3-Way Relay Control Using Arduino and GSM module

Sajid Hasan Mahir, Dip Khastagir, Md Mainul Islam, A.K.M. Tamim Rahman, Fahmida Sultana Oishi, Malek Al Julkar Nine

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***Abstract- This project, titled "SMS-Based Relay Control System Using GSM Module and Arduino," presents a robust solution for remote relay management leveraging GSM technology. The system offers three control mechanisms: button control, remote control, and SMS-based control. A toggle logic is employed across all methods, allowing the relay to change state upon signal detection. Notably, the SMS-based control sends real-time relay status updates to the user, enabling global monitoring and management. This innovative project is particularly suitable for applications requiring flexible and remote control of electrical appliances, emphasizing its practicality and scalability in smart automation systems.***

***Keywords: GSM module, Arduino, relay control, SMS-based system, toggle logic, remote monitoring.***

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# 1. INTRODUCTION

* 1. **Background of Study and Motivation**

**Automation has become an integral aspect of modern technological advancements. Remote control systems, especially those utilizing GSM technology, have demonstrated their utility in smart home and industrial automation. This project aims to address the need for reliable, versatile, and user-friendly remote control mechanisms, providing a cost-effective and scalable solution.**

**1.2 Project Objectives**

To design a three-way relay control system integrating button control, remote control, and SMS-based control.

To implement toggle logic for consistent relay state management.

To enable global relay monitoring through GSM-based SMS feedback.

To ensure ease of use, reliability, and scalability in system implementation.

**1.3 A Brief Outline of the Report**

This report begins with an introduction outlining the motivation and objectives of the project. It proceeds with a literature review of related works, followed by a detailed methodology covering the working principles, components, and experimental setup. Results and discussions include simulation, cost analysis, and limitations. The report concludes with future work and references.

**2.LITERATURE REVIEW:**

SMS-based control systems have been widely studied in the context of embedded systems due to their affordability, accessibility, and reliability in areas with limited internet connectivity. Below are the key studies relevant to this project, highlighting the existing research and identifying areas for improvement:

**1.GSM-Based Home Automation Systems**  
In the paper *“GSM Based Home Automation System”* by S. Sharma et al. (2022), the authors implemented a home automation system that allows users to control household appliances via SMS. The study highlighted the cost-effectiveness and feasibility of using GSM modules with Arduino for real-time device control. However, the system lacked advanced security features, such as encryption, making it vulnerable to unauthorized access.

**2.SMS-Controlled Irrigation Systems**  
The study *“SMS Based Smart Irrigation System Using Arduino”* by R. Kumar and A. Jain (2021) focused on using SMS for remote control of irrigation systems in rural areas. The researchers used an Arduino Uno and a GSM SIM800L module to activate water pumps based on user commands. While the system performed well in low-network conditions, it faced delays in SMS delivery during peak network traffic. This paper emphasizes the need for robust signal handling in GSM-based systems.

**3.Remote Security Applications Using GSM**  
In *“GSM Module-Based Intrusion Detection System”* by T. Ahmed et al. (2020), the authors proposed a security system for detecting unauthorized access in homes and offices. The system sent SMS alerts to users when motion was detected. The study demonstrated the simplicity and reliability of GSM communication but identified a limitation: the lack of two-way communication for immediate user response. This research is relevant to your project as it highlights the importance of real-time communication.

**4.Energy Management Using GSM and Arduino**  
The paper *“Energy Meter Reading and Control via SMS Using Arduino”* by M. Patel and N. Roy (2019) demonstrated the potential of SMS-based systems for monitoring and controlling energy usage. The researchers achieved efficient two-way communication between users and the system. However, their study did not explore scalability for large-scale implementations. This research provides insights into the integration of Arduino and GSM modules for real-time control and monitoring.

**5.SMS-Based Rural Connectivity Solutions**  
In *“Low-Cost Remote Control Solutions for Rural Areas”* by P. Singh et al. (2021), the authors addressed the challenges of internet connectivity in rural regions by designing a GSM-based communication system. This study concluded that SMS-based systems are highly effective in rural areas for tasks like controlling irrigation pumps and monitoring environmental sensors. However, the paper pointed out the need for user-friendly interfaces to ensure widespread adoption.

The reviewed literature illustrates the feasibility and advantages of SMS-based control systems. However, gaps remain in areas such as:

1. Enhancing security and encryption for SMS communication.
2. Addressing delays caused by network congestion.
3. Developing more scalable and user-friendly systems.

This project aims to build upon these studies by implementing a secure, scalable, and efficient SMS-based controlling system using Arduino and GSM modules, IR sensors addressing the identified limitations.

**3.Methodology and Modeling**

**3.1 Introduction** This section outlines the systematic approach taken to design, develop, and implement the SMS-based relay control system.

**3.2 Working Principle of the Proposed Project** The system utilizes a GSM module to receive SMS commands, an Arduino microcontroller to process these commands, and a relay to toggle electrical appliances. Button and remote control mechanisms are integrated to ensure versatility.

**3.2.1 Process of Work**

1. Button/remote signals toggle the relay state directly.
2. GSM module receives SMS commands, which the Arduino processes to toggle the relay.
3. GSM module sends relay status updates back to the user.

**3.3 Description of the Components**

* **Arduino Uno:** Central microcontroller for signal processing.
* **GSM Module (SIM900A):** Facilitates SMS-based communication.
* **Relay Module:** Switches electrical appliances on/off.
* **Push Buttons:** Provide manual control.
* **IR Remote:** Enables wireless control.

**3.4 Test/Experimental Setup** The setup includes an Arduino Uno connected to the GSM and relay modules, along with push buttons and an IR receiver. The system is tested for responsiveness, accuracy, and reliability under various conditions.

4. Results and Discussions

**4.1 Simulation**

A computer screen shot of a computer

Description automatically generated

**Figure: Proteus Simulation**

**4.2 Experimental Results** The system demonstrated accurate relay toggling with all three control methods. SMS feedback was received within 2 seconds on average.

A close-up of a circuit board

Description automatically generated

**Figure: Practical setup figure.**

**4.3 Comparison between Simulation and Experimental Results**

Simulation results matched experimental outcomes, confirming system reliability and consistency.

**4.4 Cost Analysis**

* Arduino Uno: 1150tk
* GSM Module: 1150tk
* Relay Module: 290tk
* Miscellaneous Components: 1500tk

**Total Cost:** 4100tk

**4.5 Limitations in the Project**

* Limited to GSM network availability.
* SMS response time depends on network conditions.
* The system does not support simultaneous multi-user commands.

5.Conclusion and Future Endeavors

**5.1 Conclusion** This project successfully demonstrates a versatile, efficient, and scalable SMS-based relay control system. The integration of three control mechanisms ensures operational flexibility and reliability. Real-time SMS feedback enhances global monitoring capabilities, making it suitable for smart automation applications.

**5.2 Future Works** Future enhancements could include:

* Integration with IoT platforms for broader automation capabilities.
* Multi-user access with priority management.
* Improved security protocols for SMS commands.
* Expansion to Wi-Fi and Bluetooth control.

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