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Fault Detection in Overhead Transmission Lines with SMS Notification

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***Abstract:** THigh-voltage electricity transmission through overhead lines is a critical component of modern power infrastructure. However, maintenance and fault detection in these systems pose significant safety and operational challenges due to the risk of electric shocks and delays in manual intervention. This paper presents an Arduino-based automated fault detection and access control system designed to improve safety, efficiency, and monitoring in power transmission lines. Upon detecting a fault, the system initiates a lockdown by closing barriers on either side of the affected area and simultaneously sends a secure access password to the authorized maintenance personnel via GSM. Access is granted only upon successful password entry using a keypad interface. Additionally, the system features a real-time traffic signaling mechanism, automatic street lighting control, and an overspeed vehicle detection module using IR sensors,which records vehicle data. This integrated solution offers a reliable, cost-effective, and intelligent approach to fault management and public safety in power transmission environments.*
***Keywords:** Power Transmission Lines, Fault Detection, Arduino Uno, GSM Module, Access Control System, IR Sensors, Traffic Signal Automation, Street Light Control, Vehicle Speed Monitoring, Embedded Systems.*

I. INTRODUCTION

Fault Detection in Overhead Transmission Lines with SMS Notification is a safety-focused solution designed to address the risks and delays associated with manual fault identification. Overhead lines carry high voltage, and any fault in these lines can lead to dangerous situations and service interruptions. This project proposes an automated system using an Arduino controller to detect faults in the lines, alert maintenance personnel via SMS using a GSM module, and restrict access through a password-based control mechanism. The system also manages traffic signals and street lighting around the fault location, ensuring a secure environment during maintenance activities.

II. LITERATURE REVIEW

Overhead transmission lines are exposed to various environmental and mechanical stresses that can lead to faults such as line breaks, short circuits, and grounding issues. Timely detection and response are critical to prevent damage, power outages, and safety hazards. Over the years, several approaches have been developed to enhance fault detection and maintenance processes.

In [1], the authors implemented a fault detection system using GSM technology to notify authorities during power failure. While effective in alerting users, the system lacked access control and safety mechanisms for maintenance personnel. Another study in [2] proposed a microcontroller-based monitoring system that identified phase and earth faults. However, it did not provide real-time alerts or secure access to fault zones.A method combining ZigBee communication and sensors was presented in [3], which improved data transmission and location tracking of faults. Although efficient, the setup was complex and costly for small-scale deployment. In [4], the focus shifted to automation in electrical substations using programmable logic controllers (PLCs), but these solutions were not suitable for remote or rural areas where simpler embedded systems are preferred.

More recent work, such as that in [5], introduced Arduino-based systems for real-time monitoring and control, demonstrating the feasibility and affordability of embedded solutions in grid applications. However, many of these systems lacked integrated features like traffic management and street lighting control, which are essential for safety during line maintenance.

III. SYSTEM DESIGN AND WORKING

A. Overview and Workflow

The proposed system consists of the following main components: an Arduino Uno microcontroller, GSM module, keypad, traffic signal LEDs, street lighting control, and IR sensors.

1) Fault Detection: The Arduino continuously monitors the overhead transmission line parameters. Upon detecting abnormal conditions indicating a fault, the system activates barrier gates to restrict access to the affected area.
2) SMS Notification: Simultaneously, the GSM module sends an SMS containing a unique password to the authorized maintenance personnel to ensure secure access.
3) Access Control: A keypad interface is provided at the fault site. The repair person must enter the correct password to unlock the barriers and begin repairs, ensuring only authorized personnel gain access.
4) Traffic Signal Control: Traffic lights are automatically controlled to stop vehicles near the fault area, indicated by a red LED. When no fault is detected, the traffic signals operate in a normal cyclic manner (red, yellow, green).
5) Street Light Automation: Street lights near the fault location are controlled automatically to improve visibility and safety during repair work.
6) Vehicle Speed Monitoring: IR sensors detect vehicle speed around the area. If a vehicle overspeeds, the system can alert nearby authorities (feature included for safety monitoring).

Here is the typical workflow:
- Arduino monitors transmission line conditions.
- On fault detection, barriers close, and SMS is sent.
- Maintenance personnel enter a password on the keypad.
- If the password is correct, barriers open for repair access.
- Traffic signals switch to red to stop vehicles.
- Street lights turn on automatically to illuminate the site.
- Vehicle speed is monitored continuously to enforce safety.

B. Unique Features and Innovation

The proposed fault detection system incorporates several innovative features that enhance safety, efficiency, and automation in managing overhead transmission line faults:
1) Integrated Access Control: Unlike traditional systems, this project uses a secure password-based keypad interface to restrict access to fault locations, ensuring that only authorized personnel can perform repairs.
2) Real-Time SMS Notification: The GSM module automatically sends fault alerts with secure access credentials to the maintenance team, enabling quicker response and minimizing downtime.
3) Traffic Management Automation: The system controls traffic signals near the fault site, reducing the risk of accidents by halting vehicular movement during repair operations.
4) Automatic Street Lighting: The street lights around the fault location are automatically controlled to improve visibility and safety for both workers and the public during night-time repairs.
5) Vehicle Speed Monitoring: IR sensors monitor vehicle speeds near the fault site to enforce safe driving, adding an additional layer of safety not commonly addressed in fault detection systems.
6) Cost-Effective and Scalable: Using Arduino and readily available components, the system offers an affordable solution that can be easily scaled or customized for different transmission line environments.

These features combine to provide a comprehensive safety and fault management system that goes beyond simple detection, actively protecting personnel and public safety during fault events.

C. Web Functionality and User Experience

1) Arduino Uno: Serves as the main control unit, processing inputs from sensors and the keypad, and managing outputs to the GSM module, traffic signals, street lights, and barrier gates.
2) Fault Detection Sensors: These sensors monitor the transmission line for faults. When abnormal parameters are detected, a signal is sent to the Arduino to initiate the fault response sequence.
3) GSM Module: Connected to the Arduino, this module sends an SMS notification containing the fault alert and access password to the authorized maintenance personnel.
4) Keypad: Provides a secure interface for the repair person to enter the password received via SMS. The Arduino verifies the input to grant or deny access.

5) Traffic Signal LEDs: Controlled by the Arduino, these LEDs display red, yellow, and green signals to regulate vehicle movement around the fault area. Upon fault detection, the red light activates to stop traffic.
6) Barrier Gates: Mechanically controlled by the Arduino through servo motors or solenoids, these gates restrict physical access to the fault zone until correct password authentication.
7) Street Light Control: The Arduino switches street lights on or off based on the fault status to enhance visibility during repairs.
8) IR Sensors: Positioned to monitor vehicle speed near the fault location, they send signals to the Arduino to trigger alerts if overspeeding is detected.

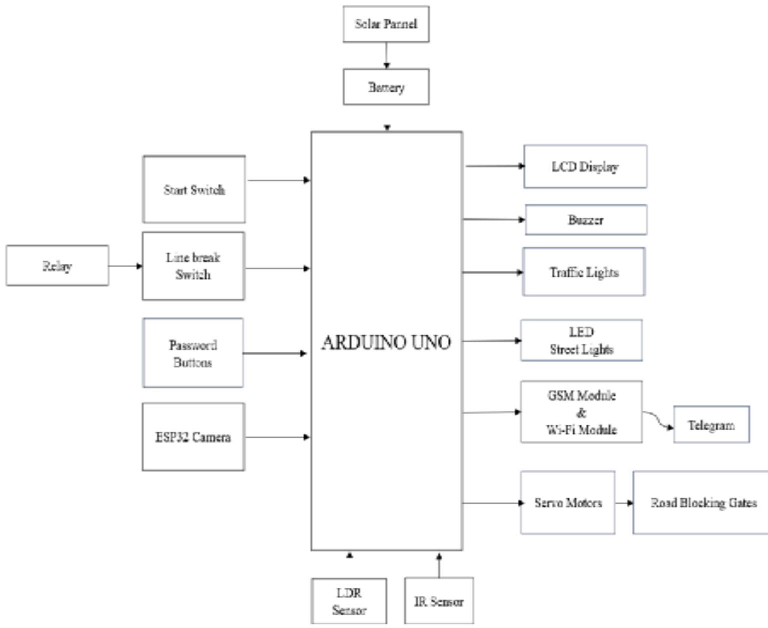

Fig. 1 Block Diagram

IV. IMPLEMENTATION AND RESULTS

The system was implemented using a structured and modular approach to ensure functionality and scalability. Initially, the sensors and relay modules were carefully integrated with the Arduino Uno, which acted as the central control unit. Real-time data captured by the sensors was transmitted via serial communication to Node-RED, which acted as the data flow manager. This data was then routed and stored in a locally hosted MySQL database using XAMPP, enabling easy access and further processing. To bring intelligence into the system, an LSTM model was developed and trained using Python libraries such as Keras and TensorFlow. This model analyzed historical data to predict future energy consumption trends. For front-end interaction, a responsive and user-friendly dashboard was created using HTML, CSS, and JavaScript, allowing users to view live updates and visual insights into their energy usage.

Figures below illustrate our results:

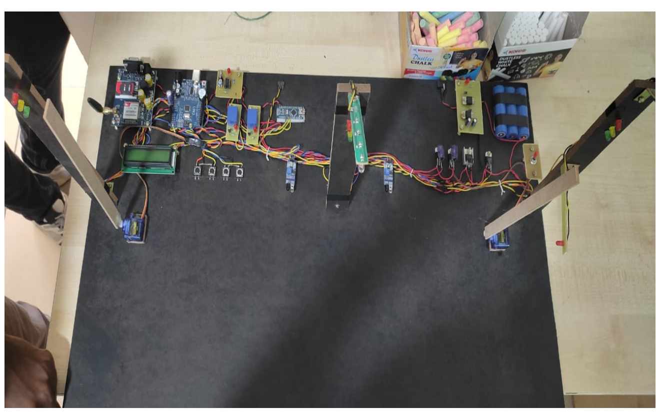

Fig. 2 Test setup

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Fig. 3 Danger Message on LCD Display

Fig. 4 OTP Message on LCD Display

Fig. 5 Shows Line Clear

V. CONCLUSION AND READER INSIGHTS

This paper presents an Arduino-based automated fault detection and access control system for overhead transmission lines. By integrating fault monitoring with GSM-based SMS notifications, secure password-protected access, traffic signal control, and street lighting automation, the system enhances safety for maintenance personnel and the public. The inclusion of vehicle speed monitoring further improves operational safety around fault sites. The proposed solution is cost-effective, reliable, and easy to implement, making it suitable for improving fault management and reducing downtime in overhead transmission line operations. Future work may focus on expanding sensor capabilities and integrating real-time data analytics for predictive maintenance.

VI. FUTURE WORK

The current system lays a strong foundation for automated fault detection and safety control. Future improvements can focus on enhancing fault localization by integrating sensors such as voltage/current transducers and thermal detectors. Adding IoT capabilities would enable real-time remote monitoring through cloud platforms.Machine learning algorithms can also be introduced for predictive maintenance, helping to anticipate faults before they occur. The system can be further upgraded with a mobile or web interface to improve user accessibility and control.To improve sustainability, solar-powered operation can be considered for deployment in remote areas. Additionally, advanced authentication methods like OTPs, RFID, or biometrics could be implemented to strengthen system security.

VII.ACKNOWLEDGEMENT

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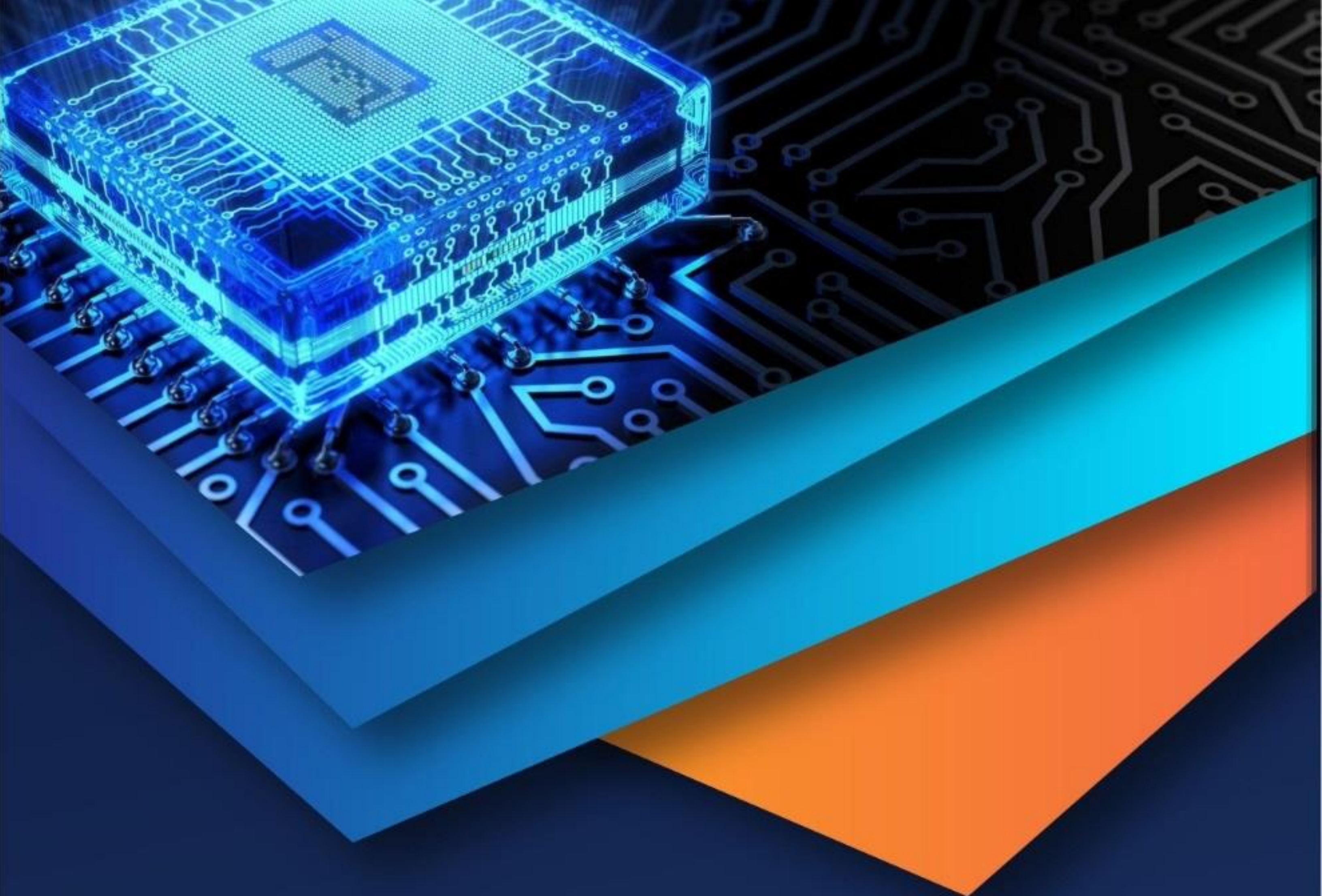

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