Project Report

Automatic Plant Watering System

A Unique Noble Approach without using microcontrollers.

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Introduction:

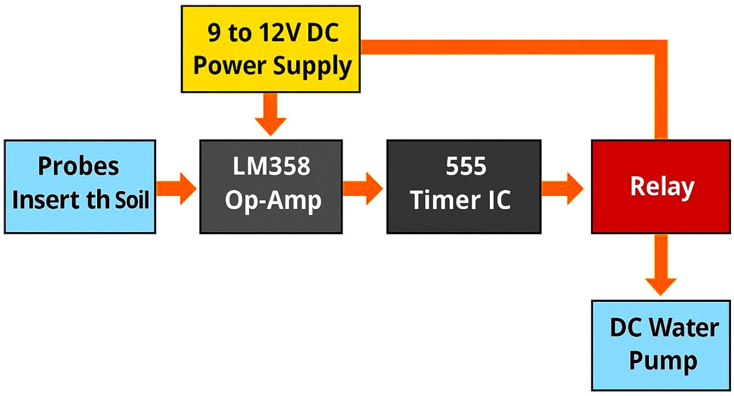
Agriculture and home gardening are crucial aspects of human life, playing a vital role in food security, sustainability, and mental well-being. With increasing urbanization and busy lifestyles, regular monitoring and watering of plants have become challenging. To address this, automation in irrigation has emerged as an efficient and sustainable solution.

This report presents a technically sound and efficient automatic plant watering system using a soil moisture sensing approach. The core of this system is a comparator-based circuit utilizing the LM358 operational amplifier to detect soil moisture levels and automate the switching of a water pump accordingly. Unlike conventional systems requiring human intervention or sophisticated microcontroller programming, this setup offers a hardware-only solution, emphasizing simplicity, reliability, and low cost. This system monitors soil moisture and waters the plant only when necessary, thus conserving water, saving time, and promoting plant health. The working is based on comparing the voltage drop across a soil probe with a reference threshold set using a variable resistor.

Model Diagram:

The block model of the system consists of the following key components:

- Soil Moisture Probe
- Voltage Divider Network
- LM358 Comparator
- Trigger Mechanism
- Relay Driver Circuit
- Water Pump
- Power Supply (12V DC)
- Resistors & Capacitors.



Automatic Plant Watering System

S.No.	Component	Quantity	Functioning
1	LM358 Op-Amp IC	1	Voltage comparator
2	Soil Moisture Probe	1	Senses Soil conductivity
3	Variable Resistor (VR1)	3	Sets the threshold voltage level
4	Resistors (various)	5-6	Current limiting setting reference voltages
5	Capacitors (various)	5-6	Filter out noise, duration and debounce the triggers.
6	BC548 (NPN Transistor)	1	Works as a switch
7	Relay (5V or 12V)	1	Switches ON/OFF the water pump
8	Water Pump	1	Pumps water to the plants when activated
9	Flyback Diode (1N4007)	1	Protects the transistor from voltage spikes
10	Power Supply (12V)	1	Provides necessary operating voltage
11	LEDs (Red, Green)	1 each	Indicating ON/OFF system

Uniqueness:

This project stands out for its minimalistic yet functional design. Most automatic irrigation systems use digital microcontrollers (Arduino, etc.), adding complexity, cost, and the need for programming. In contrast, this system operates purely on analog principles using an LM358 comparator.

Its uniqueness lies in:

- **Zero-Code Approach**: No programming required.
- **Analog Sensing and Logic**: Entirely based on voltage comparison.
- **Immediate Response**: No delay or lag from software processing.
- **Robustness**: With fewer electronic parts and no software, fewer points of failure.

This makes it ideal for remote or off-grid installations where simplicity and reliability are paramount.

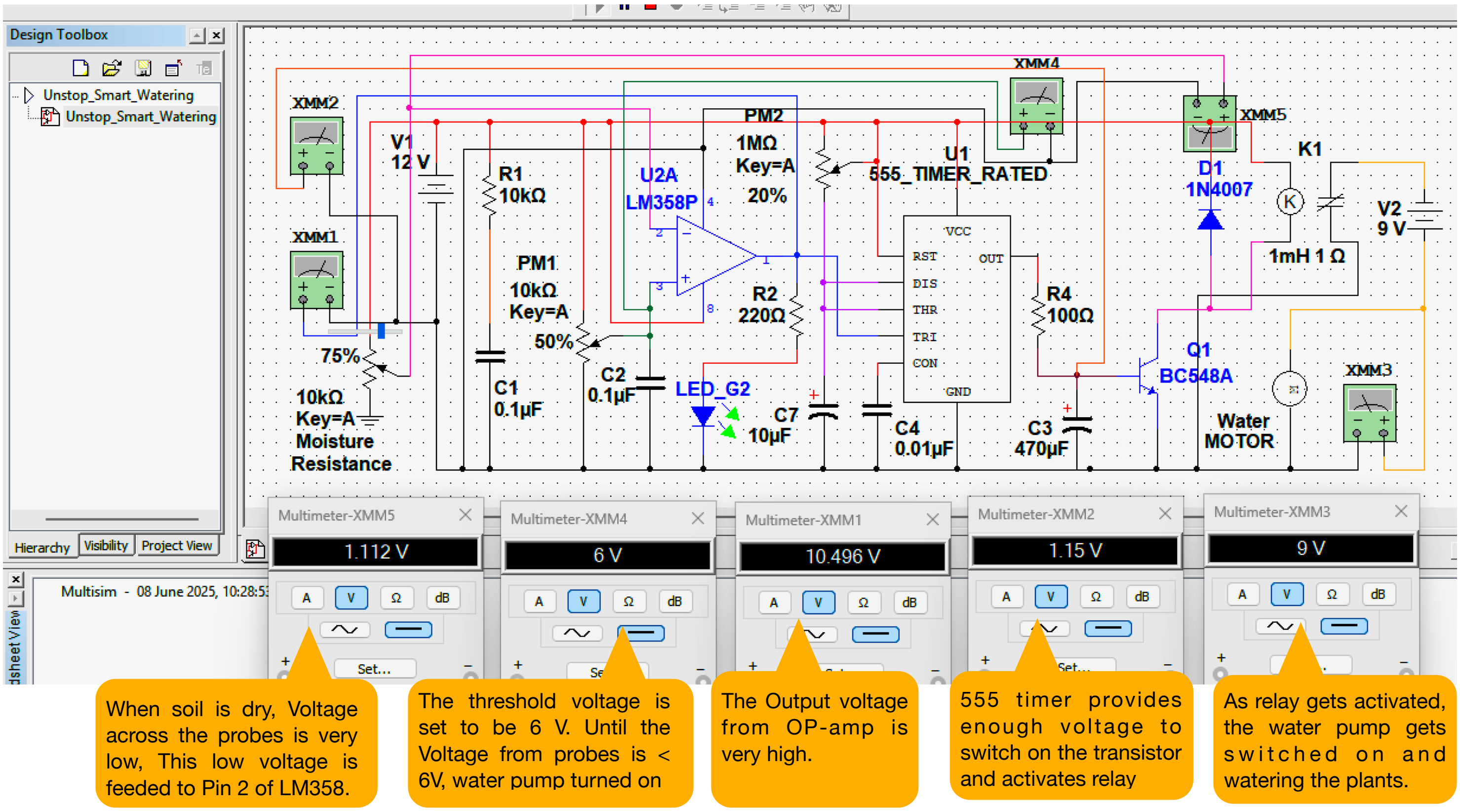
Circuit Diagram Explanation:

The circuit is built using commonly available components:

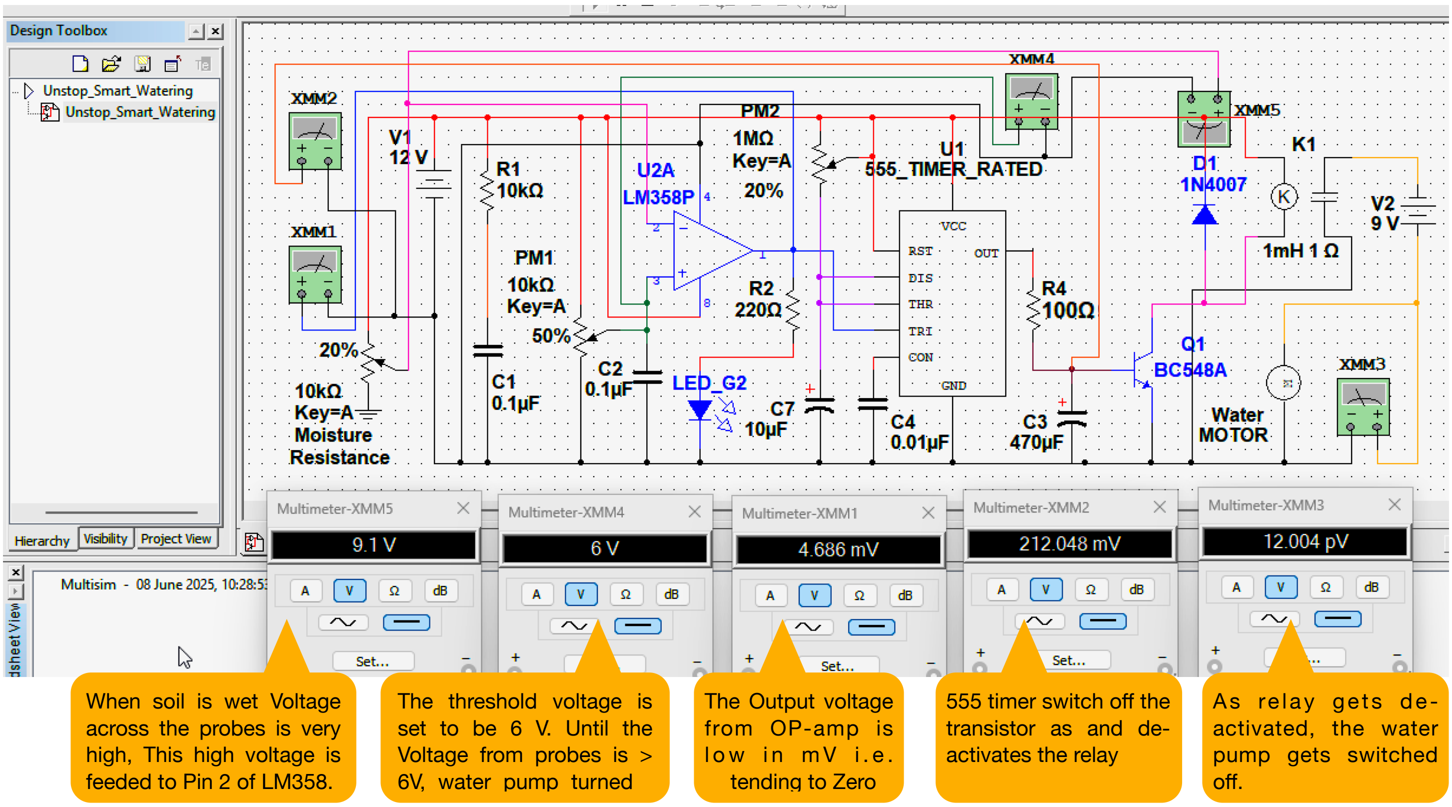
- **LM358 Operational Amplifier (IC1)**: Configured as a voltage comparator. One of its input terminals receives voltage from the soil moisture sensor (connected as part of a voltage divider), while the other input terminal receives a reference voltage set by a variable resistor (VR1).
- **Soil Moisture Sensor**: This consists of two probes inserted into the soil. When the soil is moist, it conducts more electricity, reducing the resistance between the probes. In contrast, dry soil increases resistance.
- **Voltage Divider and Reference Setting**: The variable resistor VR1 is used to set a fixed threshold voltage at the non-inverting input (pin 3) of the LM358. The voltage from the soil sensor is fed into the inverting input (pin 2).
- **Comparator Output (Pin 1)**: When the soil is dry (high resistance), the voltage at pin 2 becomes higher than at pin 3, resulting in a LOW output. When the soil is moist, voltage at pin 2 is lower, making the output HIGH.
- **Relay Driver Stage**: The output from LM358 controls a BC548 NPN transistor. When LM358 outputs HIGH (soil is moist), the transistor remains OFF. When LM358 outputs LOW (soil is dry), the transistor is turned ON, energizing the relay coil.
- **Relay**: Controls the water pump. It switches ON the pump when the coil is energized by the transistor, and OFF when not energized.
- **Power Supply**: A 12V DC source powers the entire system and additional 9 V supply to run the motor. This ensures that the motor works efficiently.

This configuration eliminates the need for any microcontroller or software.

Simulation Results:



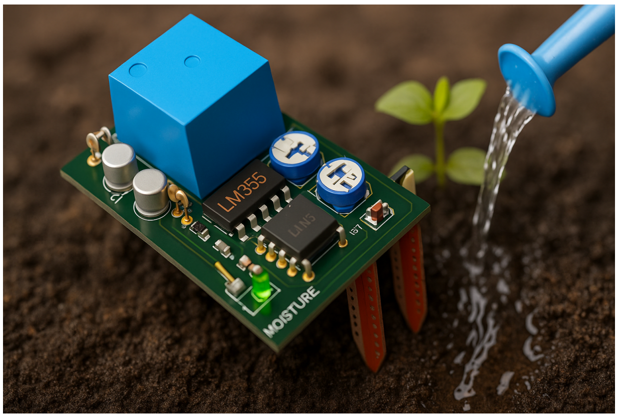
You will see Green LED glowing until voltage from the probes matches with the threshold, in this case it was 6 V i.e. until the soil becomes fully moist. Further when the soil become moist, the voltage across the probes reduces below threshold level, green light fades away.



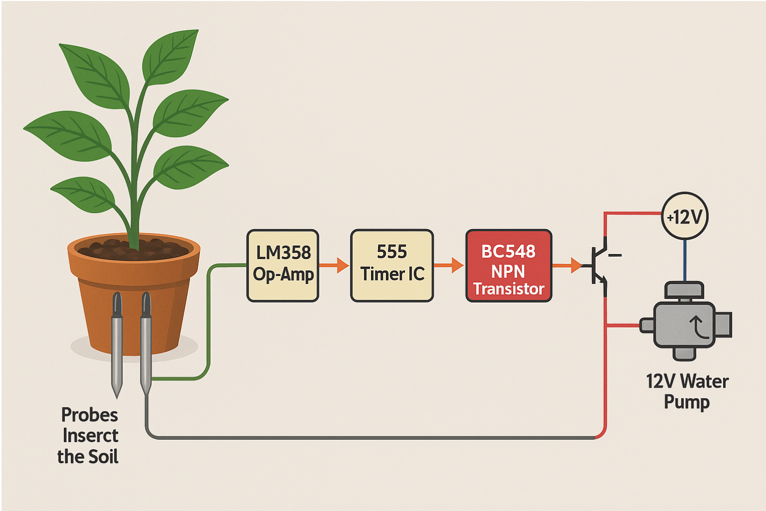
Working Mechanism:

The system relies on changes in soil conductivity. Here's how it works:

- **Soil is Moist**:
  - Low resistance between probes
  - Voltage at pin 2 (inverting) is High
  - Voltage at pin 3 (non-inverting) > pin 2
  - LM358 output = LOW
  - Transistor = OFF
  - Relay = OFF
  - Pump = OFF



- **Soil is Dry**:
  - High resistance between probes
  - Voltage at pin 2 = Low
  - LM358 output = HIGH
  - Transistor = ON
  - Relay = ON
  - Pump = ON

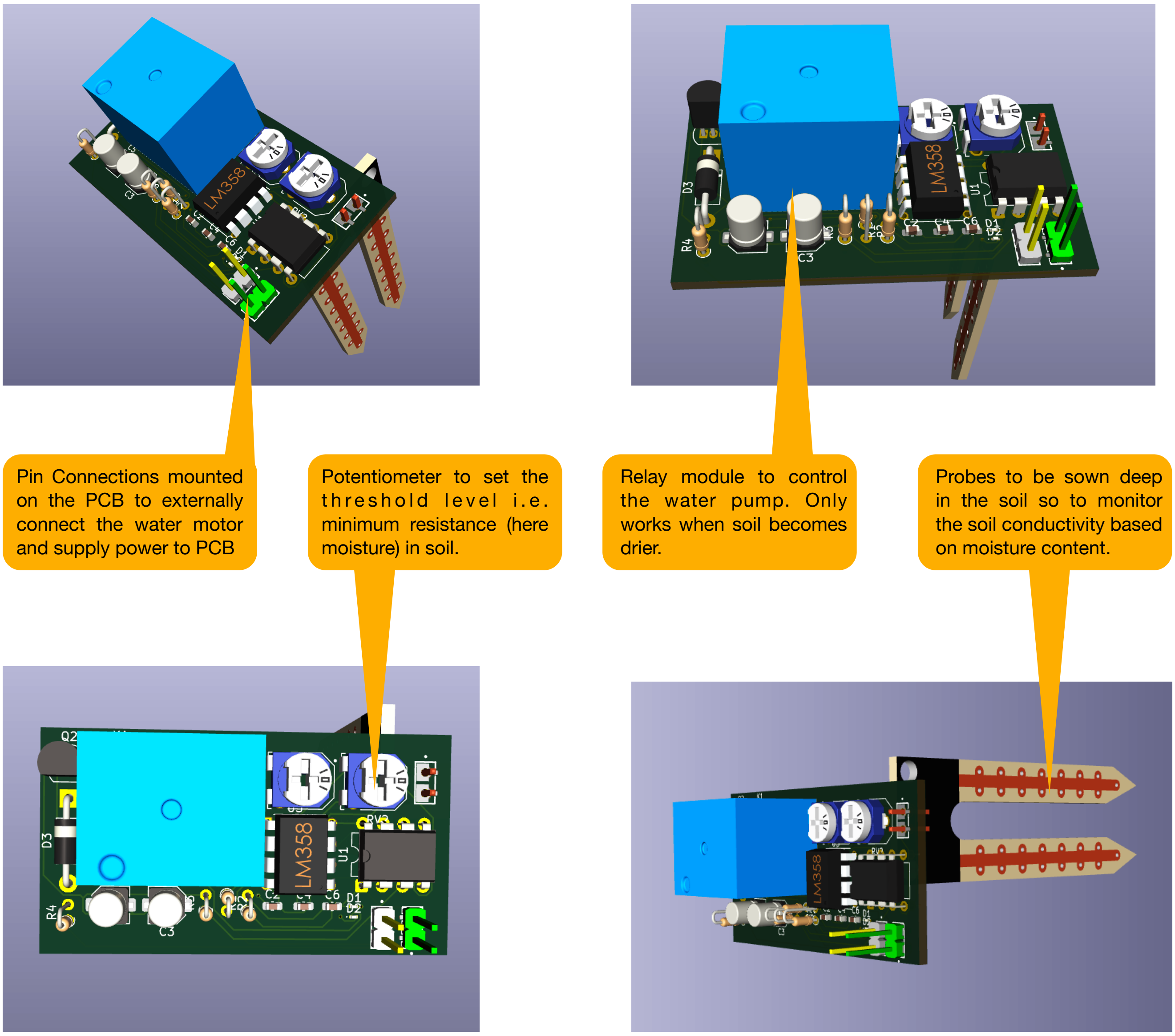


Advantages:

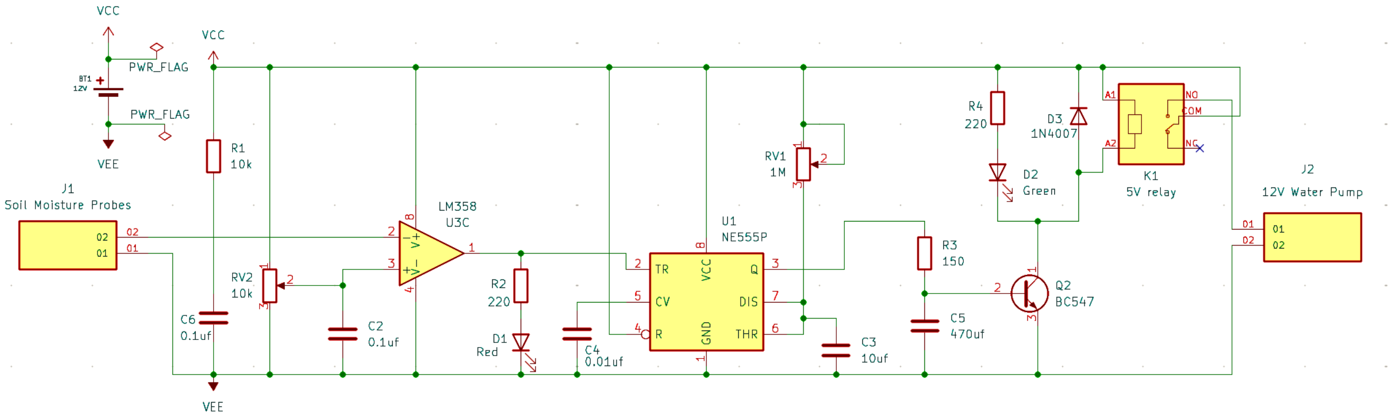
- **Water Efficiency**: Prevents over-watering and conserves water resources.
- **No Programming Needed**: Works entirely on analog hardware components.
- **Ultra Low Cost**: Inexpensive components and no microcontroller requirement.
- **Simplicity**: Easy to understand, assemble, and troubleshoot.
- **Automation**: Fully autonomous with no user intervention required.
- **Scalability**: Can be extended to multiple plants with replicated modules.

3D PCB Design and Visualization:

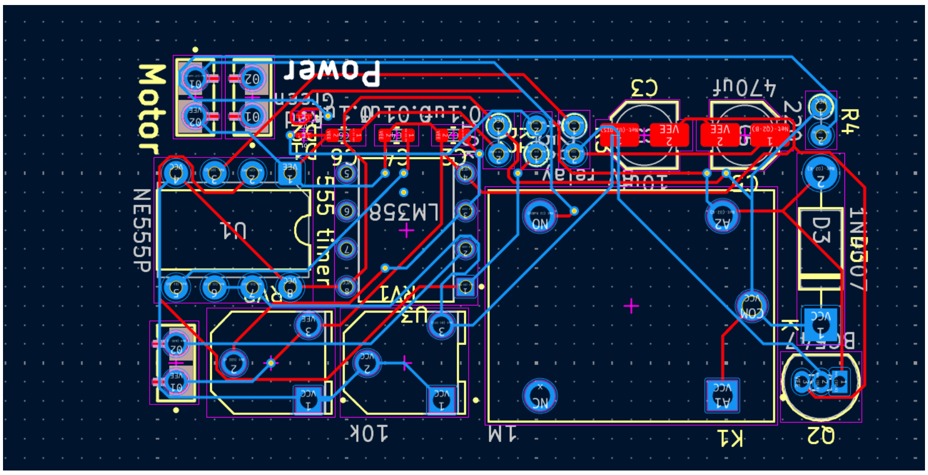
To better understand the hardware integration and spatial arrangement of components, a 3D model of the soil moisture-based automatic watering system was designed using **KiCad EDA** software. As shown in the images, the PCB layout clearly depicts the position of major components including the LM358 operational amplifier, dual variable resistors (for threshold adjustments), the relay module for pump activation, and the soil moisture sensing probes. The relay module is prominently placed for effective switching control, while the flyback diode and resistors are neatly laid out to manage current flow and protection. This 3D design offers a realistic visualization of the assembled circuit, aiding in error reduction during PCB fabrication and enhancing understanding of physical hardware layout. Such simulations help in validating circuit design before physical implementation and also serve as an excellent educational and prototyping tool.



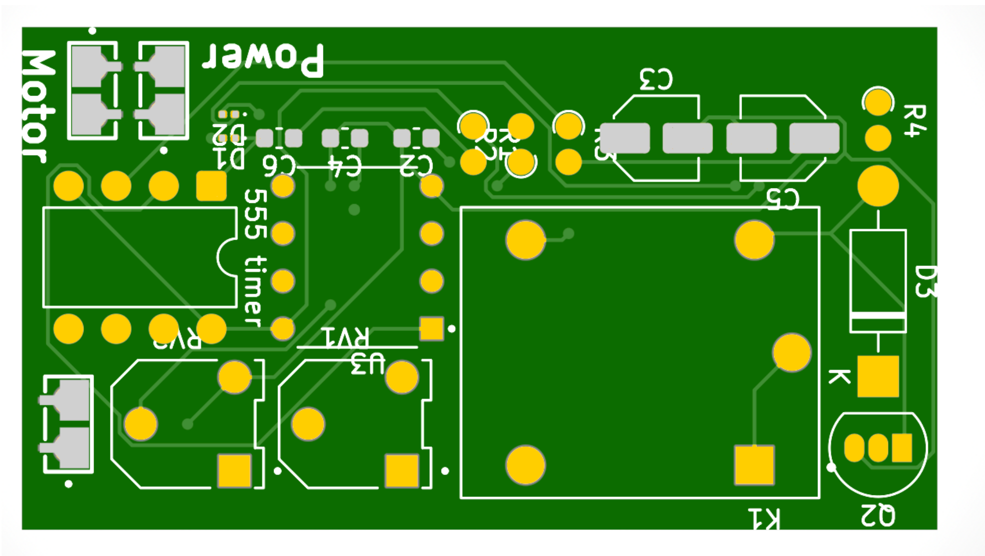
Prototype for the Autonomous Plant Watering
Designs were made on KiCad



Schematic View of the PCB



Foot print and routing View of the PCB



Gerber View of the PCB

Practical Applications:

- **Home Gardens**: Daily irrigation without human effort.
- **Greenhouses**: Controlled environments requiring moisture management.
- **Agriculture**: Scalable version for field crops.
- **Smart Pots**: Indoor potted plant monitoring and watering.

Future Enhancements:

Though the current model is basic and highly effective, it can be enhanced with:

- Battery power and solar charging for off-grid use
- Moisture level display (using voltmeter)
- Multiple sensor channels for large-scale use
- Integration with Wi-Fi module for remote alerts

Conclusion:

This report outlined the design and operation of a non-microcontroller-based automatic plant watering system using an LM358 comparator. By intelligently analyzing soil moisture levels and automating the pump via a relay driver, the system brings real-world utility, especially in regions with water scarcity or busy users who may forget regular watering.

It is a testament to the power of analog electronics in creating smart, sustainable solutions. With further enhancements, this system can be adapted for larger farms and integrated with modern technologies without sacrificing its core simplicity and robustness.