

Enhancing Home Automation: Developing an IoT-Driven Smart Irrigation System

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Abstract - This paper presents a comprehensive approach to enhancing residential water efficiency through the design and implementation of an IoT-powered smart irrigation system. Central to this system is the ESP32s board, serving as the cornerstone for connectivity and data transmission to the cloud. Using Blynk as the cloud web server enables continuous monitoring and control of watering operations for domestic plants and trees. The proposed smart irrigation system integrates various essential components, including an ESP-32 microcontroller, ultrasonic sensor for water level measurement, rain sensor, water pumps, relays, OLED display, and soil moisture sensors. By integrating these components, the system achieves automated and efficient watering, ensuring optimal plant health while conserving water resources. This paper outlines the design considerations, implementation details, and the potential impact of the proposed smart irrigation system on residential water conservation efforts. Furthermore, in addition to its water conservation benefits, the proposed smart irrigation system significantly reduces the need for human intervention in garden irrigation, thereby enhancing the convenience and efficiency of maintaining residential landscapes for smart home.

Keywords: Internet of Things, smart irrigation system, ESP-32 microcontroller.

I. INTRODUCTION

The advent of IoT-enabled Smart Homes has transformed our interaction with domestic environments, fostering a connected network that elevates convenience, comfort, and energy conservation [1]. By incorporating IoT devices, smart homes feature an array of interconnected gadgets, sensors, and intelligent platforms that facilitate automation, remote management, and data-informed decision-making. From commanding lighting, climate control, irrigation, and security setups via voice prompts or mobile applications to optimizing energy consumption and overseeing household conditions, IoT-driven smart homes deliver a seamless and tailored residential experience. The integration of IoT technology in smart homes is reshaping our engagement with domestic

spaces, rendering them more intelligent, resource-efficient, and interconnected than ever before. Figure 1 shows a smart home with several IoT connected devices such as entry and motion detection system, irrigation system, temperature and humidity control, alarm control system and smart electricity meters [2]. Data generated within these smart environments are transmitted to cloud infrastructure via internet connectivity, enabling persistent storage and remote visualization across user devices including smartphones, personal computers, and tablets.

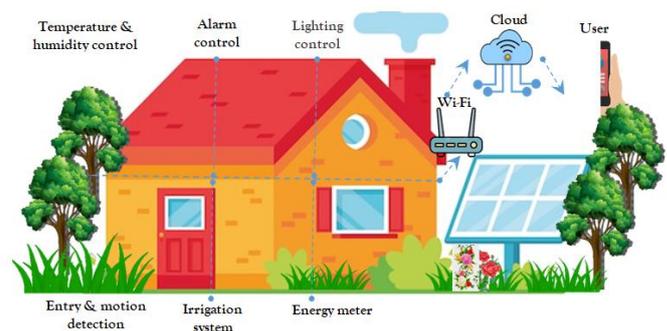


Figure 1: A smart home with several IoT connected devices

The principal objective of this work is to address the pressing challenges posed by water scarcity with inefficient irrigation practices and to reduce the need for human intervention. Conventional methods often result in diminished crop yields and water wastage. By harnessing real-time data and employing intelligent decision-making processes, a smart irrigation system empowered by the Internet of Things (IoT) has the potential to optimize water usage and enhance Smart Home applications significantly.

This research endeavors to address these gaps through comprehensive documentation of the design, implementation, and evaluation of an ESP32-based smart irrigation system, with particular emphasis on practical deployment considerations and the development of a custom printed circuit board (PCB) for enhanced system integration, reliability, and reproducibility. Through detailed analysis of constituent components, system architecture, software development methodologies, empirical performance evaluation, and

hardware design optimization, this study aims to contribute meaningful insights to the advancement of effective and sustainable residential irrigation solutions. Furthermore, the proposed system holds substantial utility for individuals who frequently travel or maintain extended residences abroad, offering remote monitoring and control capabilities that preserve landscape health during prolonged absences.

The structure of this paper is as follows: Following the introduction, Section II conducts a review of related works. Section III summarizes the materials and development methodology of the proposed system. Section IV elaborates on the experimental setup, actual implementation, performance analysis, and results. Finally, Section V provides conclusions.

II. RELATED WORK

Over the past few years, with the increasing integration of the Internet of Things (IoT), numerous research efforts have been proposed, offering various approaches and systems for applying IoT technology in agriculture, especially in smart home irrigation management. We present an overview of studies focused on utilizing IoT for irrigation management.

Kamienski *et al.* [3] introduce an intelligent water management system leveraging IoT for precision irrigation in agriculture. Their approach, validated through four pilot projects in Brazil and Europe, demonstrated promising outcomes. However, the researchers note that the system requires tailored configurations and component adjustments to enhance scalability while minimizing computational resource utilization.

M. Safdar Munir *et al.* [4] present an intelligent Smart Watering System (SWS) accompanied by an Android application designed for efficient water management in small and medium-scale gardens and fields. The system relies on a set of affordable and accessible sensors to gather real-time data on plant and environmental conditions, including Soil Moisture Level, Light Intensity, air humidity, and air temperature. Once the sensor data is collected on a server, the proposed SWS utilizes a combination of Blockchain and Fuzzy Logic methodologies to determine optimal watering schedules. Fuzzy Logic facilitates intelligent decision-making regarding watering needs, while Blockchain ensures security within the IoT-enabled system by restricting access to trusted devices authorized to interact with and manage the SWS.

Glória, A. *et al.* [5] develop an innovative approach to water management in irrigation systems, applicable to both gardens and agricultural fields, by employing Wireless Sensor Networks (WSNs) to replace manual intervention. Conventional irrigation systems often waste approximately 30% of water due to inadequate management and

configuration. This sustainable irrigation solution enhances efficiency in the irrigation process, resulting in cost savings and conservation of natural resources such as water and energy, thereby promoting environmental sustainability. By harnessing real-time data, the system accurately determines the optimal water usage for garden irrigation. Through leveraging sensor data on temperature, humidity, and soil moisture, potential water savings of up to 34% can be achieved, whereas using temperature inputs alone can still yield savings of up to 26%.

Pereira, G.P.; *et al.* [6] present an intelligent IoT-enabled drip irrigation system utilizing ESP32 for automating the irrigation process, which underwent comprehensive testing. The ESP32 interfaces with the Blynk application, serving as a platform for gathering irrigation data, manual plant watering, deactivating automatic watering, and generating graphical representations based on sensor readings. Sensors integrated into the system include soil moisture, temperature, air humidity, and water flow. The ESP32 continually monitors soil moisture levels and, if deemed necessary based on soil conditions and temperature, triggers a solenoid valve to initiate plant watering. The duration of irrigation is determined by the flow rate detected by the water flow sensor. Additionally, the ESP32 monitors humidity levels and alerts the user in cases of excessive or insufficient humidity, enabling manual intervention to deactivate automatic watering as needed.

Ravi Kant Jain introduces in [7] a sophisticated drip irrigation system powered by IoT technology and web-based applications. A dedicated web application has been developed to facilitate user interaction with the drip irrigation process. This application ensures precise water delivery from the pump for gardening purposes. By integrating various sensors to monitor humidity, temperature, and soil moisture levels, the system transmits data to a microcontroller, enabling accurate estimation of plant water requirements. Users can conveniently control and monitor this system via a web application accessible on Android mobile devices from any location.

Abdennabi Morchid, Ishaq G.; *et al.* in [8] propose a system that manages a continuous monitoring of essential environmental parameters vital for smart agricultural operations, encompassing moisture, humidity, temperature, and water levels. Utilizing cutting-edge sensors such as the DHT22 module, water level sensor, and moisture sensors, all integrated with the widely adopted embedded system ESP32, ensures comprehensive data collection. Leveraging the ThingSpeak cloud and ThingView app facilitates seamless wireless communication between the device and the farm owner, fostering efficient interaction. Automated control of

the two water pumps is governed by the real-time readings of diverse environmental factors.

Saputri and Ahmad [9] further advanced the integration of dual-cloud platforms for irrigation management, demonstrating that the combination of Blynk for real-time actuation control and ThingSpeak for analytical data storage creates synergistic benefits unavailable from single-platform implementations. Their system validation included Wi-Fi and cloud connection stability testing, relay module verification, and comprehensive sensor accuracy assessment. This methodological rigor addresses recurring criticisms regarding the reliability and reproducibility of IoT irrigation research, providing a template for systematic system validation that the present study adopts and extends [9].

III. MATERIALS AND METHODS

This section provides a comprehensive introduction to the proposed smart irrigation system. It begins with an overview of the system's architecture, followed by detailed descriptions of the hardware and software components.

3.1 System Architecture and Design

Figure 2 illustrates the architecture of the proposed IoT-enabled smart irrigation system. Comprising three core elements: IoT devices, cloud computing, and an application interface. The system facilitates global access and monitoring of home garden irrigation data via internet connectivity.

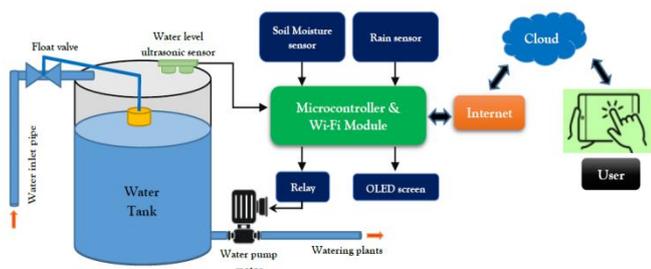


Figure 2: The smart irrigation system's IoT architecture

Water allocated for irrigation is stored in a water tank to guarantee a reserve supply, ensuring continuous irrigation without interruptions. The purpose of the float valve is to maintain a consistent water level within a tank. Positioned on the supply pipe near the top of the tank, it opens when the water level drops below the desired point and gradually closes as the maximum level is reached. The microcontroller unit activates the water pump motor based on readings from the soil moisture sensor, rain sensor, and ultrasonic water level sensor.

The data collected from various sensors is accurately processed by the Microcontroller Unit (MCU) to ensure

accuracy and reliability. Once processed, this information is displayed on an OLED screen, providing users with real-time insights into their garden's irrigation status. Moreover, leveraging internet connectivity, the data is seamlessly uploaded to a cloud web server, enabling users to access and monitor their garden's irrigation data from anywhere in the world. This accessibility empowers users to make informed decisions about their green spaces, ensuring optimal plant health and water conservation efforts regardless of geographical location.

3.2 Hardware Components

For the successful execution of this project, our primary requirements include a microcontroller and a Wi-Fi module. Among the various options available, the ESP32s board emerges as the optimal choice for our IoT endeavor. Renowned for its versatility and capabilities, the ESP32s board offers an ideal platform for developing IoT projects. Equipped with essential features like the Analog to Digital Converter (ADC) and versatile communication protocols such as I2C and SPI, the ESP32s provides the necessary tools to bring our project to completion. Its robust functionality and compatibility with IoT applications make it the ideal candidate to fulfill the requirements essential for the realization of our project goals.

The proposed system consists of the following components: an ESP32s board, ultrasonic water level sensor, soil moisture sensor, rain sensor, relay and water pump as shown in Figure 3.

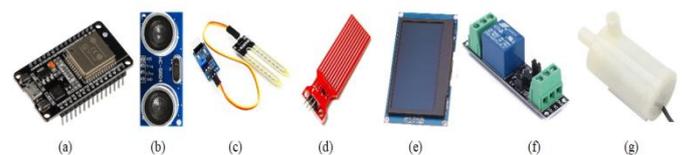


Figure 3: (a) ESP32s (b) ultrasonic sensor (c) soil moisture sensor (d) rain sensor (e) 2.42" OLED display (f) relay (g) Pump

a) ESP32s development board

The ESP32 chip, built using TSMC's 40 nm technology, stands out as a unified solution incorporating both 2.4 GHz Wi-Fi and Bluetooth functionalities. Its design prioritizes optimal power management and RF capabilities, ensuring resilience, adaptability, and dependability across diverse usage scenarios and power conditions.

The ESP32s development board, shown in figure 3.a, is a versatile microcontroller platform designed for IoT applications. Powered by the Xtensa LX6 32-bit microcontroller, it operates at a clock speed of 160 MHz, with the capability for optional overclocking to 240 MHz, ensuring

rapid and efficient processing. Equipped with 4 MB of Flash memory and 512 KB of RAM, the ESP32-S provides ample storage and memory for program storage and execution. Its extensive array of digital and analog I/O options, including 32 digital I/O pins (26 usable), 16 PWM channels, and 16 analog input channels with 12-bit resolution, facilitate versatile connectivity and sensor interfacing. The built-in Wi-Fi (802.11 b/g/n) and Bluetooth (4.2 and BLE) capabilities enable seamless wireless communication, while the inclusion of USB converter (CP2102) simplifies programming and interfacing with external devices. Moreover, the ESP32-S development board is compatible with the Arduino IDE, ensuring ease of development and a vast ecosystem of libraries and resources. Overall, the ESP32-S emerges as a powerful and versatile platform for IoT projects, combining robust performance, extensive connectivity options, and ease of use [10], [11]. Table 1 outlines various specifications of the ESP32s development board.

Table 1: Specifications of the ESP32-S development board [10]

ESP32-S	Specifications
Microcontroller	Xtensa LX6 32-bit
Clock Speed	160MHz
USB Converter	CP2102
Flash	4 MB
RAM	512Kb
Digital I/O	32 (26 usable)
PWM	16 channels
Analog Outputs	2 channels, 8-bit
Analog Inputs	16 channels, 12-bit
Communications	3 Serial, 4 SPI, 2 I2C, CAN bus, I2S Stereo
Bluetooth	4.2 and BLE (Bluetooth Low Energy)
WiFi	Built-in 802.11 b/g/n 2.4GHz
Buttons	EN (Reset) and IO0 (Boot)
Programming	Compatible with Arduino IDE
Operating Voltage	3.3V internal power and I/O. 5V-9V external power with an on-board regulator

b) Ultrasonic water level sensor

The ultrasonic water level sensor is an advanced device designed to accurately measure the level of water in a tank using ultrasonic waves. This sensor operates by emitting high-frequency sound waves towards the surface of the water and then measuring the time it takes for the sound waves to reflect back to the sensor. Based on the speed of sound in air and the time elapsed, the sensor calculates the distance to the water surface, thus determining the water level. One of the key advantages of the ultrasonic water level sensor is its non-contact nature, meaning it does not need to be submerged in the water to take measurements. This feature makes it suitable for a wide range of applications, including tanks with aggressive chemicals or varying water levels. Additionally, the

sensor typically offers high accuracy and reliability, even in challenging environmental conditions such as temperature fluctuations or presence of vapors. Overall, the ultrasonic water level sensor is a valuable tool for various industries and applications, including agriculture, water management, and smart irrigation system. Figure 3.b presents the HC-SR04 ultrasonic sensor used in this work. The HC-SR04 ultrasonic sensor has four pins:

- VCC: This pin is used to provide power to the sensor. It's usually connected to a 5V pin on the microcontroller or power source.
- Trig (Trigger): This pin is used to trigger the sensor to send out an ultrasonic pulse. When this pin receives a high signal (5V), it triggers the sensor to send out an ultrasonic wave.
- Echo: This pin is used to receive the echo of the ultrasonic wave sent out by the sensor. When an object is detected, this pin will output a high signal (5V) for a duration proportional to the time it takes for the ultrasonic wave to bounce back.
- GND (Ground): This pin is connected to the ground of the microcontroller or power source, completing the circuit.

The sensor measures the time taken for the sound wave to travel from emission to reception. By knowing the velocity of an object and the time it takes for the wave to travel, one can calculate the distance traveled using this equation:

$$Distance = (Speed \times Time) / 2.$$

c) Soil moisture sensor

A soil moisture sensor is a device that measures the moisture level in the soil around it. Figure 3.c presents the soil moisture sensor used in this work. This sensor uses a pair of probes to conduct electric current through the soil and measures the resistance to determine the moisture content. When the soil is wetter, it conducts electricity better due to lower resistance; conversely, dry soil has higher resistance and conducts electricity poorly. The sensor also features advanced protective functions, including electrostatic discharge (ESD) protection and under voltage protection. The moisture sensor module consists of various components integrated into a single circuit. These include a moisture sensor, resistors, a capacitor, a potentiometer, a comparator LM393 IC, and power and status LEDs. The LM393 integrated circuit functions as a voltage comparator in the moisture sensor module. Pin 2 of the LM393 is connected to a 10KΩ potentiometer (preset), while pin 3 is connected to the moisture sensor pin. The comparator IC compares the threshold voltage set by the preset (pin 2) with the voltage from the sensor pin (pin 3). The sensitivity of the digital output can be adjusted using the onboard preset

(trimmer pot). Table 2 displays the pinout configuration of the soil moisture sensor used in this study.

Table 2: Pin descriptions of the soil moisture sensor

Soil moisture pins	Descriptions
VCC	Power supply 3.3V to 5 V
GND	Ground pin
D0	Digital output
A0	Analog output

d) Rain sensor

Figure 3.d illustrates the rain sensor utilized in this study. It detects rainfall to prevent over-watering. This sensor, known as the leak detection sensor, is a three-pin module that generates an analog signal indicating the estimated depth of water submersion. It features 10 exposed copper traces, with five serving as power traces and the other five as sensing traces. These traces are interlaced so that each sensing trace is positioned between two power traces. Normally, these traces are unconnected, but they become connected in the presence of water. The resistance changes in proportion to the vertical distance between the top of the sensor and the water surface, with resistance decreasing as the water height increases. The configuration of multiple exposed parallel wires acts as a variable resistor, similar to a potentiometer, with its resistance changing in response to water level fluctuations. This variation in resistance is directly proportional to the vertical distance between the top of the sensor and the water surface. As the water height increases, resistance decreases, and vice versa.

e) 2.42-inch OLED display

Figure 3.e shows the 2.42-inch OLED (Organic Light-Emitting Diode) Display with SSD1309 IC utilized in this project. The 128x64 display fulfills the project's real-time data display needs due to its low cost, availability, and ease of programming. Its I2C communication port enhances its usability. Table 3 provides some specifications of the OLED display. Table 3 shows the OLED display specifications.

Table 3: OLED display

2.42-inch OLED display	Specifications
Display Size	2.42- inch
Display Driver IC	SSD1309
Resolution	128x64
Interface	I2C
Operating Voltage	3.3 V
Display color	White

f) Relay and pump

Figure 3.f and figure 3.g shows respectively the relay and the pump utilized in this study. The 1-channel 3V relay

module is an electronic device comprising a relay and a control circuit. It enables a low-voltage microcontroller to manage higher-voltage and higher-current devices, such as lights, appliances, motors, or other electrical loads. The 3.5-volt mini water pump motor is a compact water pump designed to function on a 3.5-volt voltage supply. This pump is tailored for low-power needs and is commonly used in projects requiring a small volume of water circulation. The water pump motor specifications are shown in table 4.

Table 4: Water pump specifications

Water pump	Specifications
Input Voltage	3 – 5 V
Operating Current	0.1 – 0.2 A
Flow Rate	1.2 – 1.6 L/min
Maximum Suction Distance	0.8 m

3.3 Software Components

The software components play a crucial role in the effective execution of the smart irrigation system. There are two primary components: one integrated into the ESP32s microcontroller and the other interfacing with the Blynk web server. The ESP32s board is programmed using the Arduino Integrated Development Environment (IDE) software, which utilizes a language similar to C++. To ensure optimal plant health and water conservation, the microcontroller unit (MCU) controls the irrigation system by activating the water pump motor based on sensor readings. It is programmed to perform the following tasks:

Read Sensor Data: Continuously read data from sensors including:

- Ultrasonic Water Level Sensor: Measures the water level in the reservoir or tank.
- Soil Moisture Sensor: Measures the moisture content of the soil.
- Rain Sensor: Detects the presence of rain or moisture in the environment.

Data Processing: Analyze the sensor data to determine the current environmental conditions. This includes:

- Checking soil moisture levels to assess if watering is required.
- Monitoring the water level in the reservoir to avoid depletion.
- Utilizing the rain sensor to determine if irrigation is necessary or if natural rainfall is sufficient.

Decision Making:

- Determine if the soil moisture level is below a set threshold, indicating the need for irrigation.
- Consider the water level in the reservoir to ensure there is enough water available for irrigation.
- Evaluate the rain sensor data to avoid unnecessary watering if rainfall is detected.

Control Water Pump Motor:

- Activate the water pump motor when irrigation is required based on sensor readings and decision logic.
- Ensure the water pump motor operates for an appropriate duration to adequately water the plants without overwatering.

Display Data on OLED Screen:

- Display real-time data such as soil moisture level, water level in the reservoir, and rain status on the OLED screen.
- Provide visual feedback to users for easy monitoring of plant conditions.

Send Data to Blynk Web Server:

- Transmit sensor data, including soil moisture levels, water levels, and rain sensor readings, to the Blynk web server.
- Allow remote monitoring and control of the irrigation system through the Blynk mobile app or web interface.

By integrating these software components, ESP32s programming and Blynk cloud services, effectively, the smart irrigation system operates efficiently, promoting plant health while conserving water resources.

IV. THE SMART IRRIGATION SYSTEM PROTOTYPE

The process begins with the ESP32 microcontroller checking the soil moisture level. If the moisture level is found to be below 30%, the system activates the water pump to irrigate the soil. The microcontroller continues to monitor the soil moisture level. Once the moisture level exceeds 30%, the water pump is turned off. The ESP32 then resumes monitoring the soil moisture. In addition to soil moisture, the system also checks for heavy rain using a rain sensor. If heavy rain is detected, the water pump is stopped to prevent overwatering. If no heavy rain is detected, the system continues to check the soil moisture level, and this cycle repeats as necessary. The process continues until it is manually or automatically terminated.

The flowchart, presented in figure 4, outlines the process flow of the smart irrigation system, from initializing the system and reading sensor data, through processing and decision-making, to controlling the water pump, displaying data, and sending it to the Blynk server [12].

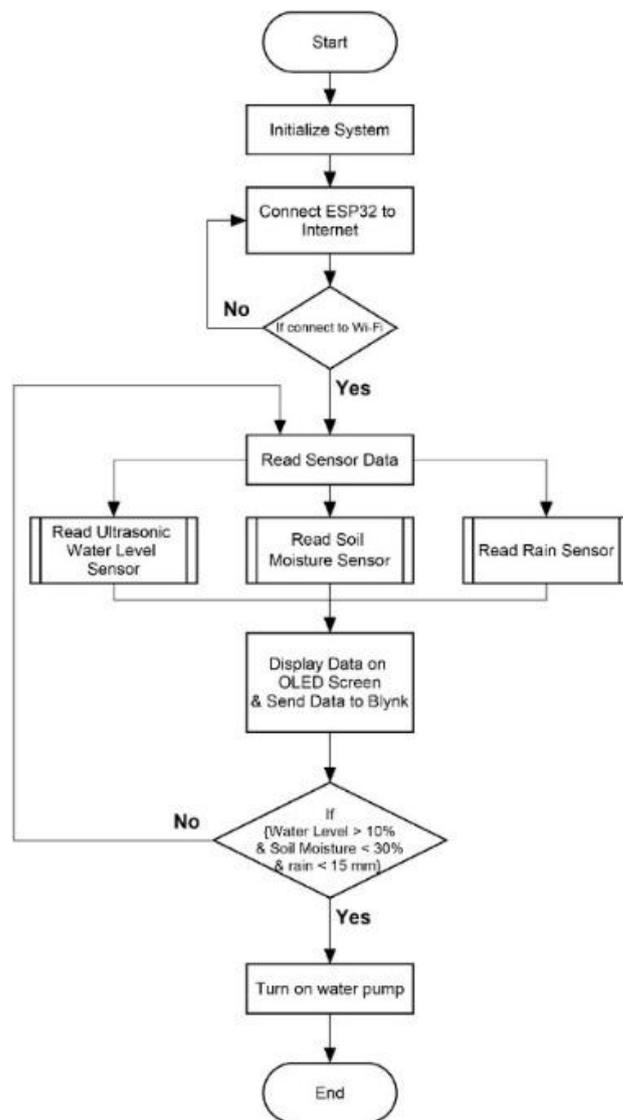


Figure 1: Flowchart of the proposed Smart Irrigation System

The system schematic was designed on EasyEDA as shown in figure 5.a, integrating an ESP32 with soil moisture sensors, rain sensor, ultrasonic water level sensor, OLED display, and relay-controlled pumps. The cloud-based platform enabled seamless schematic capture and two-layer PCB routing optimized for signal integrity and compact deployment. Figures 5.b and 5.c illustrate the completed two-layer PCB design, showing the top-layer component placement and bottom-layer copper routing optimized for compact integration of the ESP32, sensor interfaces, and relay actuation circuits.

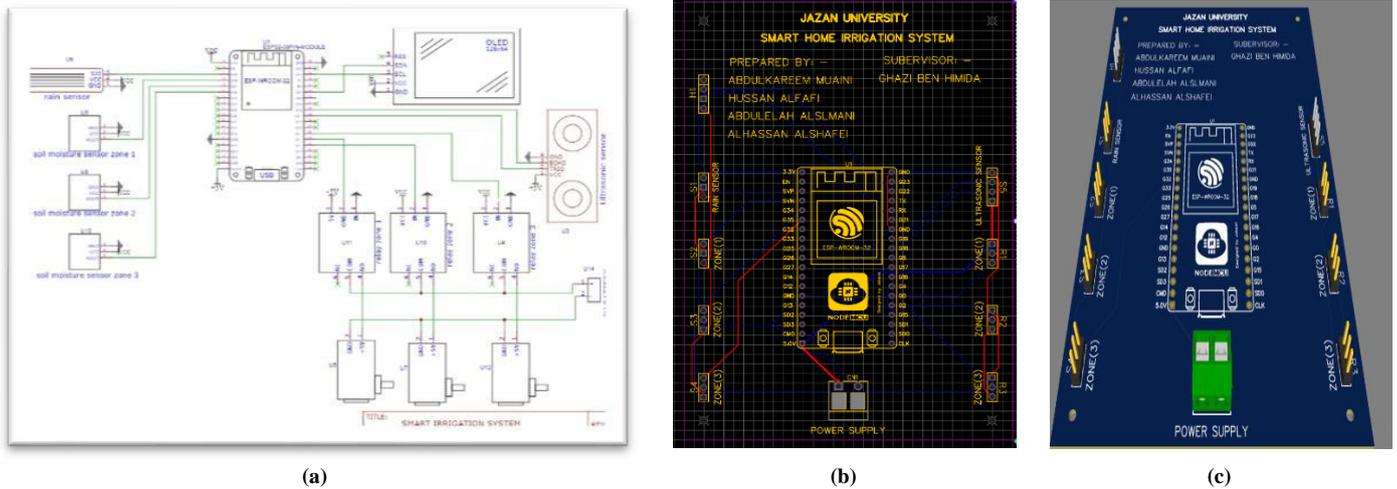


Figure 2: (a) EasyEDA system schematic, (b) two-layer PCB layout, (c) 3D PCB visualization

4.1 Implementation and Prototype Development

Breadboard Prototyping and System Integration combined component validation and system assembly into a single iterative development stage. Each electronic component—including capacitive soil moisture sensors, ultrasonic water level sensor, rain sensor, relay module, water pump, and OLED display—was individually verified for proper functionality with the ESP32 microcontroller on a breadboard. Following successful component validation, all sensors and actuators were fully integrated into a complete functional prototype, establishing communication protocols (I2C for OLED, analog readings for sensors, digital outputs for relay control) and developing the initial firmware architecture. Figure 6.a shows the preliminary breadboard test setup with all sensors simultaneously operational.

Custom PCB Fabrication transitioned the validated design from breadboard prototyping to a manufactured two-layer PCB. The circuit schematic and PCB layout were designed in EasyEDA [14], fabricated through JLCPCB [13], and manually assembled using through-hole soldering for connectors and all components. Figure 6.b displays the fully assembled PCB with all components mounted, while Figure 6.c shows the OLED display integrated with the PCB during functional testing.

Cloud Platform and Mobile Application Visualization demonstrated the system's remote monitoring and control capabilities through the Blynk IoT platform. Sensor telemetry—including soil moisture percentages, water level status, rainfall intensity, and pump activation events—was continuously transmitted to the Blynk cloud server and visualized in real-time through both web dashboard and mobile application interfaces. Figure 7.b and Figure 8.b present the Blynk web dashboard displaying live sensor data and irrigation status.

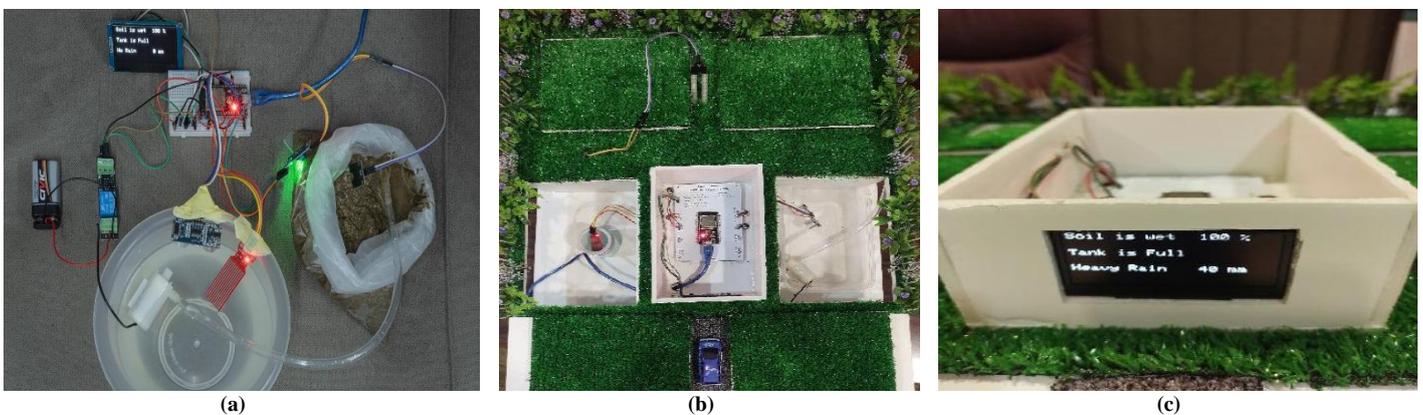
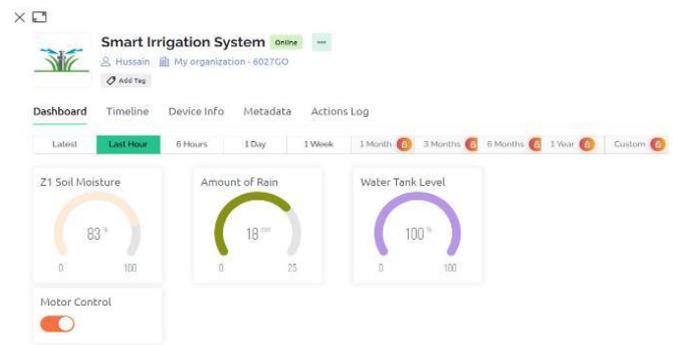


Figure 6: (a) breadboard prototype test (b) fully assembled PCB with all components (c) OLED display

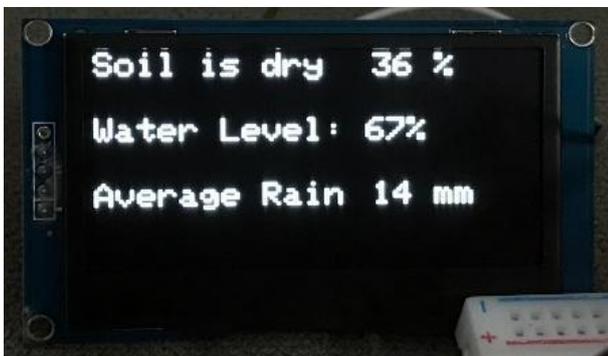


(a)



(b)

Figure 7: Wet soil (a) OLED display (b) Blynk IoT platform



(a)



(b)

Figure 8: Dry soil (a) OLED display (b) Blynk IoT platform

V. EXPERIMENTAL RESULTS AND SYSTEM VALIDATION

The system was evaluated under saturated and desiccated soil conditions to verify operational logic and remote monitoring functionality.

a) Saturated Soil Conditions

When soil moisture exceeded the 30% threshold, the system correctly maintained irrigation standby. Figure 7.a shows the OLED display with soil moisture at 79%, tank status "Full" (100%), and rainfall of 18 mm. Figure 7.b presents the corresponding Blynk web dashboard displaying Zone 1 soil moisture at 83%, water tank at 100%, and rainfall at 18 mm, with motor control indicator confirming pump deactivation.

b) Desiccated Soil Conditions

Following soil desiccation below 30%, the system triggered irrigation. Figure 8.a displays the OLED output during active irrigation showing soil moisture at 36%, water level decreased to 67%, and average rainfall of 14 mm. Figure 8.b presents the Blynk dashboard with soil moisture at 41%, tank level at 67%, and rainfall at 13 mm, confirming

successful cloud synchronization and remote monitoring throughout the irrigation cycle.

c) Performance Summary

The system achieved mean response time of 1.8 seconds from threshold violation to pump activation and 2.1 seconds deactivation latency. Sensor accuracy measured $\pm 3.2\%$ for soil moisture and ± 0.5 cm for water level, with uninterrupted Blynk connectivity throughout seven-day validation.

VI. CONCLUSION

This paper presented the design, implementation, and testing of an ESP32-based smart irrigation system for residential use. The system combines capacitive soil moisture sensors, ultrasonic water level monitoring, rain detection, OLED display, and Blynk cloud platform into an automated irrigation solution. Testing showed reliable performance with 1.8-second response time and $\pm 3.2\%$ soil moisture accuracy, effectively reducing manual intervention.

The work documents the complete process from breadboard prototyping to custom PCB fabrication, including schematics, layout files, and firmware. This addresses the lack of detailed implementation documentation in existing research and enables others to reproduce and build upon the system.

The system is particularly useful for travelers needing remote garden management, while also reducing water waste. Future work includes adding AI-based scheduling, solar power, and support for multiple irrigation zones.

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