MEASURING ABSOLUTE WATER CONTENT IN SOIL

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Abstract:

In India, agriculture is the backbone of the economy, and farmers face numerous challenges in ensuring optimal crop growth. One of the most critical challenges is the efficient management of water resources. Traditional methods of measuring soil moisture are often inaccurate, and time-consuming, leading to over-irrigation or under-irrigation. Over-irrigation results in water wastage and increased costs, while under-irrigation leads to poor crop yield and financial losses. Additionally, farmers in remote areas often lack access to reliable electricity, making it difficult to use advanced agricultural tools. To address these issues, our project focuses on designing a cost-effective and sustainable solution for measuring absolute water content in soil. Our system integrates a Soil Moisture Sensor, DHT11 Temperature and Humidity Sensor, TEMT6000 Light Sensor, and a LoRa Module for wireless communication, all powered by a Solar Panel. This system provides real-time data on soil moisture, temperature, humidity, and light intensity, enabling farmers to make informed decisions about irrigation. Our aim is to empower farmers with an affordable, easy-to-use, and sustainable tool that enhances water efficiency, reduces costs, and improves crop productivity.

Keywords: Soil Moisture, Water Scarcity, Precision Agriculture, Solar Power, LoRa Communication, DHT11 Sensor, TEMT6000 Sensor, Sustainable Farming, Irrigation Efficiency, Real-Time Monitoring.

1.INTRODUCTION

Soil moisture plays a vital role in agriculture, environmental monitoring, and water resource management. According to agricultural studies, the absolute water content in soil directly affects plant growth, microbial activity, and overall soil health. Accurate measurement of soil moisture is crucial for optimizing irrigation, preventing water wastage, and ensuring sustainable farming practices [1].A smart soil monitoring system integrates various sensors to measure absolute water content, temperature, and other environmental factors in real time. Advanced techniques such as resistive, capacitive, and time-domain reflectometry (TDR) sensors have been developed to enhance accuracy and reliability. Additionally, wireless communication modules like LoRa enable remote monitoring, making precision agriculture more accessible and efficient [2].This intelligent system combines soil moisture sensors, ambient light sensors, and temperature sensors to provide comprehensive data on soil conditions. By utilizing solar-powered energy sources, the system ensures long-term sustainability and usability in off-grid areas. Compared to traditional methods, this system offers real-time monitoring, wireless connectivity, and precise water content measurement, making it an ideal solution for smart farming and environmental applications [3].

2.RELATED WORK

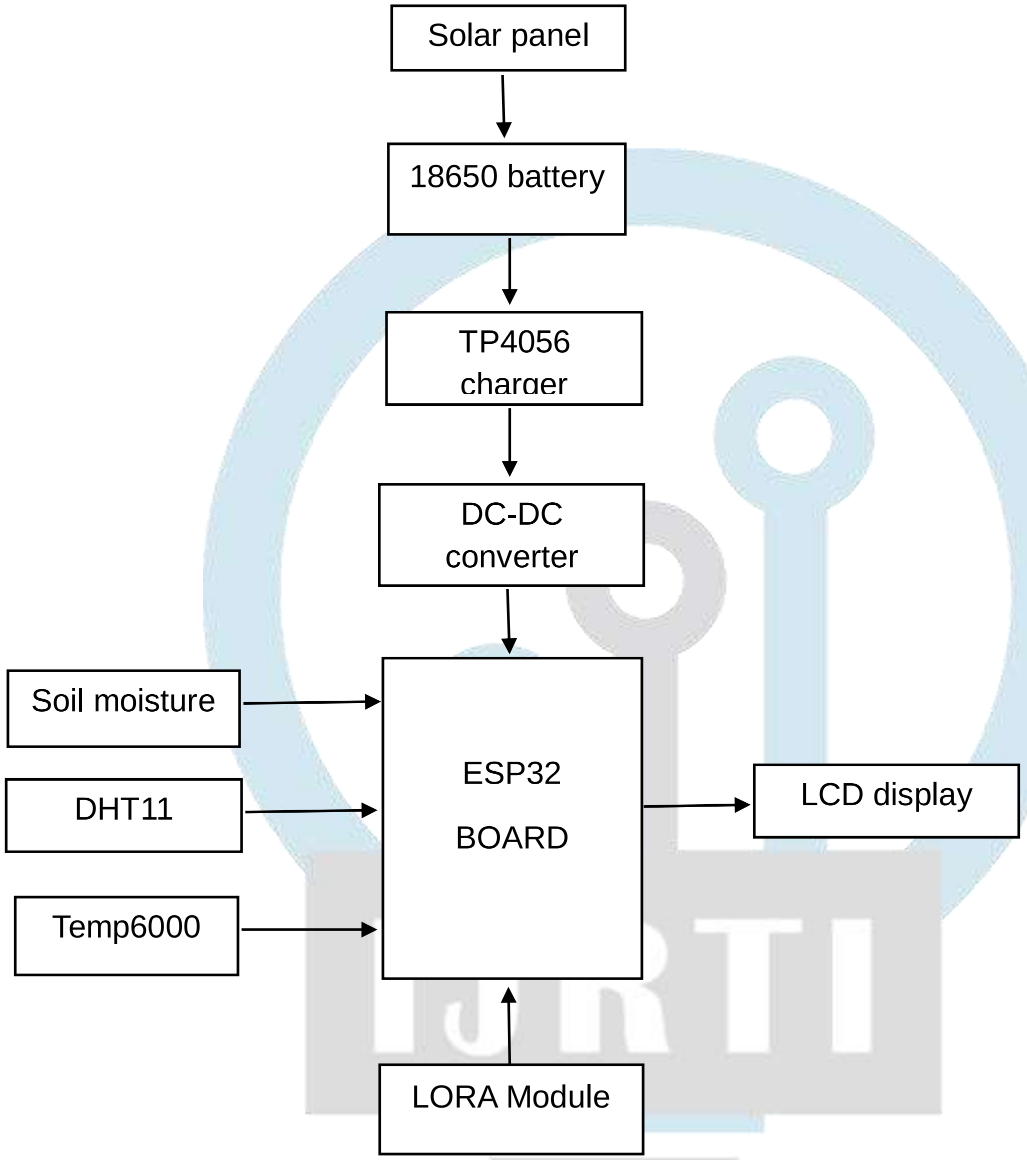
Several studies have explored techniques for measuring soil moisture. Traditional methods like gravimetric analysis are accurate but labor-intensive and unsuitable for real-time monitoring. Resistive and capacitive sensors offer faster results but may lack precision in varying soil types [1].Advanced methods like Time-Domain Reflectometry (TDR) and Frequency-Domain Reflectometry (FDR) measure soil dielectric properties for higher accuracy. These are used in smart irrigation systems but can be costly and require soil-specific calibration, limiting their widespread use [2].The system includes a solar panel that captures sunlight and converts it into electrical energy to power the sensors and the LoRa module. It also features a rechargeable battery that stores the energy generated by the solar panel, ensuring uninterrupted functionality. The soil moisture sensor provides precise measurements of water content, while the temperature and light sensors offer additional environmental data. This data is transmitted wirelessly to a mobile or web application, enabling farmers to make informed decisions about irrigation and crop management[3]. The system is portable, easy to use, and ideal for remote agricultural fields.The system generates real-time data on soil moisture, temperature, and light intensity, which is transmitted wirelessly to a central monitoring station. This solution is particularly useful for farmers in tropical regions, where high temperatures and erratic rainfall patterns make water management a critical challenge. By providing accurate and reliable data, the system helps farmers optimize irrigation, conserve water, and improve crop productivity[4].

3.PROPOSED APPROACH

In this project, we propose a smart soil monitoring system that accurately measures the water content in soil. Our prototype uses multiple sensors, including a soil moisture sensor, a temperature and humidity sensor, and a light sensor, to collect real-time environmental data. The system is powered by a 3.3V solar panel, making it energy-efficient and sustainable. A LoRa module is also included to enable long-range data transmission, which is ideal for remote farming areas. By combining these features, our system provides a reliable and innovative solution for precise soil moisture measurement, helping farmers improve irrigation practices and increase crop productivity.

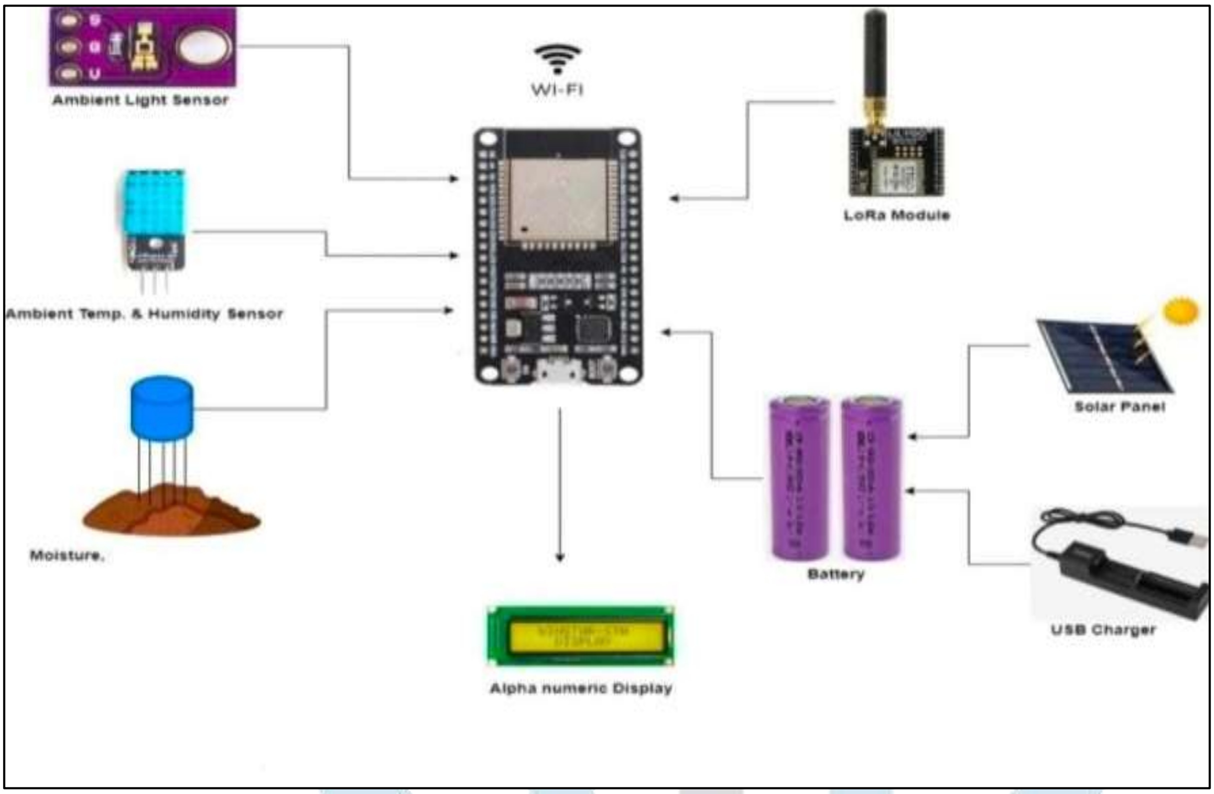
3.1 Layout Design

BLOCK DIAGRAM:-



The above figure represents the block diagram of a measuring absolute water content in soil, illustrating the connections between various electronic components such as the solar panel, 18650 lithium battery, TP4056 charger module, DC-DC converter, ESP32, sensors, LCD display, and LoRa module.The system is powered by a solar panel, which converts sunlight into electrical energy. This energy is stored in a 18650 lithium battery, ensuring continuous operation even in the absence of sunlight. A TP4056 lithium battery charger module is used to regulate the charging process, protecting the battery from overcharging and deep discharge. The DC-DC step-up converter then adjusts the voltage to a stable 3.3V, making it suitable for powering the ESP32 microcontroller and its connected components.The ESP32 serves as the central processing unit, receiving data from multiple sensors. The soil moisture sensor detects the water content in the soil, helping determine irrigation needs. The DHT11 sensor measures environmental temperature and humidity, while the Temp6000 sensor provides accurate temperature readings to analyze the soil's condition.Once the ESP32 processes the collected data, it displays the real-time soil and environmental conditions on an LCD display for local monitoring. Additionally, the system features a LoRa module, enabling wireless transmission of the data over long distances. This allows users to monitor soil conditions remotely, making the system highly useful for agricultural and research applications.

3.2 Design of Electronic Circuit



The system for measuring absolute water content in soil consists of various electronic components that work together to monitor and transmit real-time soil moisture data. The system is powered by a solar panel, which converts sunlight into electrical energy and charges a battery through a charge controller. The charge controller ensures safe charging by preventing overcharging and deep discharge of the battery. The stored energy in the battery is then regulated by a power supply unit, which provides a stable voltage to power the ESP32 microcontroller and other connected components.The ESP32 microcontroller acts as the brain of the system, collecting data from various sensors. A soil moisture sensor is inserted into the soil to detect the water content, providing crucial information about soil conditions. Additionally, an ambient temperature and humidity sensor helps in understanding environmental factors that affect soil moisture levels. An ambient light sensor is also integrated to measure sunlight intensity, which can influence soil drying rates.

To display real-time data, an alphanumeric LCD display is connected to the ESP32. The microcontroller communicates with the display using a liquid crystal driver, and power is supplied to the LCD from the regulated power source. For remote monitoring, the system includes a LoRa module, which transmits sensor data over long distances using wireless communication, allowing farmers or researchers to access real-time data remotely.

4.RESULT

This project aimed toshow that the system works well in measuring how much water is in the soil while also being energy-efficient and easy to use. The solar panel and battery provided a steady power supply, so the system could run continuously, even in remote areas without electricity. The soil moisture sensor accurately detected how wet or dry the soil was, and the temperature, humidity, and light sensors helped give a better overall picture of the environment, making the moisture readings more reliable.

Compared to traditional methods, this system made it much easier to monitor soil moisture because it used LoRa technology to send data wirelessly over long distances. This meant that farmers or researchers didn't have to check the soil manually, saving time and effort. The ESP32 board processed the sensor readings and displayed them on an LCD screen, making the information easy to read instantly.

5.CONCLUSION

The measuring absolute water content in soil system provides a reliable and efficient solution for monitoring soil moisture levels in real time. Unlike traditional methods, this system integrates an ESP32 microcontroller with various sensors, including soil moisture, temperature, humidity, and ambient light sensors, to collect accurate environmental data. The LoRa module enables long-range wireless communication, making it suitable for agricultural applications where remote monitoring is essential. Powered by a solar panel and battery, the system operates sustainably without the need for constant external power sources. The collected data is displayed on an LCD screen for easy accessibility and can be transmitted to a central monitoring system for further analysis. This solution is particularly beneficial for farmers and researchers, as it helps optimize irrigation schedules, conserve water, and improve crop yield. Its portability, low power consumption, and real-time data transmission capabilities make it a highly practical and scalable solution for modern precision agriculture.

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