

IOT Based Agricultural Greenhouse Monitoring and Control System

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ABSTRACT

Greenhouse cultivation provides a controlled environment for crop production by regulating important parameters such as temperature, humidity, soil moisture, and light intensity. However, conventional greenhouse monitoring and control methods require continuous human supervision and may result in inefficient use of water, energy, and labor. This paper presents an Internet of Things (IoT)-based agricultural greenhouse monitoring and control system for automatic regulation of the greenhouse environment. The proposed system uses an ESP32 microcontroller interfaced with temperature and humidity, soil moisture, and light sensors. Based on predefined threshold conditions, the controller automatically operates a fan, water pump, and bulb through relay modules. An LCD provides local real-time information, while the Blynk IoT application enables remote monitoring and control through a smartphone. The system can operate in automatic and manual modes, allowing the greenhouse parameters to be monitored and controlled remotely. A prototype was developed and tested to demonstrate automated environmental regulation, reduced human intervention, and efficient greenhouse management.

Keywords— Internet of Things, Smart Greenhouse, ESP32, Soil Moisture, Temperature, Humidity, LDR, Blynk, Automatic Control.

INTRODUCTION

Agriculture is strongly dependent on environmental conditions, and variations in temperature, humidity, soil moisture, and light intensity can significantly influence crop growth and productivity. Greenhouses provide a protected and regulated environment in which crops can be cultivated throughout the year. The controlled structure protects plants from unfavorable climatic conditions and helps maintain suitable environmental conditions for improved crop production.

In a greenhouse, temperature, relative humidity, illumination, soil moisture, and carbon dioxide concentration are important parameters affecting plant growth. Continuous monitoring of these parameters provides information required for maintaining suitable conditions for crops. Excessive temperature can adversely affect plants, while insufficient soil moisture can cause plants to dry. Similarly, inadequate light conditions can affect plant development. Therefore, an automated monitoring and control system can reduce the limitations of manual greenhouse management.

The Internet of Things provides an effective approach for connecting sensors, controllers, actuators, and remote monitoring applications. Sensor data can be acquired by a microcontroller and transmitted through a wireless network, allowing greenhouse conditions to be monitored from a remote location. The proposed system uses an ESP32 controller with Wi-Fi connectivity to collect environmental information and control greenhouse actuators according to predefined conditions.

The developed system focuses on automatic regulation of temperature, soil moisture, and light intensity while providing remote access through a smartphone application. When the temperature exceeds the specified threshold, the fan is activated; when soil moisture decreases below the required level, the water pump is switched ON; and when light intensity becomes insufficient, the lighting system is activated. The measured parameters are displayed on an LCD and made available to the user through the IoT application.

LITERATURE SURVEY

Renu Babu Naik, Dharavath Nikhil Naik *et al.* presented a Microcontroller-Based Intelligent Greenhouse Environment Monitoring and Controlling System. The work emphasizes the use of sensors for monitoring crop and environmental conditions and transferring information to the farmer for corrective action. The report identifies limitations associated with short-range wireless communication and the challenges involved in monitoring environmental parameters. [1]

Yajie Liu *et al.* proposed an IoT Based Greenhouse Monitoring and Control System, focusing on soil moisture monitoring and automated control. The study also considers privacy and security aspects associated with IoT-enabled greenhouse architectures. Other referenced works investigate greenhouse automation using IoT, cloud computing, Arduino-based controllers, and sensor-based environmental monitoring. These studies demonstrate the potential of IoT technology for improving greenhouse management and reducing manual intervention. [2]–[6]

PROBLEM STATEMENT

The major problem in greenhouse cultivation is maintaining adequate water supply and suitable climatic conditions for plant growth. Insufficient soil moisture may cause plants to dry, while excessive heat and changes in environmental conditions can adversely affect crop growth.

OBJECTIVES

1. To develop an IoT-based greenhouse monitoring system for continuous monitoring of temperature, humidity, soil moisture, and light intensity using sensors and an ESP32 microcontroller.
2. To automatically control greenhouse environmental conditions by operating the fan, water pump, and lighting system based on predefined threshold values, while enabling remote monitoring and control through the Blynk IoT application.

PROPOSED SYSTEM

The proposed greenhouse system consists of four major sections: sensing, control, actuation, and IoT-based monitoring. Temperature and humidity, soil moisture, and light sensors continuously measure the greenhouse environment. The sensor outputs are processed by the ESP32 microcontroller. Based on predefined threshold conditions, the controller activates or deactivates the corresponding actuators.

The actuators include a DC fan for temperature regulation, a water pump for irrigation, and a bulb for providing light and heat when required. An LCD displays the measured environmental parameters and actuator status locally. The ESP32 transmits the sensor information through Wi-Fi to the Blynk IoT platform, allowing the user to monitor and control the greenhouse remotely using a smartphone.

BLOCK DIAGRAM

The Fig 1 represents an ESP32-based smart greenhouse monitoring and control system. Temperature, light, and soil-moisture sensors provide input to the ESP32, which controls the DC fan, heat lamp, and water pump, while the LCD displays system parameters and the Wi-Fi module enables remote monitoring through an IoT website.

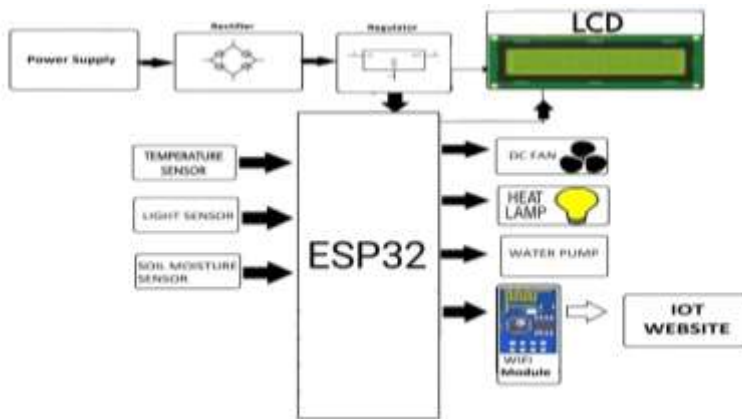


Fig 1 Block Diagram

CIRCUIT DIAGRAM

The Fig 2 shows the interfacing of the ESP32 controller with the soil-moisture sensor, LDR sensor, temperature sensor, LCD display, relay-controlled water pump, and LED indicator. A solar panel and battery supply power to the system, while the ESP32 processes the sensor inputs and controls the connected devices for automated greenhouse operation and monitoring.

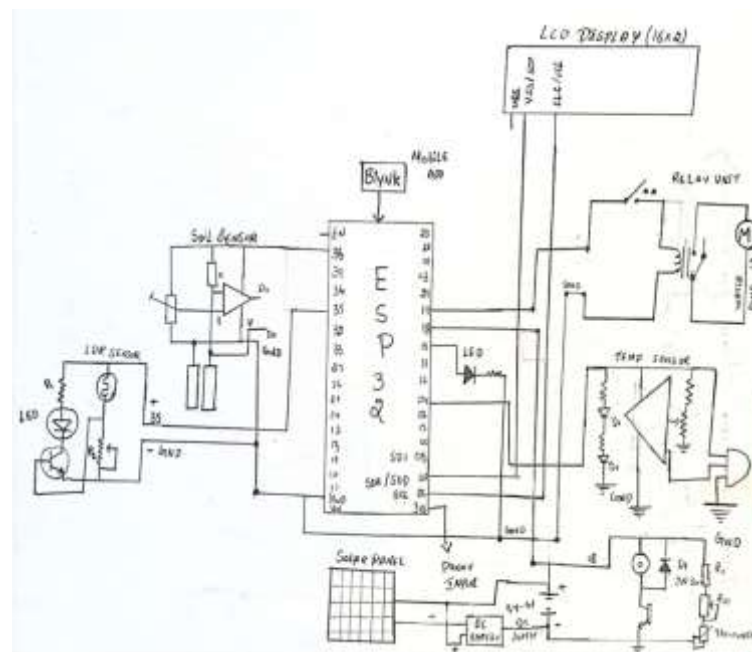


Fig 2 Circuit Diagram

METHODOLOGY

The proposed system consists of sensing, control, actuation, display, and IoT monitoring sections. Temperature and humidity, soil moisture, and light sensors continuously sense the environmental conditions inside the greenhouse and provide the measured values to the ESP32 microcontroller. The controller processes these values and compares them with predefined threshold conditions.

The current temperature, humidity, soil moisture, and light conditions are displayed on the LCD, while the ESP32 communicates the sensor information to the Blynk IoT application through Wi-Fi for remote monitoring.

Based on the sensed conditions, the ESP32 automatically controls the connected actuators through relay modules. When the temperature exceeds the specified limit, the DC fan is switched ON to reduce the temperature. When soil moisture falls below the required level, the water pump is activated for irrigation, and when the light intensity becomes insufficient, the bulb is switched ON. The system can operate in automatic mode according to sensor thresholds or manual mode through the Blynk application, enabling the user to monitor and control the greenhouse remotely.

RESULTS AND DISCUSSION

The developed prototype successfully demonstrates automated greenhouse monitoring and control. Sensor data related to moisture, temperature, and light are acquired and processed by the controller. Based on the measured conditions, the fan, pump, and lighting system are automatically operated to maintain the greenhouse environment within the desired operating range.

The LCD provides local information about the measured parameters, while the IoT application enables remote monitoring and control. The system reduces the need for continuous manual supervision and allows the user to observe greenhouse conditions remotely. The automatic operation of irrigation and environmental-control devices also supports efficient utilization of water and reduces human effort.

The proposed system is particularly suitable for small-scale farming, nurseries, indoor plantations, and cultivation of plants requiring close environmental monitoring. The report indicates that automation can reduce maintenance effort and provide useful environmental information to farmers and agricultural researchers.

CONCLUSION

An IoT-based agricultural greenhouse monitoring and control system has been developed to automate the monitoring and regulation of important greenhouse environmental parameters. The system integrates an ESP32 microcontroller with temperature and humidity, soil moisture, and light sensors to acquire environmental information. Based on predefined threshold conditions, a fan, water pump, and bulb are automatically controlled through relay modules.

The integration of the Blynk IoT application provides remote access to greenhouse information and control functions through a smartphone. The developed prototype demonstrates that IoT-based automation can reduce manual intervention, improve monitoring, and provide a controlled environment for crop cultivation.

The system therefore provides a practical approach for small-scale smart greenhouse applications and can be further expanded with additional sensors and intelligent agricultural functions.

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