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SMART IRRIGATION SYSTEM with ARDUINO and SOIL SENSOR

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ABSTRACT :

In recent years, sustainable agriculture and smart gardening solutions have emerged as key solutions to global issues such as water scarcity, labour shortages, and inefficient agricultural practices. The traditional approach of manually watering plants is not only time-consuming, but it frequently results in over- or under-watering, which harms plant health and wastes water. With advancements in electronics and embedded systems, automation in agriculture is no longer simply an option, but a requirement. This research article describes the complete design and practical implementation of an Automatic Plant Watering System using an Arduino UNO microcontroller and a soil moisture sensor. The Arduino UNO serves as the system's brain, reading data from the soil moisture sensor and commanding the pump with a relay module. The system is simple, inexpensive, and energy-efficient, making it perfect for small-scale farming, home gardens, greenhouses, and educational applications. The project's goal is to reduce human intervention, optimize water usage, and showcase the integration of electronics in real-world agricultural applications. According to experimental findings, the system provides a scalable and sustainable automated irrigation solution that reacts quickly and consistently across a range of soil conditions. Modular in nature, the entire design may be further improved with smartphone notifications, solar power, and IoT connection. For students studying Electronics and Communication Engineering (ECE), this research is extremely significant since it not only solves a critical agricultural requirement but also offers a real-world application of embedded system design.

Keywords: Agriculture, Irrigation, Automated, Arduino

II. INTRODUCTION

Many economies rely heavily on agriculture, and improving agricultural sustainability and production requires effective water management. The majority of small and medium-sized farmers continue to use manual watering methods despite the significance of irrigation. In addition to being labour-intensive, these techniques are imprecise, which results in excessive water use, plant illnesses from overwatering, and undernourishment from irregular watering. Agriculture stands to gain much from intelligent solutions in this era of automation, where embedded technologies have transformed many industries. One such invention that aims to minimize manual work, conserve water, and maintain constant soil moisture levels to promote healthy plant growth is an automatic plant watering system. This project is very important for Electronics and Communication Engineering (ECE) students since it combines fundamental topics such as analogy and digital electronics, sensors, microcontrollers, and automation. The usage of Arduino UNO, a user-friendly open-source microcontroller board, simplifies system development and gives hands-on experience with real-time system design and control. If the moisture level falls too low, the Arduino activates a relay module, which operates a DC water pump and waters the plant automatically. Once the necessary moisture level is achieved, the pump is shut off. This system is intended to be energy-efficient and cost-effective, with few components and room for modifications. It may be customized for many plants, includes a water tank level indicator, and connects to a smartphone app or web dashboard for remote monitoring. Overall, this research emphasizes the need and usefulness of smart irrigation systems, particularly in an era of dwindling natural resources. By completing this project, students develop not only technical skills but also a better knowledge of how electronics may solve real-world agricultural challenges.

III. METHOD

The project's creation, the Automatic Plant Watering System, is an embedded real-time program intended to track and regulate soil moisture levels. The technique minimizes water waste and human involvement by integrating firmware logic with hardware components to guarantee that plants only receive water when necessary.

Materials and Components :-

Utilized the following crucial elements were used in the system's construction:

Arduino UNO: The brain of the system is the Arduino UNO; a microcontroller board built on the ATmega328P architecture. Sensor input signals are processed, and output signals are sent to control devices, such as the pump.

Sensor for Soil Moisture (YL-69 with comparator module LM393): This sensor measures the soil's volumetric water content. It has both digital and analog output. We obtain accurate moisture readings by using the analog output.

Relay Module(5v): Using low-power signals from the Arduino, the relay module (5V) functions as an electronically driven switch to safely regulate the high-current DC water pump.
Submersible DC water pump (5V or 12V) : When triggered, a submersible DC water pump (5V or 12V) is in charge of providing water to the plant.
Electricity Supply (12V Adapter): Uses the relay to supply electricity to the water pump and Arduino.
Jumper Wires and Breadboard: Circuit connections are made using a breadboard and jumper wires.
Diodes and resistors: To guarantee smooth switching and stop reverse current.

System Architecture:

- Sensing: Soil humidity is measured using the soil moisture sensor. The resistance rises and the sensor produces a low analog signal when the soil is dry.
- Processing: After reading the analog input, the Arduino compares it to a threshold that has been established (for example, 400 out of 1023).
- Control Action: The Arduino turns on the water pump by activating the relay module if the value falls below the threshold. The pump stays off if the moisture content is higher than the threshold.
- Watering: Until the sensor registers adequate moisture, the pump irrigates the soil.

IV. ARDUINO CODE(SIMPLIFIED)

```
int water; //random variable
void setup() {
pinMode(3,OUTPUT); //output pin for relay board, this will sent signal to the relay
pinMode(6,INPUT); //input pin coming from soil sensor
}
void loop() {
water = digitalRead(6); // reading the coming signal from the soil sensor
if(water == HIGH) // if water level is full then cut the relay
{
digitalWrite(3,LOW); // low is to cut the relay
}
else
{
digitalWrite(3,HIGH); //high to continue proving signal and water supply
}
delay(400);
}
```

Arduino Code Review

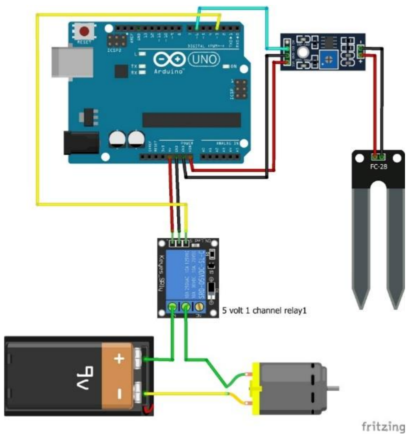
The Arduino code is designed to manage soil moisture through continuous monitoring and pump control, ensuring plants receive adequate watering based on predetermined moisture levels.

Code Structure

- Initializes the sensor and defines moisture thresholds.
- Control Logic
- Reads moisture values and activates the pump if below the threshold.
- Loop Functionality
- Continuously monitors moisture for timely watering.

V. DESCRIPTION OF A CIRCUIT DIAGRAM

The Arduino's A0 analog pin is linked to the soil moisture sensor. Digital pin 7 is connected to the input pin of the relay module. The pump is driven externally by a 12V source and connected via the relay's normally open (NO) wire. Either USB or the same supply with a voltage regulator can power the Arduino.



VI. RESULTS

Findings The Automatic Plant Watering System was constructed and tested in a variety of soil moisture levels and environmental circumstances. It was found that the system worked consistently and accurately adjusted to variations in soil moisture.

Conditions and Observations of Sensor

Soil Condition	Sensor Reading (0–1023)	System Response
Very Wet Soil	800 – 1023	Pump remains OFF
Moderately Moist Soil	500 – 700	Pump remains OFF
Dry Soil	0 – 400	Pump turns ON

System Performance Highlights

- Response Time: After detecting dry soil, the response time was between one and a half to two seconds.
- Low power consumption: Energy is saved because the pump only turns on when it's needed.
- Water Usage: About 30–50% less than when watering by hand in a controlled test setting.
- Maintenance: Except for the occasional cleaning of the soil sensor probes, there is very little maintenance required.

Noted Limitations

While Testing After extended usage, corrosion caused a minor loss in sensor performance, which can be fixed using capacitive sensors. The system requires scalability for applications involving multiple plants, as it is now only appropriate for one plant or one zone.

VII. DISCUSSION

The successful adoption of this system demonstrates the efficacy of automation in simplifying agricultural activities, particularly irrigation management. By combining simple electronics with real-time sensor feedback, the system ensures that plants receive the appropriate amount of water based on current soil conditions.

Advantages Observed:

- Water Conservation: The system watered plants only when necessary, resulting in significant waste reduction.
- Reduced Labor: This is ideal for people who forget or are unable to water their plants on a regular basis.
- Affordable: The setup costs between ₹800 and ₹1200, making it affordable for homes and small farms.
- Customizable: The programming and hardware may be tailored to different plant varieties, seasons, and even remote control via IoT.
- Educational Value: Ideal for ECE students to learn about sensors,microcontrollers, automation, and real-world embedded systems applications.

Future Improvements:

- IoT Integration: Connecting the system to Wi-Fi via ESP8266/NodeMCU or GSM module to remotely monitor moisture levels.
- Solar Power: Installing a solar panel to make the system self-sufficient in remote or rural places.
- Multi-Zone Control: Using several moisture sensors and pumps to control irrigation for different plants/zones.
- Capacitive Sensors: Replace resistive sensors with capacitive ones to improve longevity and accuracy.

VIII. CONCLUSION

This study demonstrates the successful design and implementation of an Automatic Plant Watering System utilizing an Arduino UNO and soil moisture sensors. The system is an affordable, energy-efficient, and user-friendly alternative for automating plant irrigation. It eliminates the guesswork from watering schedules, saves water, and promotes plant health by maintaining appropriate soil moisture levels. It covers real-time signal processing, embedded system design, sensor integration, and control systems. This project helps ECE students bridge the gap between theoretical understanding and actual application. The method benefits not just individual users such as gardeners and hobbyists, but it also has the potential for scalable applications in commercial agriculture, particularly in water-scarce environments. With minor changes and improvements, the system can be transformed into a smart agricultural tool that contributes to sustainable farming practices and the larger field of precision agriculture.

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