IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ※ Peer-reviewed & Refereed journal ※ Vol. 13, Issue 4, April 2025

DOI: 10.17148/IJIREEICE.2025.134110

"IoT BASED SMART MONITORING & CONTROL SYSTEM FOR GREENHOUSE POWERED BY DUAL AXIS SOLAR TRACKED PV SYSTEM"

Prof. Dr. T. H. Mohite[1], Sayali Dilip Powar[2], Siddhi Shital Yelappure[3], Shraddha Niranjan Tathe[4]

Professor, Dr. J. J. Magdum College of Engineering, Jaysingpur[1]

B.Tech (E&TC), Dr. J.J Magdum College of Engineering, Jaysingpur[2]

B.Tech (E&TC), Dr. J.J Magdum College of Engineering, Jaysingpur[3]

B.Tech (E&TC), Dr. J.J Magdum College of Engineering, Jaysingpur[4]

Abstract: Greenhouses have revolutionized the way we grow plants, providing a controlled environment for optimal growth and productivity. As the global population continues to rise, the need for sustainable and efficient agricultural practices has never been more pressing. Greenhouses offer a solution to this challenge, enabling year-round crop production, improved yields, and reduced environmental impact. Greenhouses are essential for modern agriculture, providing a sustainable and efficient solution to global food security challenges. As technology continues to advance, greenhouses will play an increasingly important role in ensuring a food-secure future. Greenhouses provide a controlled environment that extends the growing season beyond what is possible outdoors.

Innovations in greenhouse technology can significantly enhance efficiency and productivity in agriculture. Advanced systems for monitoring, automation, and data analysis can optimize resource use, leading to higher yields and better-quality crops. Innovations like smart irrigation systems, energy-efficient heating and cooling solutions, and sustainable materials contribute to resource conservation. Also, greenhouse innovations help farmers adapt to the challenges posed by climate change.

To achieve all these objectives and a non-manual interference greenhouse, this paper presents an innovative IoT-based smart monitoring and control system for a greenhouse, powered by a dual-axis solar tracked photovoltaic (PV) system. The proposed IoT-based smart monitoring and control system for greenhouses, powered by a dual-axis solar tracked PV system, demonstrates significant improvements in energy efficiency, plant growth, and water conservation. This innovative solution has potential applications in agricultural and horticultural industries. It integrates environmental sensors to monitor key parameters such as temperature, humidity, soil moisture, and light intensity, enabling real-time data collection and analysis. The dual-axis solar tracker optimizes energy generation, ensuring a reliable power supply for the system. By employing IoT connectivity, users can remotely access data and control greenhouse conditions via a mobile application. This system enhances crop yield and resource efficiency, while promoting sustainable agricultural practices. Experimental results demonstrate significant improvements in energy utilization and environmental management, highlighting the feasibility and effectiveness of the integrated approach in modern agriculture.

Keywords: Dual-axis solar tracked PV system, greenhouse, IoT, control system, soil moisture, soil temperature, humidity.

I.INTRODUCTION

In recent years, the integration of the Internet of Things (IoT) in agricultural practices has revolutionized traditional farming, leading to increased efficiency and productivity. Greenhouses have revolutionized the way we grow plants, providing a controlled environment for optimal growth and productivity. As the global population continues to rise, the need for sustainable and efficient agricultural practices has never been more pressing. Greenhouses offer a solution to this challenge, enabling year-round crop production, improved yields, and reduced environmental impact.

DOI: 10.17148/IJIREEICE.2025.134110

This paper introduces an innovative IoT-based smart monitoring and control system designed specifically for greenhouse environments. The system leverages a dual-axis solar tracked photovoltaic (PV) setup to ensure sustainable energy supply, optimizing the greenhouse operations while reducing dependence on conventional energy sources.
By combining IoT technologies with renewable energy sources, this smart monitoring and control system not only enhances the efficiency of greenhouse management but also promotes sustainable agricultural practices. The dual-axis solar tracked PV system serves as a model for future innovations in smart farming, providing a pathway toward greater sustainability and productivity in agriculture. The primary aim of this system is to create an automated environment that can monitor and control critical parameters such as temperature, humidity, soil moisture, and light intensity. By employing IoT technologies, data from various sensors can be collected in real-time, enabling precise control over the greenhouse conditions.

Problem Statement: The lack of automation in greenhouses can lead to several problems including inefficient climate control, water and nutrient waste, reduced crop yields, increased labour costs & inability to collect and analyse data.

Proposed work: The proposed IoT-based smart monitoring and control system for greenhouses, powered by a dual-axis solar tracked PV system, demonstrates significant improvements in energy efficiency, plant growth, and water conservation. It integrates environmental sensors to monitor key parameters such as temperature, humidity, soil moisture, and light intensity, enabling real-time data collection and analysis. The dual-axis solar tracker optimizes energy generation, ensuring a reliable power supply for the system. By employing IoT connectivity, users can remotely access data and control greenhouse conditions via a mobile application.

II.LITERATURE REVIEW

1)"IoT-Based Smart Agriculture: A Comprehensive Review"
Authors: A. Kumar, R. Raghav.
Published In: IEEE Access
Year: 2020
Details: This paper reviews IoT applications in agriculture, including smart greenhouse technologies.

2)"Smart Greenhouse Management System Using IoT"
Authors: P. D. Patil, S. V. Deshmukh
Published In: International Journal of Engineering Research & Technology
Year: 2021
Details: Discusses the design and implementation of an IoT-based greenhouse management system.

3)"Dual Axis Solar Tracking System: Design and Implementation"
Authors: M. H. M. Ali, N. H. M. Saad
Published In: Renewable Energy
Year: 2018
Details: Focuses on the design principles and efficiency improvements of dual-axis solar tracking systems.

III.OBJECTIVES

1)Real time monitoring of environmental parameters:
- To monitor and adjust environmental parameters such as temperature, humidity, soil moisture, light intensity.
- To maintain optimal growing conditions for plants.

2)Automated irrigation system:
- To automatically control water inflow and outflow based on predefined soil moisture data.
- To implement automated irrigation systems that respond to real-time soil moisture data and control energy consumption through efficient use of heating and cooling systems.

3)Maximize solar energy capture:
- To utilize a dual-axis solar tracked PV system to maximize solar energy capture and reduce reliance on non-renewable energy sources.
- To provide sufficient power for the greenhouse's IoT and control systems and optimize energy consumption through smart scheduling and load management.

4)Real time monitoring through IoT:
- To develop an IoT-based platform that collects data from various sensors, processes it, and allows remote monitoring and control of greenhouse conditions through web or mobile applications.

ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 13, Issue 4, April 2025
DOI: 10.17148/IJIREEICE.2025.134110

- Remote monitoring and control of greenhouse conditions through web or mobile applications.

5)Analyse historical and real-time data:
- To use data analytics and machine learning algorithms to analyse historical and real-time data.
- Offers actionable insights and predictive analytics for better management of greenhouse operations.

6)Enhance Crop Yield and Quality:
- To monitor and control greenhouse environmental parameters (temperature, light, and soil moisture).
- Create optimal growing conditions.

7)Cost reduction: -
- To minimize energy consumption, water usage and labour costs.

9)Enhance greenhouse value:
- Increase the value of the greenhouse through modernization and technological advancements.

IV.HARDWARE COMPONENTS

By combining IoT technologies with renewable energy sources, this smart monitoring and control system not only enhances the efficiency of greenhouse management but also promotes sustainable agricultural practices. The dual-axis solar tracked PV system serves as a model for future innovations in smart farming, providing a pathway toward greater sustainability and productivity in agriculture. The block diagram of IOT Based Smart Monitoring and Control System of Greenhouse Powered by Dual Axis Solar Tracked PV System is given below.

Circuit diagram:

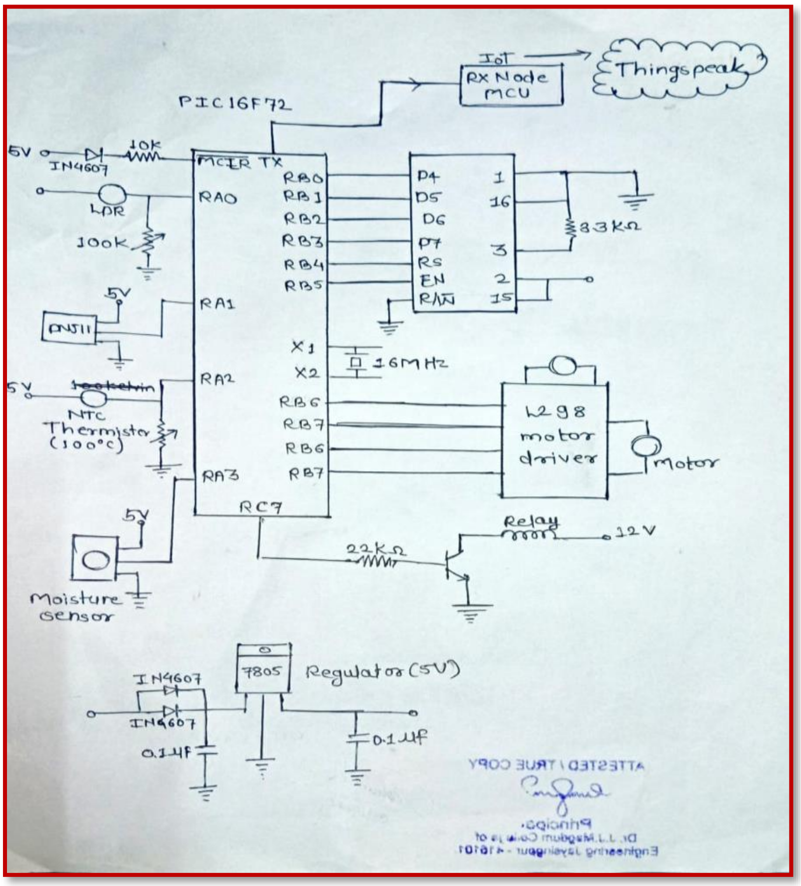


Figure: Block diagram

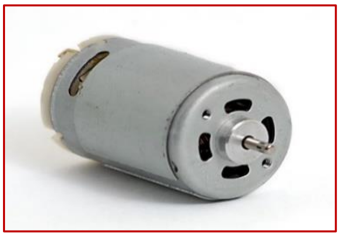
The block diagram of monitoring and control system consists of PIC18F4550 microcontroller, DC motor, LDR sensor, moisture sensor, thermistor, submersible pump, lead acid battery(12V), regulator, relay and IoT. All the components are connected to the PIC18F4550 microcontroller. Solar panels are connected to the DC motor to track the solar energy. The motor is controlled using 89552 microcontroller (8051 family).

DOI: 10.17148/IJIREEICE.2025.134110

PIC18F4550 Microcontroller-

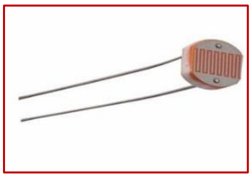
Acts as the brain of the system. Controls the dc motor, LDR & moisture sensor, thermistor, relay, regulators, etc. Can be programmed to control and monitor the greenhouse. Can send data (via IoT).

DC Motor-



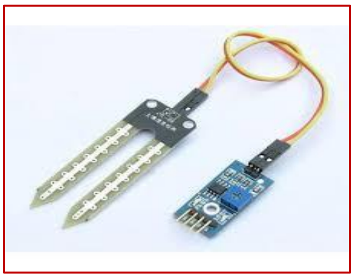
Responsible for tracking solar energy by rotating after specific time. Controlled by the 89552 controller (8051 family).

LDR Sensor -



Can be used to automatically control lighting systems based on the ambient light level.

Moisture sensor-



Detects the moisture level in the soil. If it is below the setpoint, sensor gives the feedback to pump and pump get started.

Thermistor –

Temperature of the greenhouse should be 42-45°C. Thermistor is used to control and maintain the optimal temperature conditions for the plant growth.

DOI: 10.17148/IJIREEICE.2025.134110

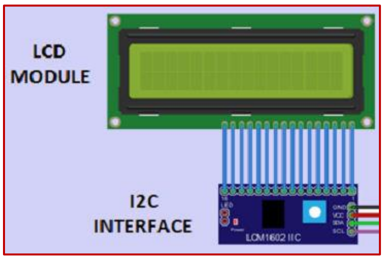
Submersible Pump-

Can be used in irrigation system. It is submerged in the water reservoir or tank, drawing in water as needed. It supplies water to the irrigation system, which distributes it to the plaint through pipes, drippers or sprinkles.

Lead Acid Battery(12V)-

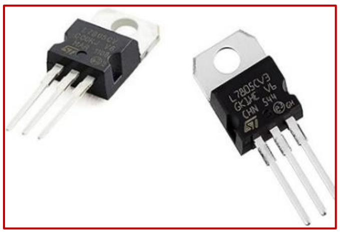
Plays a crucial role in providing backup power and stabilizing the electrical system. It is used to store excess energy generated by solar panels during the day for use during nighttime or power outages.

LCD module-



The LCD Module has 16 pins which are connected to the 16 corresponding pins of the I2C Interface device. The module is then connected to the Arduino nano board via the other 4 pins (GND, Vcc, SDA, and SCL) of the I2C Interface Device.

Voltage Regulator LM7805-



This regulator can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. It employs internal current limiting, thermal shutdown and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, it can deliver over 1A output current. Although designed primarily as fixed voltage regulator, this device can be used with external components to obtain adjustable voltages and currents

ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 13, Issue 4, April 2025

DOI: 10.17148/IJIREEICE.2025.134110

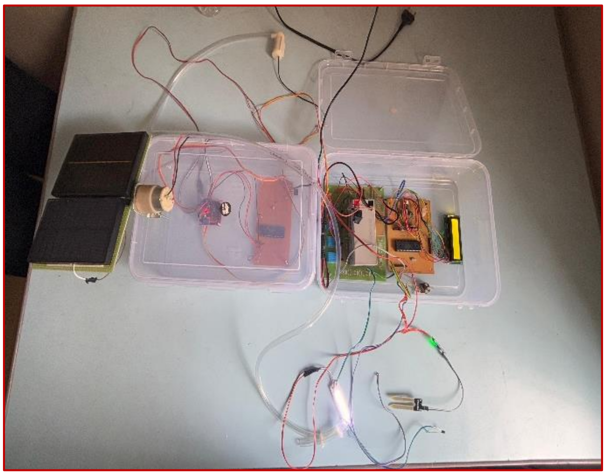
IoT-

An RX node MCU(microcontroller unit) is a type of microcontroller is designed for wireless communication, particularly in the context of IoT applications.

Other than these components solar panels, relay, transistor, capacitors, diodes, resistors and oscillators are used in the IoT based smart monitoring and control system for greenhouse powered by dual axis solar tracked PV system.

V.METHODOLOGY

The methodology for developing the IoT based smart monitoring and control system for greenhouse powered by dual axis solar tracked PV system involves a structured approach that encompasses hardware design, software development, IoT integration, and testing. Initially, the requirements were analysed based on existing plant conditions, focusing on controlling various parameters like light, temperature and moisture of the greenhouse, collecting the real time date, monitoring the system as per requirements, tracking solar path and efficient IoT system the enhances plant conditions and crop yields through automated and real-time monitoring without manual interference. logs, and a real-time clock (RTC) for maintaining accurate timing. The implementation phase began with circuit design and prototyping using simulation tools, followed by assembling the hardware on a printed circuit board (PCB). The microcontroller was programmed using Embedded C in Micro-C software to analyse the data and send it to the IoT platform. IoT sensors collect data on environmental parameters and send it to the microcontroller and provides insights on the greenhouse environment. The system automates control of the greenhouse environment based on the insights from the data analysis. The system provides real-time monitoring of the greenhouse environment through a user-friendly interface.



REFERENCES

[1]. **"Performance Evaluation of Dual-Axis Solar Tracking Systems."**
Author: Alomar M.
Name: Renewable Energy (Published in 2021)

[2]. **"Integrating IoT and Solar PV in Greenhouse Management."**
Author: Khan S.

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁖ Peer-reviewed & Refereed journal ⁖ Vol. 13, Issue 4, April 2025
DOI: 10.17148/IJIREEICE.2025.134110
Name: Journal of Agriculture Engineering (Published in 2023)
[3]. **"IoT-Based Smart Agriculture: A Review."**
Author: Kumar A.
Name: Agricultural system (Published in 2021)
[4]. **"A Cloud-Based IoT Framework for Smart Greenhouses."**
Author: Rahman M.
Name: Sensors (Published in 2020)
[5]. **"Environmental Monitoring in Greenhouses using IoT."**
Author: Zhang L.
Name: Computers and Electronics in Agriculture (Published in 2022)
This reference provides a comprehensive overview of the current state of research in this area, emphasizing the need for further exploration to fully realize the potential of these technologies.