SMART IRRIGATION SYSTEM

A PROJECT REPORT

Submitted by

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<u>BONAFIDE CERTIFICATE</u>

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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INTRODUCTION

This project demonstrates a real-time Smart Irrigation System designed to automate and remotely control the irrigation of agricultural fields using environmental data. The system leverages the capabilities of an ESP32 microcontroller, various environmental sensors, and Firebase Realtime Database for live data monitoring and control.

Key environmental parameters such as temperature and humidity (via the DHT11 sensor), soil moisture (via analog soil moisture sensor), rain detection (via a digital rain sensor), and atmospheric pressure and altitude (via BMP180) are continuously monitored. Based on these readings, the system intelligently determines whether irrigation is necessary activating a water pump (relay-controlled) only when required.

In addition to automatic control, the system also supports manual override through Firebase. A user can switch the irrigation system ON or OFF remotely in real time via the Firebase dashboard or a mobile interface.

This dual-mode functionality manual and automatic irrigation control makes the system flexible, energy-efficient, and well-suited for precision agriculture, especially in water-scarce regions. Real-time data is uploaded to Firebase for visualization, analytics, and remote decision-making, enabling users to monitor their fields from anywhere with internet access.

Overall, the integration of ESP32 with cloud-based services in this smart irrigation system not only ensures optimal water usage but also reduces the need for constant human intervention, marking a step forward in smart agriculture and IoT-based automation.

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HARDWARE DESCRIPTION

2.1 ESP32 Microcontroller

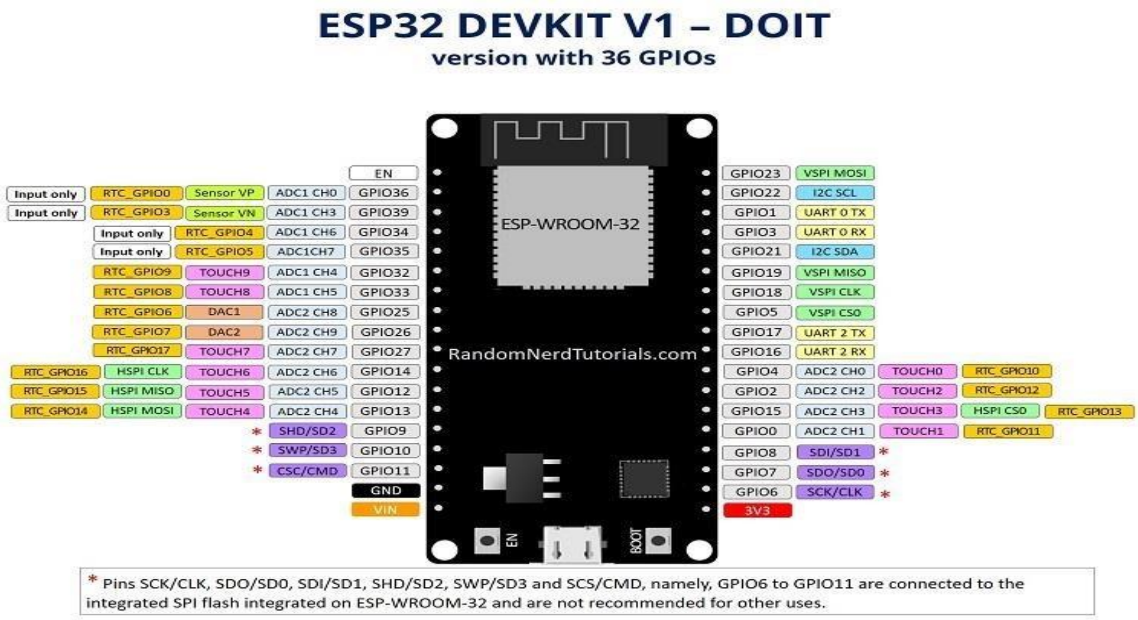

Fig 2.1 ESP32 MICROCONTROLLER PIN CONFIGURATION

The ESP32 is a low-cost, low-power system-on-a-chip (SoC) microcontroller developed by Espress if Systems, a technology company based in Shanghai, China. It is designed for a wide range of applications, particularly in the Internet of Things (IoT) domain, thanks to its integrated Wi-Fi and dual-mode Bluetooth capabilities. The ESP32 is built around a Tensilica Xtensa LX6 microprocessor, available in both dual-core and single-core configurations, or alternatively, it can feature an Xtensa LX7 dual-core processor or a single-core RISC-V microprocessor. This variety allows the ESP32 to cater to diverse processing needs, from simple tasks to more complex applications requiring significant computational power.

In addition to its powerful processor, the ESP32 integrates essential components like antenna switches, RF baluns, power amplifiers, low-noise receive amplifiers, and filters, all of which help in enhancing wireless performance and reducing power consumption. The microcontroller also includes power management modules, making it ideal for battery-operated devices that require energy efficiency.

PIN CONFIGURATION

The ESP32 peripherals include:

- 18Analog-to-Digital Converter(ADC) channels
- 3SPI interfaces
- 3UARTinterfaces
- 2 I2Cinterfaces
- 16 PWM output channels
- 2Digital-to-AnalogConverters(DAC)
- 2 I2Sinterfaces
- 10Capacitive sensing GPIOs

Applications of ESP32

- Used in IoT (Internet of Things) applications for real-time data monitoring and control.
- Commonly applied in home automation systems (e.g., smart lights, alarms, door locks).
- Utilized in industrial automation for remote monitoring, machine control, and data logging.
- Integrated into wearable devices and portable gadgets due to its low power consumption.
- Employed in wireless sensor networks for environmental monitoring and smart agriculture.
- Suitable for health monitoring systems such as pulse oximeters and fitness trackers.
- Used in educational kits and prototyping platforms for learning embedded systems and IoT.
- Ideal for robotics applications involving wireless control and sensor interfacing.
- Applied in automotive systems, including vehicle diagnostics and wireless control.
- Plays a role in dynamic wireless charging systems for electric vehicles by managing sensors, power flow, and communication.

2.2 SOIL MOSITURE SENSOR

The soil moisture sensor used in this smart irrigation system is typically a resistive-type analog sensor that measures the volumetric water content in the soil. It operates on the principle that wet soil conducts electricity better than dry soil, allowing it to output varying voltage levels depending on the soil's moisture level.

The sensor consists of two exposed probes that act as conductors; when inserted into the soil, they form part of a voltage divider circuit. As moisture increases, the resistance between the probes decreases, leading to higher conductivity and a corresponding change in the analog output voltage.

This raw analog signal, read by the ESP32's ADC pin, is mapped to a percentage to provide a user-friendly soil moisture reading. Typically, values range from 0% (fully dry) to 100% (fully wet), and calibration is crucial for accurate readings due to variations in soil type and composition. The sensor's simple design, low cost, and ease of interfacing make it ideal for real-time agricultural applications where continuous soil monitoring is essential for efficient water management.

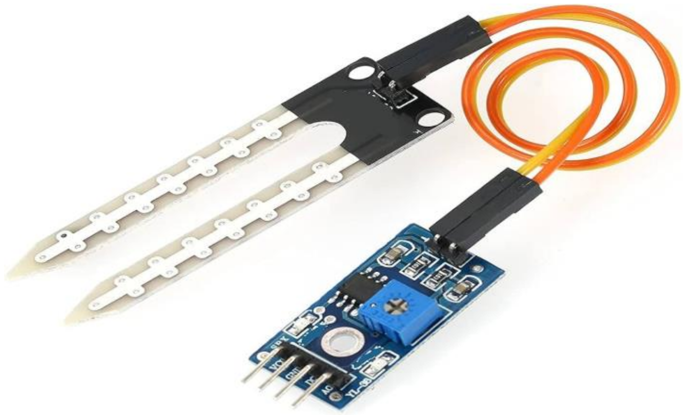

Fig 2.2 SOIL MOSITURE SENSOR

2.3 BMP085 SENSOR

The BMP085 sensor is a high-precision, low-power digital barometric pressure sensor developed by Bosch Sensortec, commonly used in weather monitoring, altitude estimation, and environmental sensing applications. It communicates via I2C or SPI protocol, making it easy to interface with microcontrollers like the ESP32. The sensor is capable of measuring absolute pressure in the range of 300 hPa to 1100 hPa, which corresponds to altitudes ranging from about -500 meters to +9000 meters above sea level.

In addition to pressure, the BMP085 can also provide altitude estimates using standard atmospheric models, which is useful in applications like GPS enhancement or indoor navigation. It features an onboard temperature sensor for temperature compensation of pressure readings, ensuring high accuracy. Typical accuracy includes ±1 hPa pressure and ±1°C temperature, with low noise and fast response time. Its compact size, reliable performance, and low power consumption make it ideal for embedded IoT and environmental monitoring systems, such as the smart irrigation system where it can provide atmospheric pressure and altitude data for correlating weather conditions with soil and crop health.

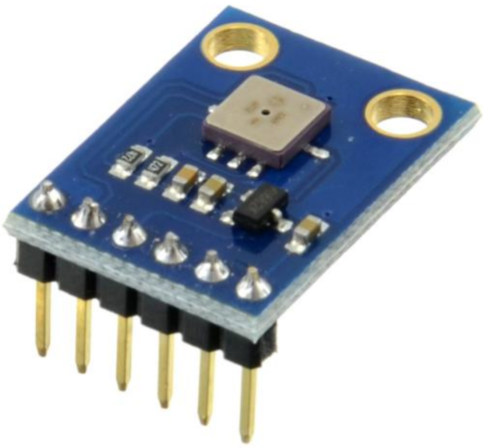

Fig 2.3 BMP085 SENSOR

2.4 RAIN SENSOR

The rain sensor used in smart irrigation systems is typically a digital rain detection module designed to sense the presence of water droplets. It consists of a rain board (conductive pad) and a control module that detects the change in conductivity when water contacts the sensor surface. The rain board is made up of exposed interlaced metal traces that form a grid; when raindrops fall on the grid, they create a conductive path between the traces, allowing a small current to flow.

This change in conductivity is detected by the control module, which outputs a digital signal (typically LOW when rain is detected, and HIGH when dry) to a microcontroller like the ESP32. Some versions of the sensor also provide an analog output, which indicates the intensity of the rain based on the amount of water present on the sensor surface.

The module is simple, low-cost, and easy to use, making it ideal for automation projects. In smart irrigation systems, it helps prevent unnecessary watering during rainfall, conserving water and improving system efficiency. For best performance, it’s recommended to install the sensor in an open area and periodically clean the sensing surface to prevent false readings caused by dirt or residue buildup.

Fig 2.4 RAIN SENSOR

2.5 TEMPERATURE SENSOR

The DHT11 sensor is a widely used, low-cost digital sensor designed for measuring temperature and relative humidity in environmental monitoring and automation systems. It combines a thermistor (for temperature sensing) and a capacitive humidity sensor in a single compact package. The sensor provides calibrated digital output through a single data pin, making it easy to interface with microcontrollers like the ESP32 using libraries that handle its proprietary 1-wire protocol.

The DHT11 offers a temperature measurement range of 0°C to 50°C with an accuracy of ±2°C, and a humidity range of 20% to 90% RH with ±5% accuracy. It updates its readings every 1 second (1 Hz sampling rate), which is sufficient for most non-critical, real-time applications. Although it is less accurate and has a narrower range than its advanced counterparts like the DHT22 or SHT sensors, the DHT11 is preferred in many low-power, cost-sensitive projects due to its simplicity and reliability.

In a smart irrigation system, the DHT11 plays a critical role by providing temperature and humidity data, which helps determine environmental conditions that affect soil moisture evaporation rates and plant water needs. Its integration allows for more intelligent irrigation decisions, either automatically or via cloud-based control platforms like Firebase.

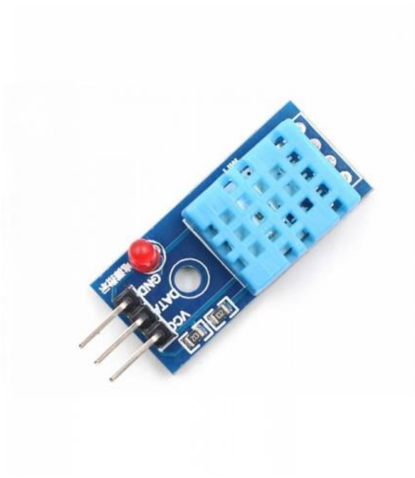

Fig 2.5 TEMPERATURE DHT11 SENSOR

2.6 RELAY

A low-level trigger relay is an electronic component used to control high-voltage or high-current devices with a low-voltage signal, typically from microcontrollers like the ESP32. It is called "low-level trigger" because it is activated (switched ON) when the control input is pulled to a low voltage (0V or ground), as opposed to a high-level trigger, which activates when the control input is high (typically 3.3V or 5V).

In a low-level trigger relay, the relay's input pin is connected to the microcontroller's output pin, and when the microcontroller outputs a LOW signal (0V), the relay closes its switch, allowing current to flow through the connected load (such as a motor or pump). When the microcontroller outputs a HIGH signal (3.3V or 5V), the relay switch opens, cutting off the current flow to the load.

In a smart irrigation system, a low-level trigger relay is commonly used to control the water pump. When the sensor system detects conditions that require watering (e.g., high temperature or low soil moisture), the ESP32 sends a low signal to the relay, activating the pump and irrigating the field. When the system determines that no watering is needed, it sends a high signal to deactivate the relay.

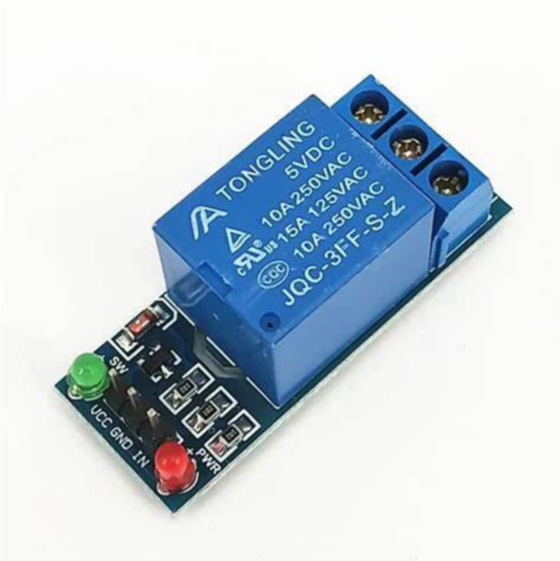

Fig 2.6 RELAY

2.7 MOTOR PUMP

A motor in a smart irrigation system is typically used to drive the water pump for irrigation purposes. Motors convert electrical energy into mechanical motion, and in this case, the motor controls the flow of water from a reservoir or storage tank to the field. The most commonly used motor types in such applications are DC motors or AC motors depending on the power requirements and the system setup. A DC motor is often preferred for low-voltage systems, especially in embedded applications with microcontrollers like the ESP32, due to its ease of control, where it can be driven by relays or motor drivers.

The motor's operation is controlled by an electrical relay or motor driver, such as the L298N, which switches the motor ON or OFF based on the input signal. In a smart irrigation system, the motor is activated when environmental conditions, like temperature or soil moisture, signal the need for irrigation. The motor starts the water pump to deliver water to the crops. When the conditions change, such as when the soil moisture level is sufficient, the motor is turned off. This helps conserve water and ensures the irrigation process is energy-efficient and automatic.

Fig 2.7 MOTOR PUMP

CHAPTER-3

SOFTWARE DESCRIPTION

3.1 FIREBASE REALTIME DATEBASE

The Firebase Realtime Database is a cloud-hosted database in which data is stored as JSON. The data is synchronized in real-time to every connected client. All of our clients share one Realtime Database instances and automatically receive updates with the newest data, when we build cross-platform applications with our iOS, and JavaScript SDKs.

The Firebase Realtime Database is a NoSQL database from which we can store and sync the data between our users in real-time. It is a big JSON object which the developers can manage in real-time. By using a single API, the Firebase database provides the application with the current value of the data and updates to that data. Real-time syncing makes it easy for our users to access their data from any device, be it web or mobile.

The Realtime database helps our users collaborate with one another. It ships with mobile and web SDKs, which allow us to build our app without the need for servers. When our users go offline, the Real-time Database SDKs use local cache on the device for serving and storing changes. The local data is automatically synchronized, when the device comes online.

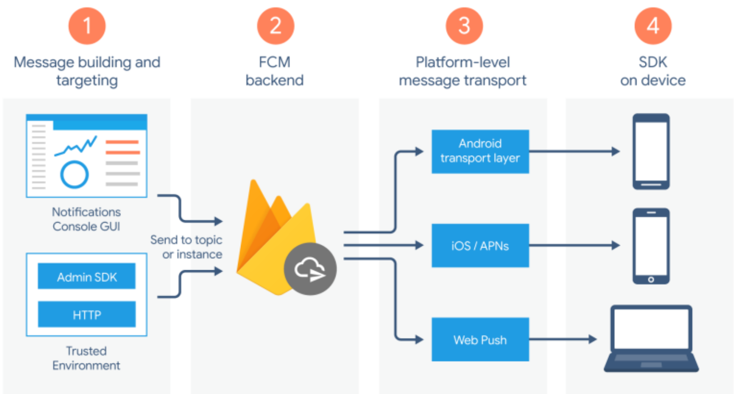

Fig 3.1 FIREBASE SETUP

CHAPTER-4

RESULT

Fig 4.1 MOBILE APP

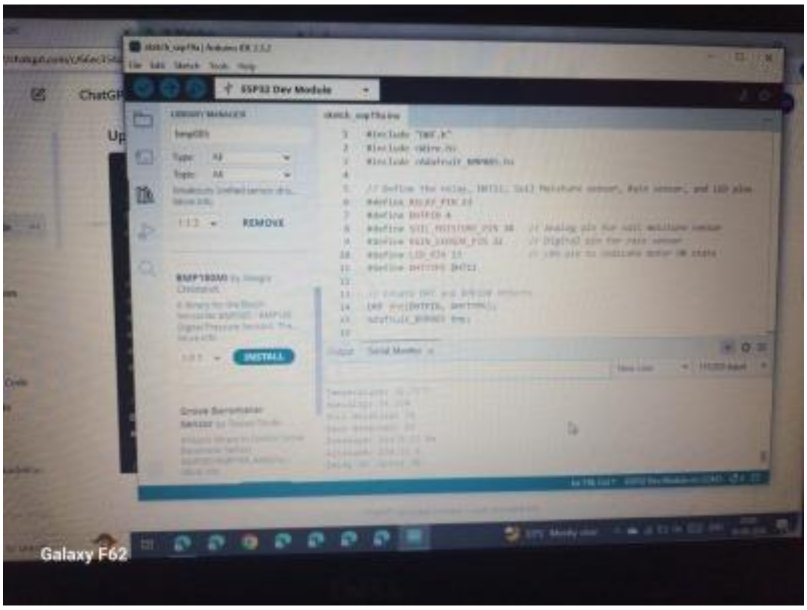

Fig 4.2 CODE AND OUTPUT

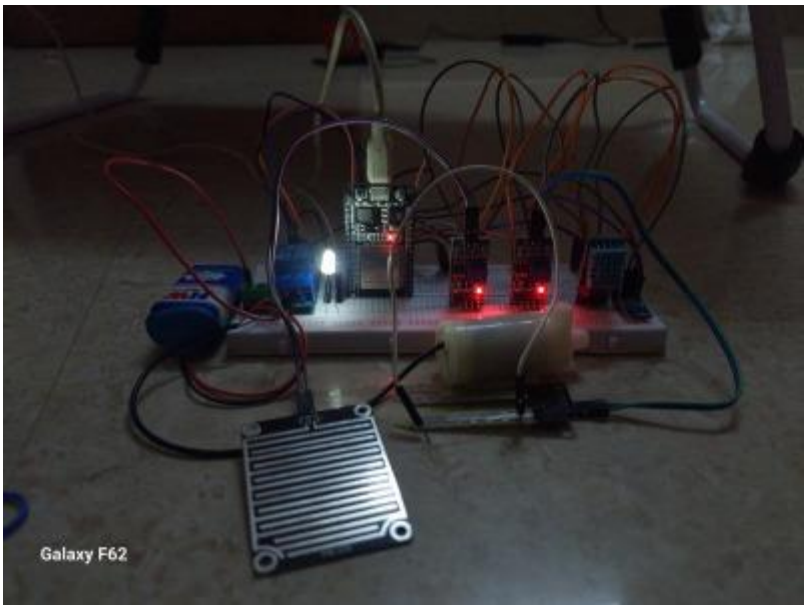

Fig 4.3 HARDWARE OUTPUT

CHAPTER-5

CONCLUSION

The Smart Irrigation System developed in this project efficiently integrates various environmental sensor such as the DHT11 for temperature and humidity, BMP085 for pressure and altitude, a soil moisture sensor, and a rain sensor along with an ESP32 controller, relay module, and a motor to automate irrigation. By accurately collecting real-time data from the field, the system ensures that irrigation only occurs when soil moisture is low and weather conditions are dry, thereby conserving water and enhancing crop health. The visual interface (mobile app) provides a clear, real-time status of all essential environmental parameters, including soil moisture, temperature, humidity, atmospheric pressure, and rain status, making the system user-friendly and effective for farmers and agriculturalists.

FUTURE WORK

Future enhancements can include integrating solar panels for a self-sustaining power source and using machine learning algorithms to predict optimal irrigation schedules based on historical weather and soil data. Expansion into IoT-based cloud platforms could allow remote access and advanced data analytics, enabling large-scale deployment across agricultural fields. Additional sensors like pH and EC (electrical conductivity) sensors can be introduced to monitor soil quality in-depth, making the system more intelligent and adaptable for precision agriculture