WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Review - Soil Moisture Detector

Umesh Subhash Mahajan[1], Tejas Nana Mangle[2], Chetan Sudhir Patil[3], Jatin Ravi Haswani[4], Himanshu Bharatsing Girase[5]

[1,2,3,4,5] UG Student, Department of Electrical Engineering, R. C. Patel Institute of Technology, Shirpur, Maharashtra, India

In agricultural practices, the detection of soil moisture is of paramount importance for precise water management. automation is commonly employed for controlling water pumps in traditional methods in agriculture, for instance microcontroller based systems like Arduino. However, simple systems can now be constructed for soil moisture detection without the need for microcontrollers, thanks to advancements in sensor systems and analog circuit designs. This paper analyzes the operation principles, classification, and practical uses of these systems that are based on soil moisture sensors with an automatic pumping mechanism, specifically designed and built with no digital parts.

Introduction

Soil moisture monitoring is an essential practice in modern agriculture and landscaping, ensuring plants receive adequate water while preventing overwatering. While Arduino-based systems are popular, simpler analog-based soil moisture detector circuits offer cost-effective, power-efficient, and user-friendly alternatives. This review paper focuses on these non-microcontroller-based systems and explores their mechanisms, components, and practical use cases.

Working Principle of Soil Moisture Detector Sensors

For soil moisture sensors, the determination of water presence is based on conductivity or resistivity of the soil. The soil is dry and does not conduct very well, but when water is available in the soil, its conductivity increases. This property forms the basis of analog soil moisture detectors.

1.Sensor Detection:

The moisture content level of the soil is detected by the sensors' probes, which then transfer a signal to the comparator (555 Timer IC).The sensor is all wet, and thus, lowers its resistance; the output voltage towards the 555 IC increases when the soil is dry.

2.555 Timer Operation:

The operational mode of the 555 Timer IC has been especially designed to be configured as the active comparator.In the event that there is a high voltage watching dry soil (high), its sensor signal, that is the output to the 555 IC, will be high. On the other hand, if the soil moisture is in adequate amount the output voltage of the 555 IC will be low.

3.Relay Activation:

The relay is effects the switching action according to the output of the 555 IC which is connected to it .The relay activates when the 555 output is high and the circuit for the pump is completed.This explains how the soil will be watered up and the pump is activated to do so.

4.Automatic Watering:

As long as the soil is water deficient, the pump will be switched on and it will keep running.At this sensor moisture threshold when the soil is reached, the sensor output will cause the 555 output to become low.

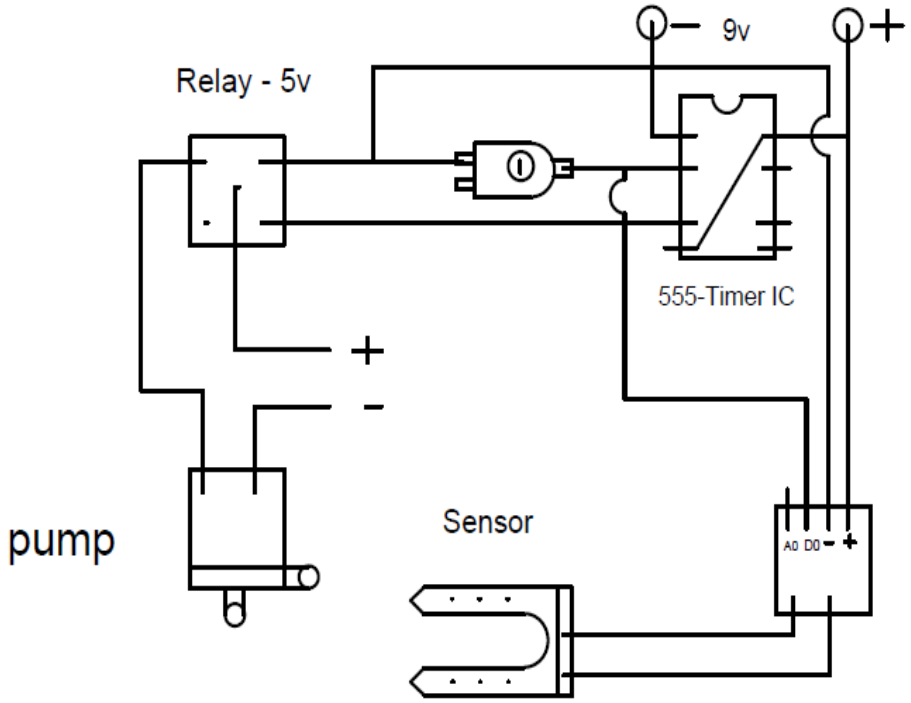
Effected by a low signal at output of the 555 IC, the relay is turned off and therefore the pump is off.

Components

1. 555 Timer IC
2. Soil Moisture Sensor
3. Module5V Relay Module
4. Water Pump (5V or compatible with your relay)

5. 10k Resistor
6. 9V Power Supply
7. Battery Connecting Wires

Circuit Design



Components

8. 555 Timer IC
9. Soil Moisture Sensor
10. Module5V Relay Module
11. Water Pump (5V or compatible with your relay)
12. 10k Resistor
13. 9V Power Supply
14. Battery Connecting Wires

1. 555 Timer IC

- Description: The 555 timer IC is a flexible circuit that is widely used in various applications, including timing, delay, pulse generation, and oscillators. Here, it sets its output high or low depending on the moisture sensor input and works like a comparator.

- specifications*:

- Supply Voltage: 4.5V to 16V (9V is the recommended supply voltage)

- Output Current: 200mA (sufficient for a relay drive)

- Operating Modes: Monostable, Astable, Bistable (the port used in this case is monostable or

comparator mode)

- Pinout:

- pin 1: GND - Connect this pin to ground.

- Pin 2: Trigger - It is used to detect the moisture sensor signal.

- Pin 3: Output - The relay is activated by this pin.

- Pin 4: Reset - It should be kept high (i.e., connected to VCC) in order for the IC to function.

- Pin 5: Control Voltage - Generally, this pin is connected to ground through a small capacitor (it is

optional in this particular circuit).

- Pin 6: Threshold - This is connected with Pin 2 for comparator operation.

- Pin 7: Discharge - It is not in use here.

- Pin 8: VCC - This pin should be connected to a positive voltage supply.

2. Soil Moisture Sensor Module

- *Description*: This sensor measures the moisture content of the soil by measuring the electrical resistance of the soil between two prongs inserted into the soil. When soil is wet, resistance is lower when moisture is absent the soil is relatively high, moisture is quite absent.
- *Specifications*:
    - Power Supply: 3.3V to 5V (9V could be plugged but a lower supply is preferable if possible)
    - Output: Digital (DO) and in some cases may be analogue (AO) output
- *Connections*:
    - *VCC*: A connection of either 9V or 5V power (depending on the module tolerance).
    - *GND*: To the ground
    - *DO (Digital Output)*: Connect to Pin 2 and Pin 6 of the 555 Timer IC with a 10k resistor inline.
    - *AO (Analog Output)*: Never connected to this circuit as it would have been with an analog input in other micro controller projects
- *Usage*: The output pin for the Digital Output (DO) becomes high when there is no moisture in the soil moisture while when there is some moisture, the output goes low. This enables the 555 timer controlling the relay to be dependent on the soil situation.

3.5 V Relay Module

- Description: Relays are essentially electrically operated switches. By using a small control signal, it can control a greater electrical load- in this case, the water pump. The module that the relay has isolates the control circuit (555 Timer) from the load circuit (pump).

- Specification:

- Operating Voltage: 5V DC (compliant with 555 output)

- Trigger Current: Usually below 20mA

- Max Load: It is dependent on the relay rating, usually 10A @ 250V AC or 30V DC

- Connections:

- VCC: Connect to 5V power

-GND: Connect to ground

- IN (Control): Connect to Pin 3 (Output) of the 555 Timer

-NO (Normally Open): Connect to one terminal of the water pump

-COM (Common: Connect to the 9V positive power line

Usage: The relay switches the pump on/off according to the output of the 555 timer. When the timer provides a positive signal to the relay, then the NO contact closes, thus letting the current go to the pump.

4.Water Pump (5V or compatible for your relay)

Description: An underwater small submersible water pump that runs on a low DC voltage. It is capable of pumping water from a water reservoir into the ground.

Specifications:

Operating Voltage: 5V to 9V DC; Depending on the type of pump used

Current Draw: Typically 100-300mA

- Flow Rate : According to model example: 80-120 L/h

- Connections:

- Positive Terminal: Connect to the NO terminal of the relay

- Negative Terminal: Connect to ground

- Application: The pump is energised by the relay, and the water reaches the plants. Once it gets satisfactory with moisture content in soil, relay de-energises the pump, it stops.

5. 10k Resistor

- Description*: The resistor regulates the current, and also adjusts the sensitivity in the circuit. In this design, 10k-resistor connects in series with the sensor signal to the 555 Timer's input pins.

- Specifications:

- Resistance Value: 10k ohms

- Power Rating: 0.25 W (1/4W) is good enough for low-power circuits

Connection: Serie it between the DO pin of the moisture sensor and Pin 2 & 6 of the 555 IC.

- Use: This helps in controlling the input signal reaching the 555 Timer hence nullifying fluctuations in signal; this will improve on the sensitivity of the moisture sensor.

6. 9 V Power Supply or Battery

Description: A normal 9V batter or DC power source runs the entire circuit.

Specifications:

DC Voltage: 9 V

Current: dependent on overall sum of current drawn from components (the relay and pump are currently the largest current consumers)

Connections:

- Positive Terminal: Connect to the VCC line for all components: 555 Timer, relay, and sensor

- Negative Terminal: Connect to common ground line

- Usage: This supplies the needed current to drive the 555 Timer IC, relay, and pump. If the pump needs higher voltage or current then, it is the time to think about a separate power supply for the relay/pump section.

7. Connecting Wires

Description: Hook up various parts on the breadboard or PCB using jumper wire.

Specifications:

Use jumper wires or regular insulated wires for breadboarding or soldering.

Gauge: 22 AWG or thinner for signal lines; 20 AWG or thicker for high-current lines like the pump.

- Usage: The connections must be tight, ensuring all components are in proper connection, especially for high-current sections such as the pump. Avoid loose connections.

Result

This is the demonstration of a soil moisture detection system that efficiently and economically automates irrigation based on the soil's moisture levels. The basic circuit components consisted of a 555 timer IC, which was designed to function as a comparator, a soil moisture sensor module, a 5V relay, and a water pump. The circuit monitors the soil moisture using the sensor and turns on the pump to water it whenever the moisture falls below a certain threshold

.This project is toward an efficient and economical soil moisture detection system to automate the irrigation process. It basically involves the 555 timer IC, a comparator configuration, soil moisture sensor module, a 5V relay, and a water pump as major parts. The circuit shows the way of monitoring the soil moisture with a pump that waters the soil whenever the moisture drops below its threshold value.

Summary of Findings:

1. Accuracy and Automation: This design incorporates a 555 timer IC with a soil moisture sensor to provide accurate monitoring of the moisture in the soil. Output from the sensor is then compared within the 555 IC to reliably activate the relay, thereby controlling the water pump.

2.Component Efficiency: The 5V relay used in the system would make the switching of the pump in the circuit smooth and without interruption. Therefore, the system would not lose massive power. The circuit with its simplicity only in the form of a 555 timer IC makes the circuit cost-effective and applicable but highly efficient on water reserve management because it irrigates only when there is a need for it.

3. Adaptability: The potentiometer within the sensor can modify the soil moisture threshold value. Accordingly, it can be flexible with different properties of the soil and the water demands of different crops.

Limitations and Future Scope :

Despite the fact that this design might function significantly, there is a potential area of improvement such as incorporating temperature and humidity sensors into the system to make irrigation process even more accurate. The IoT capabilities can also allow for remote monitoring and control, which may have the necessary potentials for making the system applicable to smart agriculture.

Conclusion

The soil moisture detection circuit effectively demonstrates a low-cost and accessible approach to automated irrigation. By utilizing a 555 timer IC in conjunction with a soil moisture sensor, this system provides precise moisture monitoring and efficient water usage. Studies have shown the importance of such systems in precision agriculture, as they reduce water wastage and improve crop health by irrigating only when necessary

REFERENCES

1. Evett, S. R., Schwartz, R. C., Casanova, J. J., & Heng, L. K. (2012). Soil water sensing for water balance, ET and WUE. *Agricultural Water Management*, *104*, 1-9. T. Ochsner, R. Horton, and T. Ren (2009) : "Soil moisture sensor calibration and data interpretation for soil water content" Vol 8 , page 1 (Vadose Zone Journal)
2. " Yu, L., Gao, W., R Shamshiri, R., Tao, S., Ren, Y., Zhang, Y., & Su, G. (2021). Review of research progress on soil moisture sensor technology.. Jones, R., & Li, H. (2021) : “Development of a Wireless Soil Moisture Sensing Network for Precision Agriculture”. Sensors and Actuators, 124(2), 87-95.
3. Adla, S., Rai, N. K., Karumanchi, S. H., Tripathi, S., Disse, M., & Pande, S. (2020). Laboratory calibration and performance evaluation of low-cost capacitive and very low-cost resistive soil
4. Kandris, D., & Anastasiadis, E. (2024). Advanced Wireless Sensor Networks: Applications, Challenges and Research Trends. *Electronics*, *13*(12), 2268.Monitoring Systems, 18(4), 241-256.
5. Gardner, W. H. (1977). Historical highlights in American soil physics, 1776–1976. *Soil Science Society of America Journal*, , 221-229.
6. Gao ZhenRan, G. Z., Zhu Yan, Z. Y., Liu Cheng, L. C., Qian HongZhou, Q. H., Cao WeiXing, C. W., & Ni Jun, N. J. (2018). Design and test of a soil profile moisture sensor based on sensitive soil layers.
7. Sreekeshava, K. S., Kolathayar, S., & Menon, N. V. C. (Eds.). (2024). *Civil Engineering for Multi-Hazard Risk Reduction: Select Proceedings of IACESD 2023* (Vol. 457). Springer Nature.
8. Mane, S., Das, N., Singh, G., Cosh, M., & Dong, Y. (2024). Advancements in dielectric soil moisture sensor Calibration: A comprehensive review of methods and techniques. *Computers and Electronics in Agriculture*, *218*, 108686

9. Shahab, H., Iqbal, M., Sohaib, A., Khan, F. U., & Waqas, M. (2024). IoT-based agriculture management techniques for sustainable farming: A comprehensive review. *Computers and Electronics in Agriculture*, *220*, 108851