ISSN Number: 2454-2024(Online)

International Journal of Technical Research & Science

SMART IRRIGATION SYSTEM USING IOT FOR SOIL MOISTURE MONITORING AND CONTROL IN AGRICULTURE

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Abstract -The primary objective of this project is to monitor soil moisture content under dry and wet conditions using a moisture sensor circuit, compute the corresponding relative humidity, and automate irrigation accordingly. The system integrates a PC-based LabVIEW interface, GSM communication, and an automatic water inlet mechanism to ensure efficient irrigation. In addition to soil moisture, the system also monitors and records environmental parameters such as temperature, humidity, rainfall, and sunlight. These data are continuously updated, stored in a database for backup, and further utilized for weather forecasting and crop planning. The information helps guide farmers in selecting suitable crops for future cultivation based on prevailing soil and climatic conditions. By leveraging IoT technology, the system provides real-time feedback and remote access to operators, ensuring optimized resource utilization. Experimental analysis is carried out on different soil types suitable for various crops under diverse climatic parameters, enabling high-frequency data collection with minimal labor. Overall, the proposed IoT-based smart irrigation framework enhances plant growth, improves crop yield, and supports sustainable agricultural practices.
Keywords: Smart Irrigation, IoT, Soil Moisture Monitoring, LabVIEW, GSM Communication, Precision Agriculture, Climate Data, Automated Irrigation, Crop Recommendation, Sustainable Farming

1. INTRODUCTION

Objective of this paper is to design a simple, easy to set up method to monitor and indicate soil moisture levels that is continuously controlled to achieve maximum plant growth as well as using the monitoring software LabVIEW and Optimization of available irrigation resources is done on the sensor. The data can be viewed on the internet. To replace expensive controllers in current available systems, Arduino Uno will be used in this project as it is an economical microcontroller. The Arduino Uno can be programmed to analyze certain signals from sensors such as humidity, temperature, and rain. A pump is used to pump fertilizer and water in an irrigation system. The use of readily available components reduces manufacturing and maintenance solutions, especially for rural areas and small-scale farmers.

Bulk of the existing systems employ micro-processor based system. these systems offer several technological advantages but are unaffordable, bulky, difficult to maintain and less accepted by the technologically unskilled workers in the rural scenario. the internet of things(IOT) is transforming the agriculture industry and enabling farmers to contend with the enormous challenges they face. the industry must overcome increasing water shortages, limited availability of lands, difficult to manage costs ,while meeting the increasing water shortages , limited availability of lands, difficult to manage costs, while meeting the increasing consumption needs of a global population that is expected to grow up to 70% by 2050.

The objective of this research is to conduct a systematic review of the available literature regarding smart irrigation systems. In this scenario, the availability of more technological options becomes a driver for the transition to more intelligent farming systems, which when implemented helps improve quality and quantity. While optimizing the use of resources needed to produce food.

2. SMART IRRIGATION SYSTEM MONITORING TECHNIQUES

- Soil Moisture Monitoring
- Plant Monitoring
- Environmental Monitoring

2.1 Soil Moisture Monitoring

The temporary storage of water in soil is known as soil moisture inside a shallow level of the earth's top surface in comparison to the quantity of freshwater resources world-wide. It is vital in all spatial scales, agricultural, hydrological and weather forecasting processes. It is critical in detecting water stress and managing irrigation. Soil moisture data can also be used to forecast natural disasters like dryness and flooding, as well as environmental changes like sandstorms and erosion. Accurate estimation of soil moisture through in situ measurement, on the other hand, is prohibitively expensive because it necessitates a replication sampling process to evaluate the periodic change in soil moisture. The accuracy level depends on weighing accuracy, though these errors are negligible compared to soil variability in the field.

ISSN Number: 2454-2024(Online)

International Journal of Technical Research & Science

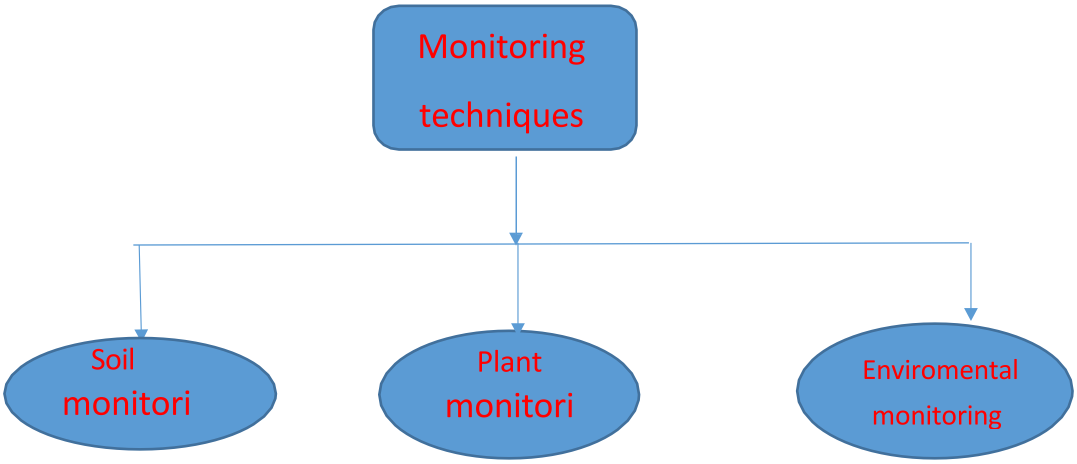


Fig. 2.1 Smart Irrigation System

2.1.1 Resistive Soil Moisture

A resistive soil moisture sensor is a type of sensor used to measure the moisture content of soil. It works based on the principle that the electrical resistance of the sensor changes with the amount of moisture present in the soil. Typically, a resistive soil moisture sensor consists of two or more metal probes or electrodes that are inserted into the soil. These probes are made of conductive materials such as stainless steel or copper. When the soil around the probes is dry, it has high electrical resistance. As the soil becomes more moist, the resistance decreases. The sensor is connected to a measuring circuit or microcontroller that applies a small voltage across the probes and measures the resulting electrical current or resistance. By analyzing the resistance value, the sensor can estimate the moisture level in the soil.

The working of a resistive soil moisture sensor is based on the principle of electrical conductivity and resistance changes in the presence of moisture. Here's a step-by-step explanation of how it operates:

1. **Sensor Construction**: A resistive soil moisture sensor typically consists of two or more metal probes or electrodes made of conductive materials like stainless steel or copper. These probes are embedded in the soil to measure its moisture content.
2. **Electrical Resistance**: When the soil is dry, it has a high electrical resistance. This is because dry soil acts as an insulator, impeding the flow of electrical current between the probes. The resistance value between the probes is relatively high
3. **Moisture Absorption**: As the soil moisture content increases, the conductivity of the soil also increases. Moisture acts as a conductor, allowing electrical current to flow more easily between the probes. This leads to a decrease in the electrical resistance of the soil.
4. **Measurement Circuit:** The resistive soil moisture sensor is connected to a measurement circuit or a microcontroller. A small voltage is applied across the probes, and the circuit measures the resulting electrical current or resistance.
5. **Calibration**: To obtain accurate moisture measurements, the sensor requires calibration. Calibration involves determining the relationship between the electrical resistance and the actual moisture content of the soil. This is typically done by taking measurements at different moisture levels and establishing a calibration curve or equation.
6. **Moisture Measurement**: By analyzing the resistance value obtained from the sensor, the moisture level in the soil can be estimated. The calibration curve or equation is used to convert the resistance reading into a moisture content value.

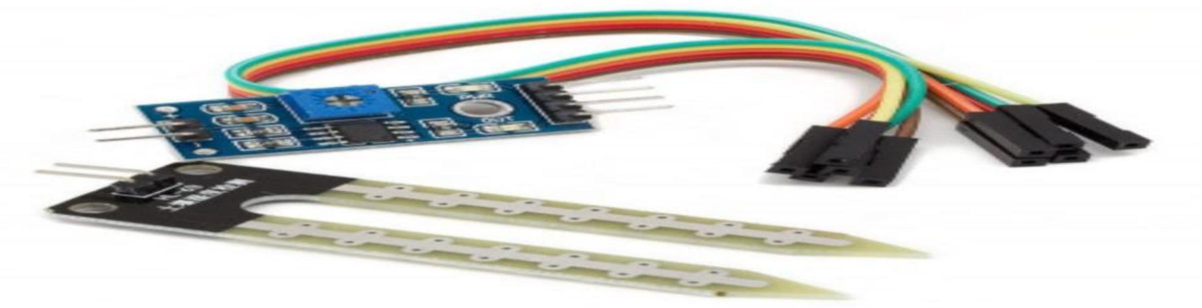


Fig. 2.2: Soil Moisture Sensor

3. MICRO-CONTROLLER NODE MCU ESP8266

Node MCU is an open-source firmware and development kit based on the ESP8266 Wi-Fi chip. The ESP8266 is a popular and low-cost Wi-Fi module that enables Internet of Things (IOT) applications. Node MCU provides an easy-to-use programming interface and a development board, making it accessible for developers and hobbyists to build IOT projects.

3.1 Features

Here are some key features of Node MCU and the ESP8266:

1. **ESP8266 Wi-Fi Chip**: The ESP8266 is a highly integrated chip that provides Wi-Fi connectivity and includes a microcontroller unit (MCU). It has built-in TCP/IP protocol stack, which allows it to connect to Wi-Fi networks and communicate over the internet.
2. **LUA -Based Firmware**: Node MCU firmware is based on the LUA scripting language. It provides an interactive and lightweight programming environment for developing IOT applications. LUA scripts can be uploaded and executed on the Node MCU board.
3. **Development Board**: Node MCU development boards are designed to make it easy to prototype and develop IOT projects. They typically include GPIO pins, analog input pins, and power pins for connecting external components such as sensors, actuators, and displays.
4. **Programming:** Node MCU can be programmed using the LUA scripting language, which is embedded in the firmware. Additionally, the ESP8266 can also be programmed using ARDUINO IDE, Micro Python, or other programming languages with appropriate libraries.
5. **Wi-Fi Connectivity**: The ESP8266 chip provides Wi-Fi connectivity, allowing the Node MCU board to connect to local Wi-Fi networks and access the internet. This enables IOT devices built with Node MCU to send and receive data, interact with cloud services, and communicate with other devices on the network.

Fig. 3.1 NODE MCU ESP8266

6. **Community Support**: Node MCU and the ESP8266 have a large and active community of developers, providing extensive documentation, tutorials, and examples. This makes it easier for beginners to get started and for experienced developers to find resources and assistance.

4. SOLENOID VALVE

A solenoid valve is a valve using a built-in actuator in the form of an electrical coil and a plunger. This is an electromechanical valve. In this, electrical signal control mainly controls the opening and closing of the solenoid valve. Solenoid mainly works in two modes. This mode is to open and close the solenoid valve. Solenoid valves can operate on AC and DC. For this the DC supply is provided through the battery, on the other hand the AC supply can be taken from the AC mains voltage through a transformer..

4.1 Solenoid Valve

This valve is used to open, close, mix, or divert liquid and gaseous media in an application. This valve is used in industrial sector and domestic sector. These types of solenoid valves range from controlling standard process valves to controlling specialized valves such as overpressure protection systems and emergency stop valves. This valve has a lot of advantages compared to conventional valves as it saves a lot of time and has good efficiency. Some common applications include.

- Solenoid valve in refrigeration reverse the flow of refrigerant. It gives cool during summer and heat during cool.
- The solenoid valve are also used in compressor.
- It is used in irrigation field.
- In washing machine and dishwashers Solenoid valves are used to control water flow as per need.
- Solenoid valve is also used in air conditioning systems to control Air pressure.
- Door lock system also uses Solenoid valve for proper working.

- The flow of water, soap and chemical in car washing plant is controlled by solenoid valve
- The solenoid valve is also used to control the flow of inflow and outflow water.
- In Healthcare field, Dental equipments in which pressure flow, direction is needed can be controlled by solenoid valve.

5. 5V RELAY MODULE

Relay is one kind of electromechanical component that functions as a switch. The relay coil is energized by DC so that contact switches can be opened or closed. A single channel 5V relay module generally includes a coil, and two contacts like normally open (NO) and normally closed (NC). This article discusses an overview of the 5V relay module & ITS working but before discussing what is RELAY module is, first we have to know what relay and its pin configuration is.

5.1 5V Relay

A 5v relay is an automatic **switch** that is commonly used in an automatic control circuit and to control a high-current using a low-current signal. The input voltage of the relay signal ranges from 0 to 5V.

5.1.1 5V Relay Pin Configuration

The pin configuration of the 5V relay is shown below. This relay includes 5-pins where each pin and its functionality are shown below.

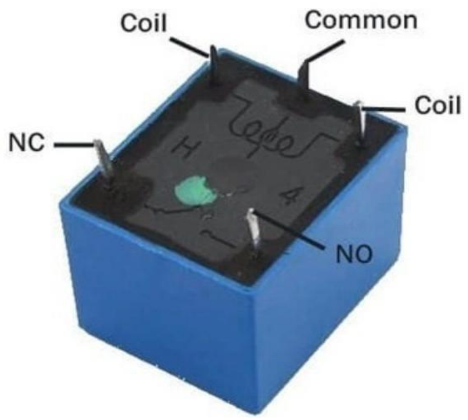
Pin1 (End 1): It is used to activate the relay; usually this pin one end is connected to 5Volts whereas another end is connected to the ground.

Pin2 (End 2): This pin is used to activate the Relay.

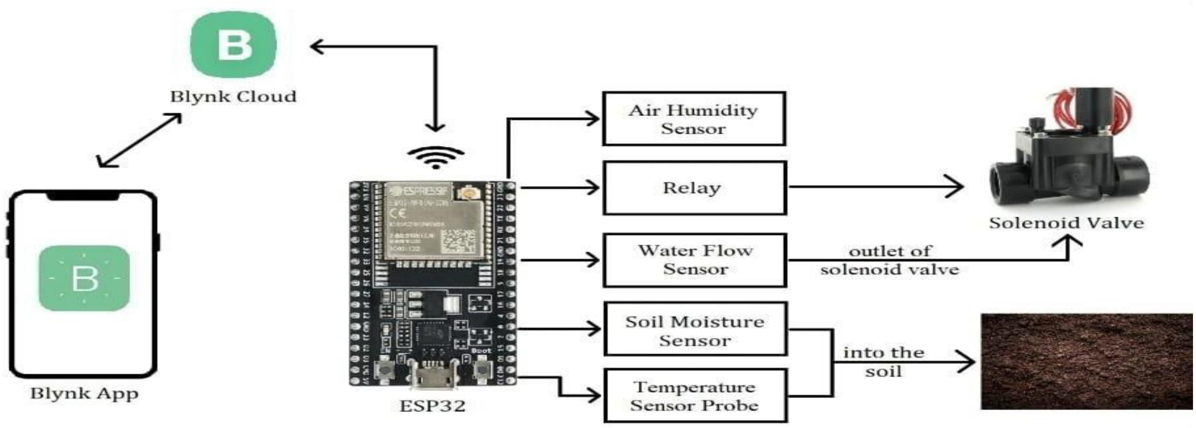
Pin3 (Common (COM)): This pin is connected to the main terminal of the Load to make it active.

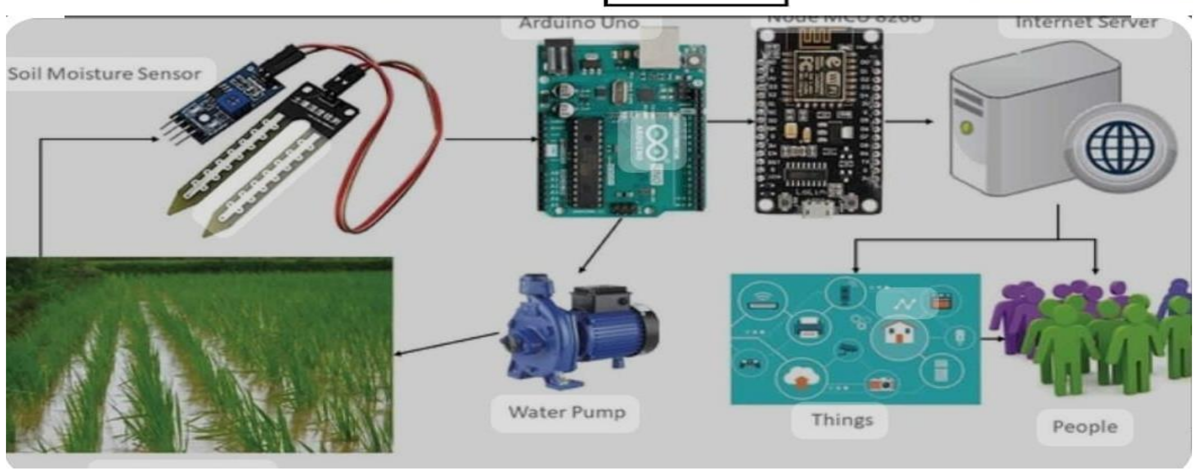
Pin4 (Normally Closed (NC)): This second terminal of the load is connected to either NC/ NO pins. If this pin is connected to the load then it will be ON before the switch.

Pin5 (Normally Open (NO)): If the second terminal of the load is allied to the NO pin, then the load will be turned off before the switch.



6. BLOCK DIAGRAM





7. WORK DONE

This model consists of two sections: the external sensor unit, and the inbuilt processing unit. In the external sensor unit, the basic requirement of sensing sand or soil moisture through capacitive reactance is met, with the sensor arms being able to detect resistance and provide input to the node MCU.

When the soil dries, it produces a large voltage drop due to the high resistance, and this is sensed by the soil moisture sensor, and this resistance causes the operational amplifier to generate an output that exceeds the required threshold value. This causes the relay to change from the normally open to the closed position – the relay is triggered. When the relay is switched on, the valve opens and water reaches the crops through the pipe. When the water content in the soil increases, the soil resistance decreases and transmission of the probe begins, preventing the triggering of the operational amplifier relay. Ultimately the valve connected to the relay is closed.

The Comparator monitors the sensors and when the sensors sense a dry condition the solenoid valve will be turned on and when the sensors are wet the solenoid valve will be turned off automatically. The Comparator performs the above functions, it receives signals from sensors. A transistor is used to operate the relay during soil wet conditions. 5V double pole - double through relay is used to control solenoid valves. LED indicator is provided for visual identification of relay/load status.

A switching diode is connected to the relay to neutralize the reverse emf. This project works with a 5V regulated power supply for the internal blocks and uses a regulated 12V power supply for the relay board. Power on LED for visual identification of power status when connected. First, sensor probes are inserted into the soil at specific locations in the field at regular intervals to a depth of 5 cm from the soil surface. The wiring is designed with 23 protective covers so that it does not get damaged by any unexpected factors like rocks in the field. Since wet soil is more conductive than dry soil, the soil moisture sensor module contains a comparator. The voltage from the prongs and the predetermined voltage are compared and the output of the comparator is high only when the soil conditions are dry. When the moisture in the soil exceeds the limit, the relay will trigger. The relay coil energizes and starts the motor. The LED is also on as an indicator. The soil begins to get supplied with water, and the water content of the soil increases. When the moisture content of the soil increases and reaches the threshold value, the output of the soil moisture sensor is low and the motor is turned off. This prevents a case of over-watering.

8. ADVANTAGES

There are many advantages of IoT-based smart irrigation system using Node MCU project. Here are some of them:

- Water Conservation: The primary advantage of smart irrigation systems is efficient water usage. By incorporating sensors, the system can monitor real-time weather conditions, soil moisture levels, and plants' water requirements. This data allows the system to deliver the exact amount of water only when it is needed, reducing water wastage and promoting water conservation.
- Cost Savings: With traditional irrigation systems, water is often overused, leading to high water bills. A smart irrigation system helps optimize water usage, resulting in significant cost savings over time. By automating the watering process and adjusting it based on environmental conditions, you can avoid unnecessary water expenditure and reduce your overall irrigation expenses.
- Remote Monitoring and Control: The IoT aspect of the system enables remote monitoring and control of the irrigation system. Through the mobile app or web interface, you can access real-time data about soil moisture levels, weather forecasts, and system status. This feature allows you to make informed decisions about irrigation scheduling, adjust settings, and even control the system remotely, providing convenience and flexibility.
- Precise irrigation scheduling: By analyzing data from various sensors such as soil moisture sensors, rainfall sensors and temperature sensors, the smart irrigation system can create precise watering schedules tailored to the specific needs of your plants. This ensures that plants get the right amount of water at the right time, thereby optimizing their health and growth.
- Alerts and Notifications: The system can generate alerts and notifications based on predefined thresholds or critical events. For example, if the soil moisture level drops below a certain threshold, you can receive an alert indicating that the plants need to be watered. These notifications help you stay informed about the status of the system and take quick action when needed.
- Integration with weather forecasting: Smart irrigation systems can integrate with weather forecasting services to gather information about rainfall, humidity and temperature. By considering upcoming weather conditions, the system can adjust the watering schedule accordingly. If rain is predicted, the system can delay watering, avoid unnecessary irrigation and preventing waterlogging.
- Scalability and Expandability: The Node MCU, an open-source development board based on the ESP8266 Wi-Fi module, provides a flexible and scalable platform for IoT-based projects. You can easily add more sensors, actuators or modules to the system as needed, expanding its capabilities over time. This scalability allows you to adapt the system to different garden sizes or even integrate it into large-scale

farming operations.

- Environmental sustainability: By using IOT-based smart irrigation systems, you contribute to environmental sustainability. Optimized water use reduces stress on water resources, promotes conservation and reduces the environmental impact of irrigation practices. Additionally, a precise watering schedule helps prevent issues such as overwatering, which can lead to soil erosion, nutrient leaching and water pollution.

CONCLUSION

In this system, we employed automated irrigation plants for use in drip irrigation with the use of wireless technology. With the help of this technique, one can estimate the moisture content of the soil. This technology system has some advantages such as preventing moisture stress of trees, reducing excessive water usage, ensuring weeding of fast-growing weeds. This is a very different aspect of the use of Artificial Intelligence in irrigation system. There are several available techniques, some of which use basic measures of soil moisture, and some will predict soil moisture in advance. This technique prove that smart irrigation systems are better than traditional irrigation to get better efficiency and timeless function. This type of research should continue to improve agricultural processes. Using Blynk software app entire drip irrigation system is being controlled.

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