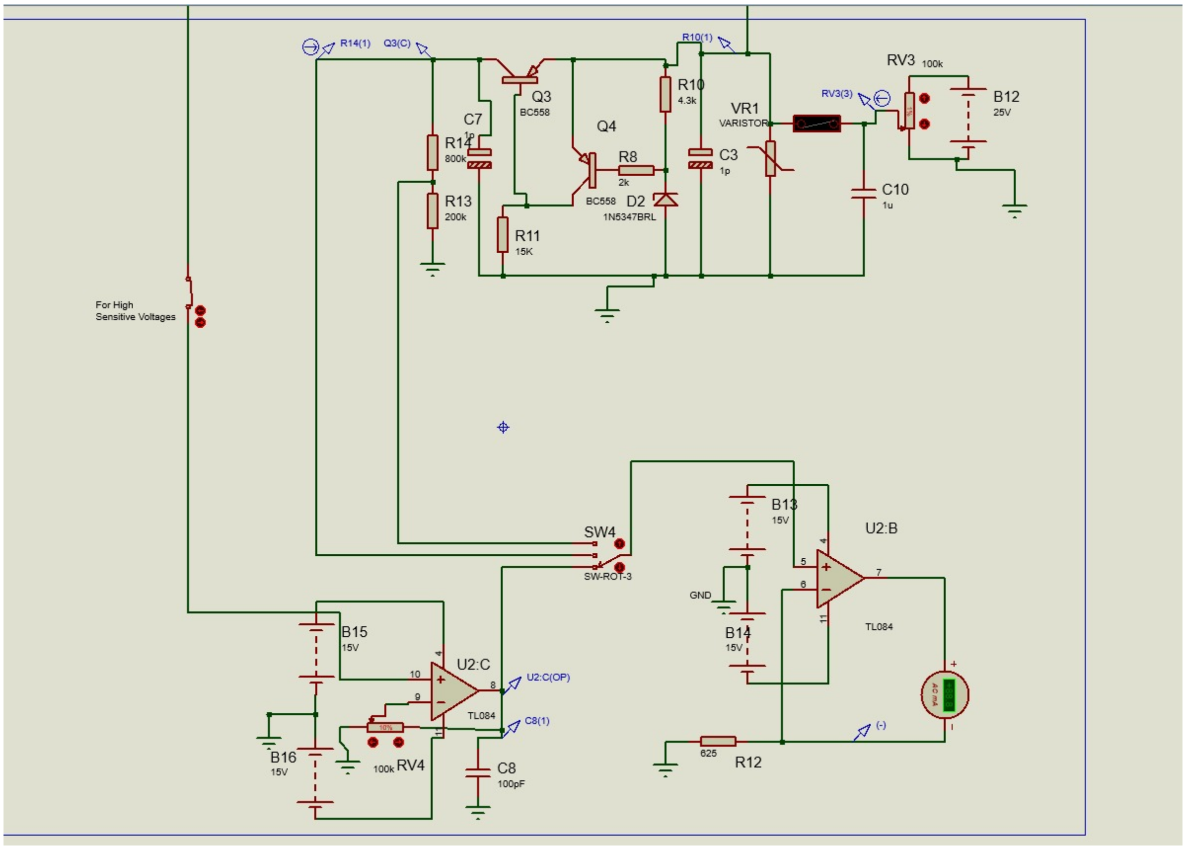

Figure 5: simulation

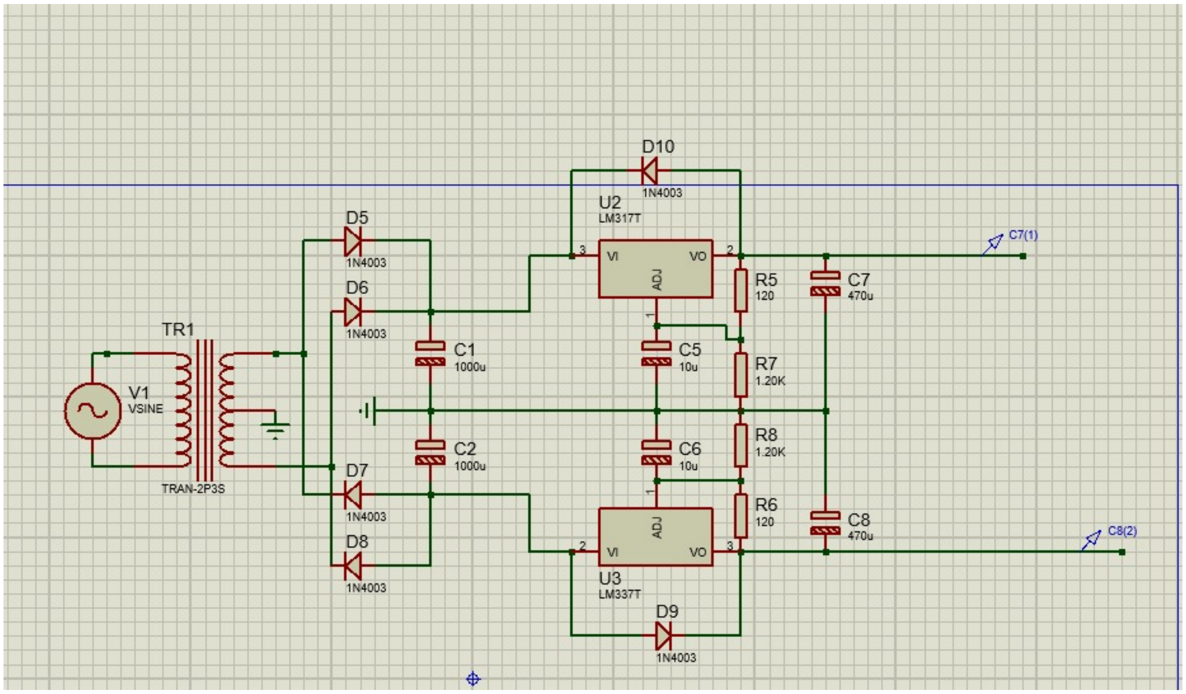

Figure 6: power supply

8 Bill of Materials

Component	Description	Quantity
tl072cp	As non inverting amplifier and voltage to current converter	1
potentiometer	to create voltage dividers	2
capacitors	for power supply and various others	10
Resistors	Various tasks	7
BC558 transistor	for overvoltage protection	2
diodes	rectifying bridge	4
transformer	to step down AC voltage	1
Voltage regulator	for the power supply	2
varistor	for overvoltage protection	1
Zenor	for overvoltage protection	1

Table 1: Bills of material

9 Conlusions and future work

The designed analog voltmeter successfully measures voltage across three distinct ranges, providing flexibility for different measurement needs. The inclusion of a reliable AC-to-DC power supply on the PCB ensures stable power delivery to critical components such as the operational amplifier, thereby improving overall performance. The precision of the op-amp and the well-designed resistive networks contribute to accurate voltage readings, while the two-layer PCB layout ensures efficient routing and reduced interference.

This project effectively demonstrates a functional, low-cost, and reliable analog voltmeter that can be applied in educational settings, laboratories, and basic electronic troubleshooting scenarios.

- Range Auto-Selection - Implement an automatic range selection system to eliminate the need for manual switching between the three voltage ranges.
- Add a battery-powered option for portability and field use

10 References

The analog voltmeter project incorporates multiple design principles and circuit configurations to ensure accurate and reliable voltage measurements. During the development phase, the following references were instrumental in shaping the design:

1. **Overvoltage Protection Circuit**
   To safeguard the circuit components from voltage spikes and ensure durability, we implemented an overvoltage protection circuit as outlined in the guide from Circuit Digest. The details of the circuit can be found at https://circuitdigest.com/electronic-circuits/overvoltage-protection-circuit.

2. **TL072 Operational Amplifier**
   The TL072 low-noise JFET-input operational amplifier was selected as a core component for signal conditioning and processing due to its high input impedance and low offset voltage. Technical specifications and design guidelines were obtained from the Texas Instruments product page at https://www.ti.com/product/TL072.

3. **BC558 PNP Transistor**
   The BC558 transistor was used for amplification and switching applications in the circuit. Its low noise and high current gain made it suitable for our design. The detailed datasheet for the BC558 transistor is available at https://www.alldatasheet.com/view.jsp?Searchword=BC558.

4. **1N4749 Zener Diode**
   For voltage regulation and protection, the 1N4749 Zener diode was included in the design. It ensures stable operation by clamping the voltage at a specified level. Further details about this component can be found at https://www.futurlec.com/Diodes/1N4749pr.shtml.

5. **LM317 Adjustable Voltage Regulator**
   The LM317 was utilized to provide a stable and adjustable voltage supply to various parts of the circuit. Its versatility and ease of use made it an ideal choice. The datasheet and application notes for the LM317 are accessible at https://www.ti.com/lit/gpn/LM317.

6. **LM137 Negative Voltage Regulator**
   To generate a negative voltage supply for certain circuit elements, the LM137 regulator was employed. It offers precise voltage control in negative voltage applications. Comprehensive information is available in the datasheet at https://www.ti.com/lit/ds/symlink/lm137.pdf.