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IOT BASED: Smart Irrigation system using RTC Module

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Abstract:

The IoT-based Smart Irrigation System using a Real-Time Clock (RTC) module is an automated solution designed to improve water management in agriculture. Traditional irrigation methods often require manual operation and fixed schedules, which can lead to water wastage and inefficient crop management. This project integrates embedded systems, sensors, and IoT technology to develop an intelligent irrigation system that automatically supplies water to plants based on soil conditions and scheduled timing.

The system uses a NodeMCU (ESP8266) microcontroller as the main controller, along with a DS3231 Real-Time Clock module to maintain accurate irrigation scheduling. A soil moisture sensor continuously monitors the moisture level of the soil and sends real-time data to the microcontroller. When the soil moisture level falls below a predefined threshold and the scheduled time is reached, the system automatically activates a relay module that turns on the water pump. Once the soil reaches the desired moisture level, the pump is turned off automatically, preventing overwatering.

The system also integrates IoT functionality through the Blynk platform, enabling users to monitor soil moisture levels, pump status, and irrigation schedules remotely using a smartphone. A 16×2 LCD display provides real-time information such as soil moisture percentage, current time, and motor status for local monitoring.

This smart irrigation system helps conserve water, reduce human effort, and improve crop productivity by ensuring efficient and precise irrigation. It can be applied in agricultural fields, greenhouses, residential gardens, and landscaping systems to support sustainable and modern farming practices.

Keywords — Smart Irrigation System, Internet of Things (IoT), Soil Moisture Sensor, NodeMCU ESP8266, Real-Time Clock (RTC), DS3231 Module, Automated Irrigation, Water Conservation.

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I. INTRODUCTION

Agriculture plays a vital role in the economy and development of many countries, especially in India where a large population depends on farming for their livelihood. Efficient water management is one of the most important factors for successful crop production. Traditional irrigation systems mainly depend on manual operation or fixed timers, which often lead to overwatering or insufficient watering of crops. This results in water wastage and reduced crop productivity.

With the advancement of technology, smart irrigation systems have been developed to improve the efficiency of water usage in agriculture. The Internet of Things (IoT) allows devices to communicate and exchange data through the internet, enabling real-time monitoring and automation of various processes.

In this project, an IoT-based Smart Irrigation System is developed using NodeMCU (ESP8266), a soil moisture sensor, a Real-Time Clock (RTC) module, and a relay-controlled water pump. The system monitors soil moisture levels and automatically activates the irrigation pump when the soil becomes dry during scheduled times. The RTC module ensures accurate timing for irrigation, while the IoT platform allows users to monitor and control the system remotely through a mobile application.

This automated irrigation system helps conserve water, reduce manual labor, and maintain optimal soil moisture conditions for healthy plant growth. It provides a cost-effective and efficient solution for modern agriculture and smart farming applications.

II. LITERATURE REVIEW

Several researchers have proposed automated irrigation systems to improve water management in agriculture. Early irrigation systems mainly relied on timer-based methods where water pumps were activated at fixed time intervals. Although these systems reduced manual effort, they often resulted in water wastage because they did not consider the actual soil moisture condition.

Later studies introduced soil moisture sensors in irrigation systems to monitor the water content in soil. These sensor-based systems automatically activate irrigation only when the soil becomes dry, improving water efficiency and crop health. However, some of these systems lacked proper scheduling and remote monitoring capabilities.

With the advancement of Internet of Things (IoT) technology, modern irrigation systems now combine sensors, microcontrollers, and wireless communication for better monitoring and control. Researchers have used microcontrollers such as Arduino, NodeMCU, and ESP8266 to collect sensor data and control irrigation pumps automatically. IoT platforms like Blynk, ThingSpeak, and Firebase are commonly used to provide real-time monitoring through mobile applications.

Many studies also highlight the importance of Real-Time Clock (RTC) modules such as DS1307 and DS3231 for accurate irrigation scheduling. RTC modules ensure that irrigation occurs at optimal times of the day, reducing water loss due to evaporation.

Overall, the literature shows that combining soil moisture sensing, RTC-based scheduling, and IoT monitoring can significantly improve irrigation efficiency, reduce water wastage, and support sustainable agricultural practices.

III. METHODOLOGY

The methodology of the Smart Irrigation System involves monitoring soil moisture and controlling irrigation automatically using a microcontroller and IoT technology. The system uses a soil moisture sensor to detect the water content present in the soil. The sensor sends analog signals to the NodeMCU (ESP8266) microcontroller, which processes the data and determines whether irrigation is required.

A Real-Time Clock (RTC) module is used to provide accurate time and scheduling for irrigation. The system checks both the soil moisture level and the preset time to decide when the irrigation process should start. If the soil moisture level falls below the predefined threshold and the scheduled time is reached, the NodeMCU sends a signal to the relay module.

The relay module acts as a switch that controls the water pump. When activated, the pump starts supplying water to the plants. Once the soil reaches the required moisture level, the sensor detects the change and the microcontroller turns the pump OFF automatically.

At the same time, the system sends real-time data such as soil moisture level and pump status to the Blynk IoT platform through Wi-Fi. Users can monitor the system remotely using a mobile application. The LCD display also shows the current time, soil moisture percentage, and motor status for local monitoring.

IV. HARDWARE DESCRIPTION

The Smart Irrigation System consists of several hardware components that work together to monitor soil moisture and control the irrigation process automatically. The main controller used in this system is the NodeMCU (ESP8266), which acts as the brain of the entire setup. It is an open-source IoT development board that has built-in Wi-Fi capability, allowing the system to connect to the internet for remote monitoring. The NodeMCU receives input from the soil moisture sensor and the Real-Time Clock module, processes the data, and sends control signals to the relay module to operate the water pump. Because of its compact size, low power consumption, and wireless communication ability, it is widely used in IoT-based projects.

The soil moisture sensor is an important component used to measure the water content in the soil. It consists of two conductive probes that are inserted into the soil. These probes measure the electrical resistance between them, which changes according to the moisture level present in the soil. When the soil is wet, the conductivity increases and the resistance decreases. When the soil becomes dry, the conductivity decreases and resistance increases. The sensor converts these changes into analog voltage signals and sends them to the NodeMCU. Based on this data, the microcontroller determines whether irrigation is required or not. This helps prevent both overwatering and underwatering of plants.

The DS3231 Real-Time Clock (RTC) module is used to maintain accurate time and date information in the system. The RTC module communicates with the NodeMCU through the I2C communication protocol using SDA and SCL pins. It continuously provides real-time clock data which allows the system to schedule irrigation at specific times of the day. For example, watering can be scheduled early in the morning or late in the evening to reduce water loss due to evaporation. Another important feature of the DS3231 RTC module is its battery backup. A small coin cell battery enables the module to keep track of time even when the main power supply is disconnected.

The 5V relay module acts as an electrically operated switch in the system. Since the NodeMCU operates at a low voltage and cannot directly control high-power devices, the relay module is used as an interface between the microcontroller and the water pump. When the NodeMCU sends a signal to the relay, the relay coil is energized and the internal switch closes, allowing current to flow to the pump. When the signal is removed, the relay opens the circuit and stops the pump. This switching mechanism allows safe and efficient control of the irrigation pump.

The water pump is responsible for supplying water to the plants during irrigation. In this project, a small DC submersible pump is used, which is placed inside a water container. When the relay module is activated by the NodeMCU, the pump starts operating and pushes water through the irrigation pipe to the plants. Once the soil moisture level reaches the desired value, the system automatically turns off the pump to prevent water wastage.

A 16×2 LCD display with an I2C interface is used for local monitoring of the system. The LCD displays important information such as the current time, soil moisture percentage, and motor status. The I2C module reduces the number of connection wires required and simplifies communication with the NodeMCU. This display allows users to quickly observe the system status directly without using a mobile application.

The entire system is powered using a 12V battery power supply. The water pump operates on 12V power, while the NodeMCU and other electronic components require lower voltage. Therefore, a voltage regulator or buck converter is used to step down the voltage to a stable 5V supply for the microcontroller and sensors. A stable power supply ensures reliable and continuous operation of the smart irrigation system.

V. RESULTS AND DISCUSSION

The Smart Irrigation System was tested to evaluate its performance in soil moisture monitoring and automatic irrigation control. The soil moisture sensor effectively detected moisture levels and sent data to the NodeMCU microcontroller. When the moisture level dropped below the predefined threshold, the NodeMCU activated the relay to turn ON the water pump, ensuring precise irrigation only when needed.

The Real-Time Clock (RTC) module ensured irrigation occurred at scheduled times, preventing watering during periods of high evaporation, like midday, and maintaining accurate timing even during power outages due to its battery backup. The 16×2 LCD displayed soil moisture, time, and pump status for on-site monitoring, while integration with the Blynk IoT platform allowed remote monitoring and control via a smartphone app, making the system highly user-friendly and convenient.

Test results showed that the automated system reduced water consumption compared to traditional manual irrigation, as the pump operated only when required. This approach minimized wastage and reduced the need for continuous human supervision. The system also demonstrated reliability, responding accurately to changing soil conditions, and maintained consistent performance over repeated tests.

VI. HARDWARE FIGURES

A. Circuit Diagram

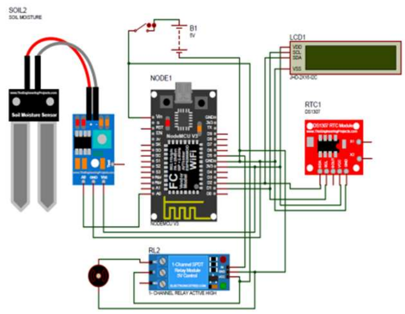

Fig. 1 Circuit Diagram

The circuit diagram shows the complete connection of smart irrigation system including NodeMCU, soil moisture sensor, relay, battery pack, BMS and RTC module .

B. NodeMCU ESP8266

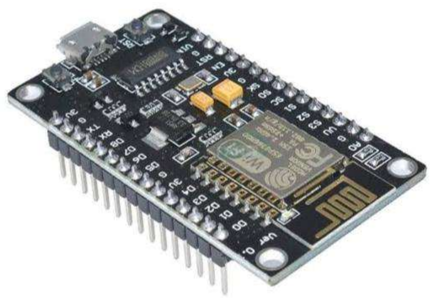

Fig. 2 NodeMCU ESP8266

The NodeMCU acts as the main controller for processing data and enabling Wi-Fi communication with the mobile application.

C. Relay Module

Fig. 3 5V Relay Module

Relay is one kind of electro-mechanical 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 going to discuss what is relay module.

D. Soil Moisture sensor

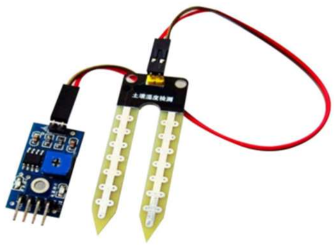

Fig.4 Soil moisture Sensor

The YL-69 soil moisture sensor detects soil moisture by measuring resistance between two probes—wet soil has low resistance, while dry soil has high resistance. Paired with the YL-38 module, it provides both analog (A0) and digital (DO) outputs, with an adjustable threshold using a potentiometer. It is a simple and low-cost tool for monitoring and maintaining plant watering.

E. Battery Management System (BMS)

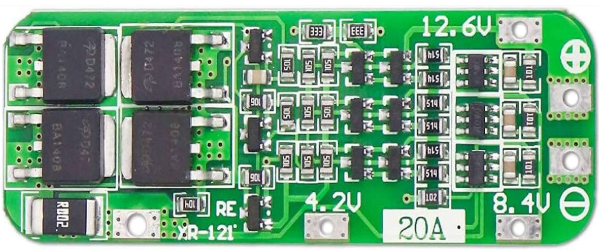

Fig. 5 Battery Management System

The BMS ensures safe operation of the battery by protecting it from overcharging, over-discharging, and short circuits.

F. Battery Pack

Fig. 6 Lithium-ion Battery Pack

A 12V battery is versatile and a reliable power source for many applications. It is primarily used for commercial purposes. Being one of the top power sources available, these batteries are the most appropriate units for BESS (Battery Energy Storage System)

G. Real Time Clock Module

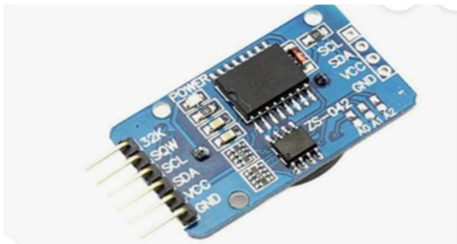

Fig.6 DS3231 RTC Module

The DS3231 is a high-precision, low cost Real-Time Clock (RTC) module that maintains accurate time and date even when the main power to a device is disconnected. It is significantly more accurate than older modules like the DS1307 because it features a temperature-compensated crystal oscillator.

H. ***Voltage Regulator***

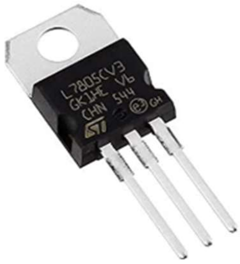

Fig.7 DS3231 RTC Module

The LM7805 is a classic three-pin linear voltage regulator that converts a higher, fluctuating DC input voltage into a rock-steady +5V output. It is the go-to component for powering microcontrollers (like Arduino) and sensors in your irrigation system.

VII. CONCLUSION

The proposed Smart Irrigation System effectively improves traditional irrigation by reducing water wastage, manual effort, and inefficient watering practices. By integrating soil moisture sensing, RTC-based scheduling, and IoT connectivity using the NodeMCU ESP8266, the system automates irrigation based on real-time soil conditions and predefined schedules. Remote monitoring through the Blynk platform and local display via a 16×2 LCD enhance system usability and monitoring. Experimental results indicate water savings of approximately 30–40% while maintaining optimal soil moisture for healthy plant growth. Overall, the system provides a reliable, cost-effective, and sustainable solution for modern irrigation in gardens, greenhouses, and agricultural fields.

VIII. FUTURE SCOPE

The proposed system can be further enhanced by integrating weather-based irrigation using rainfall and humidity data to optimize watering schedules. Future improvements may include multi-zone irrigation control to support different crop types and soil conditions. Cloud-based data storage and analytics can enable machine learning models to predict irrigation requirements more accurately. Incorporating solar-powered systems and energy-efficient components can improve sustainability. Additionally, expanding the IoT interface to web dashboards, mobile applications, and voice assistants can enhance user accessibility. These advancements can lead to a fully autonomous and intelligent irrigation system capable of efficient water management and improved crop productivity across large agricultural areas.

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