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A Web-based Computerization Tool Environment for Smart Motor controller Deployment

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Abstract: India has a vast variety of irrigational settings and conditions due to its geographically diverse terrain. A government survey conducted in India indicates that 75% of people live in rural regions where farming is the primary source of income. Recent studies demonstrate that globalisation and resource scarcity have led to a significant change in weather patterns, which has a detrimental impact on farming. Inefficient irrigation systems, losses, improper techniques, etc. are the primary issues that hasten the deterioration of agricultural conditions. Farming is quite labor-intensive and needs the physical presence of the farmer using the existing irrigation system. We investigated the problems farmers faced and offered them an inexpensive, low-maintenance irrigation option. Sometimes the system's power supply was timed incorrectly, making the conditions too unpleasant and dangerous for field irrigation. In order to control the functioning of water irrigation systems using automated AC motor starters, we use an already-existing WiFi network. The fundamental timer-based Starter Automation Structure forms the basis of the whole design. The principal objective of this design is to limit design criticality, hence enabling straightforward maintenance and repair.
Keywords: automation tool, motor controller, IOT, irrigation, smart motor

I. INTRODUCTION

One of the most important activities for sustaining and increasing the human population is agriculture, which includes the raising of food and animals. In addition to giving humans sustenance, it also helps to eradicate severe poverty and strengthen a nation's economy. By 2050, agriculture is expected to feed over 9.7 billion people and provide 4% of the world's GDP.

Technology has always played a role in agriculture in one form or another. More than 12,000 years ago, farming was done using very basic equipment. Wood or animal bones were often used to make agricultural implements. Better agricultural equipment were created by mankind throughout time. Tractors were a familiar sight on farmlands by the time of the second agricultural revolution in the United States.

Both plant development and the delivery of nutritional minerals depend on water. Water is applied to the soil during irrigation using a system of pumps, tubes, and sprays. In regions with little rainfall, it is often used. There are a wide variety of irrigation system types. Drip irrigation systems are a fantastic match for sustainable agriculture in arid regions where effective water utilisation is required. Water is gradually supplied in the form of droplets to the soil near the plant roots using drip irrigation. The quantity of water saved by drip irrigation systems is by far their greatest benefit over other methods. Any application that calls for automation, control, or data collecting may make use of the Internet of Things (IoT). The concepts around smart agriculture technology have increased in tandem with the IoT's rising popularity. In this research, we used an ESP32 microcontroller to develop an intelligent Internet of Things irrigation system. An ESP32, a solenoid valve, and a web application for remote access make up the system. We created a web application with a dashboard to manage the valve's opening and shutting as required. Water may enter the plant roots when the valve is opened. Our goal was to cultivate crops in a nearby area in Coimbatore. The crops had grown significantly after the irrigation system was turned on for a week. Throughout the whole week, the farmers used the technology to remotely manage the irrigation.

II. RELATED WORKS

Throughout history, people have developed devices to enhance the comfort of the water supply to their homes and communities. The increasing need for water availability led to the creation of water storage tanks, which are used to store water for a number of uses [1].

These days, practically every home and business uses overhead tanks. These tanks are refilled by an electric pumping system, however overflow and water dissipation provide additional difficulties. A lot of electrical solutions have been created to deal with the problem of water overflowing into the tank above.

555 timer circuit design for a water level alarm The integrated circuit was supposed to display the water level in the above tanks. The circuit obviously sounds when the water level reaches its level point. According to the design, in the event that the water level drops below the probe, the astable multivibrator in the circuit won't oscillate. As a result, there will be no noise from the circuit. If the water level is higher than the probe, current flows through the water and the circuit sounds. Because of this, the buzzer sounds and an astable multivibrator produces an oscillation when the water level reaches a certain level [2].

The electrical conductivity of water served as the inspiration for a different technique. The signals that the control circuit and detecting probes use to detect changes in the water level are used to switch the pump motor ON or OFF, depending on the circumstances. The probe placed into the top tank sends out a signal to the NE555 IC controller, which then reacts suitably [3].

An ultrasonic sensor was employed by a separate inventor to monitor and initiate pumping [4]. Assuming the tank is empty, the microcontroller pulses the sensor's trigger pin for ten microseconds when the system is switched on. The sensor then emits an 8 x 40 KHz sound wave, which activates the echo pin; the reflected sound wave then causes the echo pin to become inactive. The microcontroller measures the time it takes to broadcast and receive a sound wave in order to calculate the distance. The process continues until the set minimum distance is reached or exceeded by the measured distance, at which point the pumping machine activates automatically.

An overview of smart irrigation systems may be found in Refs. [5, 6]. They discuss wireless communications, irrigation techniques, sensors that may be used with smart irrigation systems, and other kinds of field monitoring. Similarly, ref. [7] offers an in-depth analysis of irrigation scheduling, control, and monitoring, and [8] looks at the problems, difficulties, and use cases of IoT in agriculture. A resistive soil moisture sensor, temperature sensor, water flow metre, and Arduino UNO single board computer (SBC) were used in ref. [9] to construct a smart irrigation system. The field is watered whenever the temperature rises over 30 °C or the soil is dry. The system keeps track of both temperature and soil moisture levels. A smart system that uses IoT to monitor and regulate agricultural productivity is described in Ref. [10]. It keeps track of the data and sends it to the farmer, who may use it to remotely operate the system as necessary, cutting down on labor-intensive tasks. A temperature sensor, an air humidity sensor, an Arduino UNO SBC, and a resistive soil moisture sensor were used in ref. [11] to construct a smart watering system. The humidity and temperature values are tracked by the system and shown. The engine is turned on to provide water to the soil if it is very dry. A novel concept for a solar-powered smart drip irrigation system was presented in Reference [12]. It makes use of a node microcontroller unit (MCU) that uses a DHT11 sensor to monitor temperature and humidity. The soil moisture value is used to decide when the pump goes on. A smart farm using a long-range wireless area network (LoRaWAN) is suggested in Ref. [13].

Some of the shortcomings of the related previous work for a better water management system will be addressed by this endeavour. One of the proposals employed the MC14066 integrated circuit, which lacks the programmable characteristics of a microcontroller and is difficult to apply in designs. Another design that was made using a metal probe has a long-standing fault caused by oxidation and water pollution, which is an effort to rectify an existing problem. This increases the danger to one's health. In this attempt, these inadequacies found in previous research will be solved by developing a device that detects water without coming into contact with it using an ultrasonic sensor.

III.METHODOLOGY OVERVIEW

Figure 1 displays a summary of the smart drip irrigation system with IoT capabilities. System intelligence is provided by the ESP32. Several sensors and a relay were attached to the ESP32. Information on the water flow rate is provided by the water flow sensor. Relays are used by the system to open the solenoid valve, which waters the plants. Utilising the MQTT server, the ESP32 connects over Wi-Fi to the online dashboard. For controlling the valve, we have been using the web application.

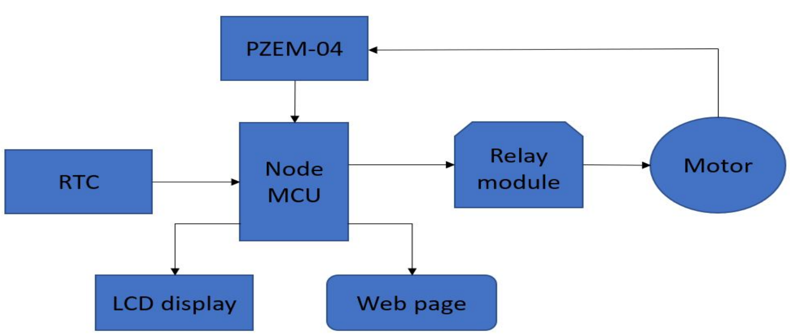

Fig. 1 Data Flow Chart

In the morning or early evening is when it is best to water the plants. Plants may burn if afternoon crop watering causes the water to become too hot. If crops are watered in the late evening, it might cause water stagnation, which can promote insects, rot, and fungal development [14, 15]. Our morning and evening irrigation windows are set for five and eight hours, respectively. Within these time frames, the ESP32 will use real-time data to monitor the temperature and moisture content of the soil and water the plants as needed.
Data on humidity was collected using an air humidity sensor. There will be excessive evaporation of water by transpiration in a very heated environment with little humidity. Plants that are experiencing water loss will try to take in more water, and as a result, they will take in more nutrients. The leaves will wilt if there are too many nutrients because they will burn at the tips [16]. It may not be a good idea to water the soil when the humidity is too low. If the relative humidity is too high or too low, the ESP32 will alert us. We are able to switch the automated watering function on or off based on the humidity measurements and other sensor data.
Should the need arise, we may manually open the valve by using the app. Because irrigation data may be used to identify patterns and ultimately enhance the system, it is stored to the app. The date, time, and soil temperature at the moment of irrigation, together with the drip line's water flow rate, make up the irrigation data.

IV. PROPOSED METHODOLOGY AND MODULES

To construct the system for managing the irrigation system, we combined quite a few components. Below is a summary of the many components that make up the system.

A. ESP32 Module

The ESP32 is a semiconductor that gives embedded devices, or Internet of Things devices, Wi-Fi and (in some variants) Bluetooth connection. Although ESP32 is just the chip, the manufacturer also often refers to the development boards and modules that incorporate this chip as "ESP32."
A single core Tensilica Xtensa LX6 microprocessor powered the original ESP32 chip. With a clock rate of more than 240 MHz, the CPU processed data at a comparatively fast pace. Newer devices have been introduced; they include the ESP32-C and -S series, which come in versions with one or two cores.
Instead of using Xtensa, these two series additionally use a Risc-V CPU type. Though open source and simple to use, Risc-V has similarities to the well-known and supported ARM architecture. More specifically, GNU compilers provide decent support for Risc-V and ARM, but further support and development were required for Xtensa to be compatible with the compilers. For the purpose of communicating with the MQTT web server for the web dashboard, we have used the ESP32 module's built-in WiFi. Relay control time data is sent by ESP32 to the MQTT server. Using the online application, we may adjust the irrigation time or operate the valve.

B. MQTT Protocol

MQTT is a messaging protocol, or collection of rules, based on standards that is used to communicate between machines. Wearables, smart sensors, and other Internet of Things (IoT) devices usually need to send and receive data over a network with limited bandwidth and resources. MQTT is used by these Internet of Things devices to transmit data because it is simple to set up and effectively communicates IoT data. MQTT enables communication between the cloud and devices as well as between devices and the cloud.
MQTT can even be implemented on tiny microcontrollers since it uses very little resources when implemented on an Internet of Things device.
For instance, two data bytes might be the minimum size of a MQTT control message. Additionally, MQTT message headers are condensed to maximise network capacity.
Developers may easily encrypt communications and authenticate users and devices with MQTT by using contemporary authentication protocols like TLS1.3, OAuth, Customer Managed Certificates, and more.
We have decided to publish the web application for managing the water pump from distant places using the MQTT protocol.

C. Real Time Clock (RTC)

The main purpose of a real time clock, or RTC, is to maintain precise timekeeping even when a device is in low power mode or the power source is switched off. An embedded quartz crystal resonator, an oscillator, and a controller make up an RTC.
In order to arrange the water pumps' operating periods, we have included an RTC in our programme. A relay is used to operate the solenoid valves.

D. Relay

A relay is a basic switch that is electrically operated. The switch may be turned on and the solenoid valve can be supplied with 12V AC power to open by sending a signal from the ESP32.

E. Step-Down Voltage Regulator

A 12 V DC converter is used to power the smart drip irrigation system. We provided the ESP32 with the 5 V required for functioning using a step-down voltage regulator.

F. FS300A G3/4 Inch Water Flow Sensor

A plastic valve body, a hall-effect sensor, and a water rotor make up the FS300A. Because of the water flow, which causes the wheel and magnet to rotate, water enters via the inlet and exits through the outlet. The hall-effect sensor is activated by the magnet's rotation, and it produces high- and low-square waves. By counting the square waves, we may determine the water flow.

G. Hunter PGV-100G (24VAC) Solenoid Valve

We used an electrically operated one-inch solenoid valve, made by Hunter PGV. An electric coil having a moveable magnetic core is called a solenoid. This coil produces a magnetic field when an electric current is applied, which moves the core and allows water to flow. The valve shuts and the water flow ceases if the current is switched off.

H. LCD Display

Applications for liquid crystal displays (LCDs) are many in the electronics industry. It is often used to display different parameters and statuses in a variety of systems. The current and voltage values drawn by the motor are shown in real time thanks to the usage of an LCD module. The smart IoT-based irrigation monitoring and control system's low-cost autonomous sensor interface is implemented to confirm the system's functionality and meet the user's operational requirements for measurement and assessment. The key metrics that the smart system will be measuring are well-defined and established. The moisture sensors are placed two centimetres below the surface of the earth.

The sensors alert the microcontroller to shut off the relay circuits that drive the water pump when the soil achieves the appropriate moisture content. The specified location may be used to test the implementation. One of the experiments involves placing the built system prototype in a key farming region so that the sensors can keep an eye on the environmental factors. Through a MQTT service provider, the processed sensor data are sent to the web server so that users may see and manipulate the data. Figure 2 displays the web application's control page.

The embedded moisture sensor, which is buried in the soil, monitors the moisture level and relays the data to the microcontroller. The components are connected by a smart interface.

The water pump supplies water to the plants when the soil's moisture content falls below normal. Subsequently, the WiFi module uploads the data that has been observed and controlled to the web server and sends it to the LCD screen. Figures 3 and 4 show the valve and relay configurations for the system, respectively.

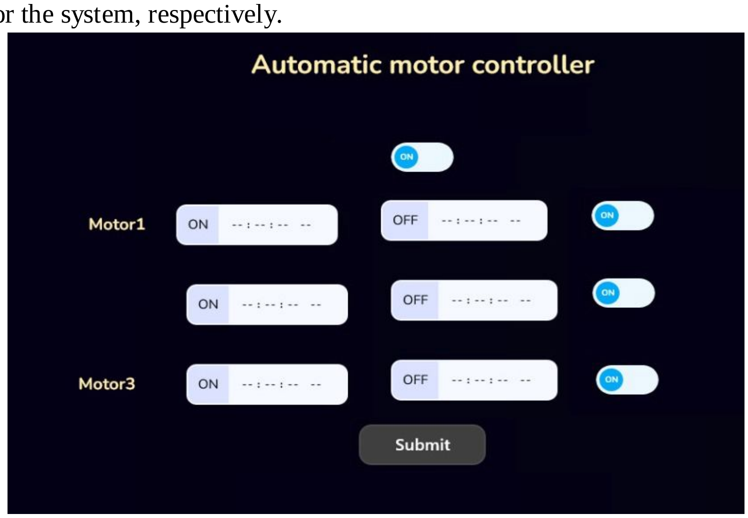

Fig. 2 Motor Control Page of Web Application

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Fig. 3 Valve Setup of the System

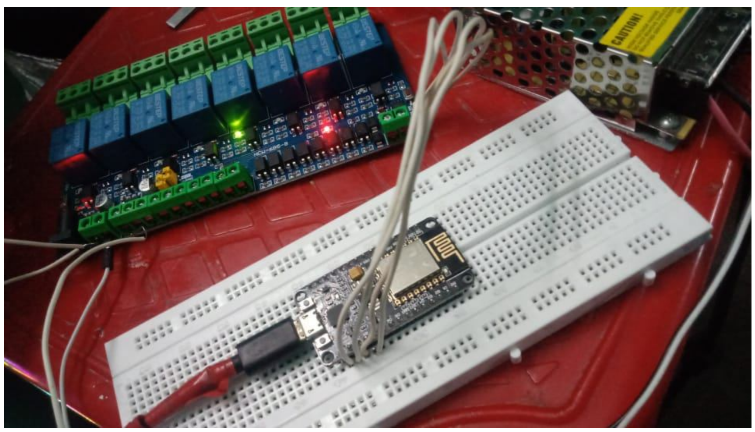

Fig. 4 Relay Setup of the System

V. CONCLUSION

The low-cost autonomous sensor interface presented in this article may be used to construct an Internet of Things (IoT)-based smart irrigation monitoring and control system. A functional prototype was created and executed. The main aim of this project was to empower farmers to independently oversee and manage isolated agricultural land, resulting in a rise in crop yield. This research employed a water pump to provide the plants the necessary quantity of water, a moisture sensor to gauge the water content of the soil, and a WiFi module to enable the sensed data to be accessed over the Internet. Sensor readings are stored on the web server, which acts as the primary base station. The web server's stored data underwent thorough analysis. Real-time sensor readings were broadcast to the Internet. A farmer can accurately track the amount of water in the soil on his or her property thanks to the obtained data. Regarding the collected data, speed, precision, and integrity of the sensed data that is gleaned from the sensors, the system's performance assessment is dependable. A farmer may assess the health of a plant with respect to the amount of water in the soil below it by looking at the plotted graphs, which are descriptive in nature. The water pump is turned on or off according on the moisture content, and the technology instantly alerts farmers to any excess or insufficient water delivery. Large-scale farms may use the suggested inexpensive technology to ease the burden of providing water to their land, which would otherwise cause them unneeded stress. Farmers and other decision-makers will find the suggested approach and the trial findings to be of great use in properly monitoring and controlling agricultural farm goods.

Our attempt to create an Internet of Things-enabled smart drip irrigation system worked. It has an improved automation function wherein the ESP32 will open the solenoid valve and water the plants if the soil is dry, the temperature is within the optimal range for optimum water absorption, and the time falls within the specified morning or evening irrigation windows. To avoid situations like over-watering, forgetting to water, or leaving the plants without water, we installed safety measures.

We may further keep an eye on air humidity, temperature, and soil moisture using the web application IoT dashboard. The admin user gets a notice on the web application app if the humidity is too high or too low. Based on the tracked data, we have the option to manually open the valve or halt the automated function via the online application dashboard.

Currently, rose plants from rose bushes are being grown using the smart drip watering method. Despite the system's good performance, there are still some areas that might be improved, like:

Looking at a companion app where we can choose the crop that has been planted and the watering schedule will adjust to suit the crop's need.

1) Adding more sensors and valves to the system's control list.
2) Examining the effects of watering plants at the optimal temperature to maximise their uptake of water.
3) Managing many smart drip irrigation systems via Bluetooth or Wi-Fi mesh.
4) Examining several possibilities for mobility and solar energy systems.
5) Combining rain, wind, and pH sensors, among other sensors.

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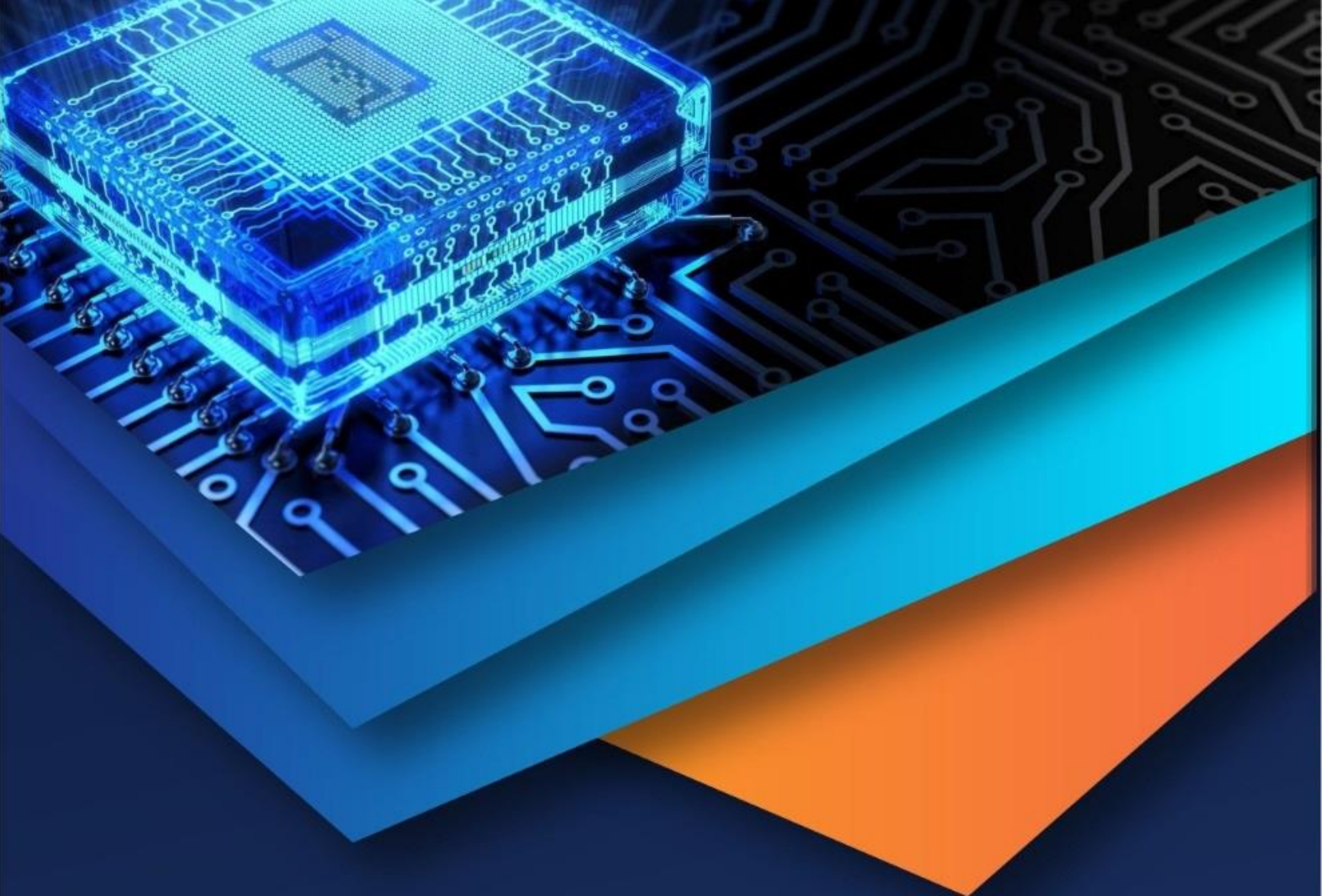

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