

Design And Implementation of A Solar - Powered Smart Rain Shield System For Household Clothes With GSM - Based SMS and IOT Monitoring

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Abstract- *The increasing adoption of smart home technologies has created a demand for automated and energy-efficient household solutions. Traditional clothes drying methods are vulnerable to unexpected rainfall, leading to inconvenience and repeated drying efforts. Existing systems provide rain detection and mechanical covering mechanisms but lack SMS notification and remote monitoring, limiting user awareness. The proposed system presents the design and implementation of a Solar-Powered Smart Rain Shield System integrated with GSM-based SMS alerts and IoT monitoring. A rain sensor detects precipitation and sends signals to the ESP32 microcontroller, which controls a servo motor to automatically deploy a protective shield. Unlike existing models, the system sends real-time SMS notifications through a GSM module and enables remote status checking via a web-based IoT platform. The system operates using solar energy with battery backup, ensuring sustainable and uninterrupted performance. By integrating renewable energy, embedded control, and wireless communication, the proposed solution enhances safety, improves user convenience, and reduces manual intervention.*

Keywords: Solar Smart Rain Shield, GSM Module, IOT Monitoring, Rain Detection, ESP32 Microcontroller, SMS Alert, Home Automation, Wireless Communication.

I. INTRODUCTION

The rapid advancement of **smart home technologies** and **renewable energy systems** has significantly transformed modern household applications [1]. Automation plays a vital role in improving efficiency, convenience, and sustainability in daily life. Clothes drying is a common household activity that is highly affected by sudden weather changes, particularly unexpected rainfall [2]. Traditional drying methods rely on manual supervision, requiring users to monitor weather conditions continuously. Even in partially automated systems, protection mechanisms operate without providing user notifications or remote monitoring capabilities

[3]. This lack of communication can result in inconvenience, repeated drying efforts, and unnecessary energy consumption. With the development of **Internet of Things (IoT)** and **embedded systems**, intelligent monitoring solutions have become more practical and efficient [4]. Sensors combined with microcontrollers can detect environmental conditions and automatically perform control actions. Additionally, wireless communication technologies such as **GSM modules** enable real-time SMS alerts to users [5]. In this paper, a **Solar-Powered Smart Rain Shield System for Household Clothes** is proposed. The system integrates a **rain sensor**, **ESP32 microcontroller**, and **servo motor** to automatically deploy a protective shield upon rain detection. Unlike existing systems, the proposed model incorporates **GSM-based SMS notifications** and an **IoT-based web monitoring platform**, allowing users to check system status remotely. The integration of **solar energy with battery backup** ensures sustainable and uninterrupted operation [6]. The proposed system enhances safety, reduces manual intervention, and provides an efficient solution for modern smart home environments.

II. LITERATURE REVIEW

Recent studies on smart home automation systems focus on reducing manual effort through sensor-based monitoring and automatic control mechanisms [1]. Rain detection systems using moisture sensors and embedded controllers have been implemented to protect outdoor setups; however, many lack user notification features [2]. The integration of IoT technology has enabled real-time monitoring through web-based dashboards and mobile platforms [3]. Similarly, GSM-based systems have been used to send SMS alerts in automated applications without relying on Wi-Fi connectivity [4]. Additionally, the use of solar energy in automation systems promotes sustainability and uninterrupted operation [5]. However, limited research combines rain detection, GSM-based SMS alerts, IoT web monitoring, and solar power into a single integrated solution.

The proposed system aims to address this gap by providing an efficient and sustainable smart rain protection system for household clothes drying.

2.1 ExistingSystem

In the existing system, rain detection mechanisms automatically deploy a protective cover when rainfall is detected. Although basic automation is implemented, the system does not include an **SMS notification feature** to inform users about rain detection or shield deployment status. As a result, users remain unaware of the system operation when they are away from home. Furthermore, **remote monitoring through a web interface** is not available in conventional models. The absence of communication modules limits real-time user awareness and system transparency. Additionally, many existing systems rely on conventional power sources and lack renewable energy integration. Hence, the existing system provides limited functionality in terms of communication, monitoring, and sustainability.

2.1.2 Rule-BasedEvaluationApproach

The proposed system operates based on predefined rule-based logic implemented in the ESP32 microcontroller. The system continuously monitors input data from the rain sensor and evaluates conditions according to programmed rules. If rainfall is detected, the controller automatically activates the servo motor to deploy the protective shield. Simultaneously, the GSM module sends an SMS notification to the user, and the IoT platform updates the system status on the web interface. When no rain is detected, the shield remains retracted. This rule-based approach ensures fast response, reliable automation, and real-time user awareness without requiring manual intervention.

Table1.1 Comparison of ExistingandProposed Rain Shield System

Criteria	Existing System	Proposed System
Rain Detection	Basic Sensor Detection	Advanced Sensor with Automated Control

User Notification	Not Available	GSM – Based SMS Alerts
Remote Monitoring	Not Available	IOT Web – Based Monitoring
Energy Source	Grid Electricity	Solar Power with Battery Backup
Automation Level	Partially Automated	Fully Automated
User Awareness	Limited	Real – Time Status Updates
System Efficiency	Moderate	High
Manual Intervention	Required	Reduced

RESEARCH METHODOLOGY

The proposed system is developed using a structured approach that integrates sensing, processing, communication, and actuation modules. A rain sensor is used to detect precipitation, and the sensed data is processed by an ESP32 microcontroller. Based on the detected condition, a servo motor automatically deploys a protective shield to safeguard clothes. To enhance user awareness, a GSM module sends real-time SMS notifications, while an IoT-based web platform enables remote monitoring of system status. The entire system operates using solar energy with battery backup, ensuring sustainable and uninterrupted performance.

Data Collection

The data required for the proposed system is collected using environmental sensing components and system monitoring modules. A **rain sensor** is employed to detect the presence of moisture and rainfall conditions in real time. The sensor continuously monitors environmental changes and generates signals based on water contact intensity. These signals are transmitted to the **ESP32 microcontroller** for further processing and decision-making.

In addition to rainfall detection, system-related parameters such as **shield position status**, **power availability**, and **battery condition** are also monitored. The collected data is processed and transmitted through a **GSM module** for SMS notifications and through an **IoT-based web platform** for remote monitoring. This structured data collection process ensures accurate environmental detection and reliable system performance.

Feature Selection

Feature selection in the proposed system focuses on identifying essential parameters required for accurate rain detection and automated shield control. The primary features include **rain intensity data from the rain sensor**, **shield position status**, **power supply level**, and **battery backup condition**. These features are selected to ensure reliable environmental monitoring, efficient decision-making by the ESP32 microcontroller, and real-time user communication through GSM and IoT platforms. Selecting these relevant features improves system responsiveness, reduces unnecessary processing, and enhances overall performance.



Fig1.1 GSM and IoT Enabled Smart Rain Shield System.

3.1.3 Hardware and Software Components

The proposed system integrates both hardware and software modules to ensure efficient operation. The hardware components include a rain sensor, ESP32 microcontroller, servo motor, GSM module, and solar panel with battery backup. The software components consist of embedded programming for automation control and an IoT web platform for real-time monitoring. The integration of these components enables automated rain detection, shield deployment, SMS notification, and remote system status tracking.

3.1.4 System Operation and Testing

The system operation begins when the rain sensor detects moisture and sends input signals to the ESP32 controller. Based on the programmed logic, the servo motor deploys the protective shield to prevent clothes from getting wet. Simultaneously, the GSM module sends an SMS alert to the user, and system parameters are updated on the IoT web dashboard. The system was tested under different rainfall conditions to verify response time, communication reliability, and power efficiency.

3.1.5 System Architecture of the Implementation

The system architecture consists of sensing, processing, communication, and actuation layers. The rain sensor functions as the input unit, while the ESP32 serves as the central processing controller. The servo motor performs mechanical shield control, and the

GSM module enables SMS communication. The IoT platform provides remote monitoring through a web interface. The entire system operates using solar energy with battery backup, ensuring continuous and sustainable performance.

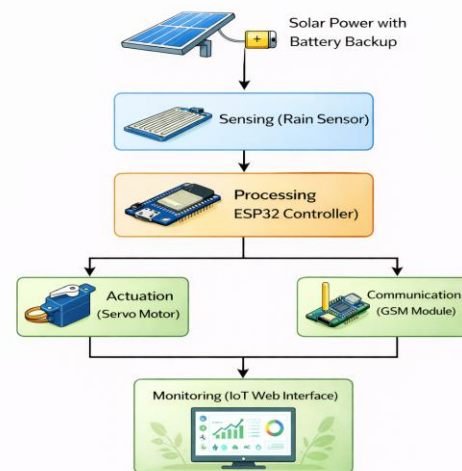


Fig 3.1 Proposed Solar Powered Smart Rain Shield System

3.2 Proposed System

The proposed system enhances the existing model by integrating **GSM-based SMS notification** and **IoT-based web monitoring**, thereby improving communication and real-time user interaction. Unlike conventional systems that operate without informing the user, the proposed solution ensures continuous awareness and remote accessibility. When rain is detected, the **rain sensor** sends a signal to the **ESP32 microcontroller**, which processes the input and immediately

activates the system response. The **servo motor** automatically deploys the protective shield to prevent clothes from getting wet. At the same time, the **GSM module** sends an instant SMS alert to the user indicating rain detection and shield deployment status.

Simultaneously, the **IoT platform** updates real-time data on a web dashboard, allowing users to remotely monitor rain status, shield position, battery level, and overall system condition from any location. The integration of **solar power with battery backup** ensures uninterrupted operation even during power outages.



Fig 1.3 Implementation Architecture of Solar-Powered Smart Rain Shield with SMS Alert and Web Monitoring.

This improvement significantly enhances user awareness, ensures faster response time, reduces manual intervention, and provides reliable protection for household clothes under varying weather conditions.

IV. RESULTS AND DISCUSSION

The proposed **Solar-Powered Smart Rain Shield System** was implemented and tested under various environmental conditions to evaluate its functionality and performance. The **rain sensor** effectively detected rainfall and transmitted accurate signals to the **ESP32 microcontroller**. Upon detection, the controller processed the input data and activated the **servo motor**, which automatically deployed the protective shield over the clothes drying area.

The response time of the system was observed to be quick and consistent during repeated trials. The communication performance of the system was also analyzed. The integrated **GSM module** successfully sent real-time SMS notifications to the user immediately after rain detection and shield deployment. Simultaneously, the **IoT-based web dashboard** displayed live updates, including rain status, shield position,

and battery level. The remote monitoring feature allowed users to check system conditions from any location, enhancing convenience and accessibility. Furthermore, the integration of **solar energy with battery backup** ensured uninterrupted operation even during power interruptions.

The system operated efficiently with minimal manual intervention and demonstrated stable performance across different weather scenarios. Overall, the results confirm that the proposed model improves protection efficiency, enhances user awareness, and provides a reliable smart home solution for automated clothes drying management.

V. CONCLUSION

This paper presented the design and implementation of a Solar-Powered Smart Rain Shield System for Household Clothes aimed at protecting drying clothes from unexpected rainfall. Existing systems were analyzed and compared with the proposed model to highlight limitations such as the absence of user notifications and remote monitoring features. The proposed system integrates a rain sensor, ESP32 microcontroller, and servo motor to automatically deploy a protective shield when rainfall is detected. Additionally, the inclusion of a GSM module enables real-time SMS notifications, while the IoT-based web monitoring platform allows users to remotely check system status, including rain detection, shield position, and power availability. Experimental implementation demonstrates that the system effectively reduces manual intervention, enhances user awareness, and improves operational efficiency. The use of solar energy with battery backup ensures sustainable and uninterrupted performance. Overall, the proposed system provides a reliable, energy-efficient, and scalable solution for modern smart home applications.

Future enhancements may include weather prediction integration, mobile application control, and advanced environmental sensing for improved system intelligence.

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