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Smart Voltage Detection and Protection Box for Prevention of Electrocution Using Esp32 and GSM

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Abstract:
Electrical accidents caused by fallen or faulty power lines are a serious threat to human life, especially in wet places such as agricultural fields and waterlogged streets. When a live wire touches wet ground, the soil becomes conductive and the current spreads over a wide area, creating dangerous step and touch potentials that cannot be seen. Existing distribution systems depend mostly on manual inspection and delayed fault reporting, so the line often stays live for a long time after it has fallen.
This paper presents a Smart Voltage Detection and Protection Box that monitors the voltage near an electric pole and reacts to an unsafe condition by itself. An ESP32 microcontroller reads the voltage sensor and compares the reading with a preset safe limit. When the limit is crossed, the ESP32 switches a relay to cut the supply, sends an SMS alert through a SIM800L GSM module to the authorities, linemen and nearby users, and sounds a buzzer to warn people around. A battery backup keeps the box working during power failures. The prototype was tested by raising the input voltage above the threshold, and it cut the power, sent the message and sounded the alarm as intended. The design is low cost, easy to install and suitable for rural as well as urban areas.
Keywords: Voltage Detection, Electrocution Prevention, ESP32, GSM Module, Relay Control, Fault Detection, Embedded Systems, Public Safety.

I . INTRODUCTION

Electrical energy supports homes, farms and industries, but faults in overhead distribution lines put human life at risk. The most dangerous case is a live wire that falls on wet ground. The soil then conducts the current over a large radius and produces step potential and touch potential, which can cause severe injury or instant death [2]. Farmers working barefoot in wet fields and people walking through flooded roads are the most exposed, and the danger is invisible until it is too late.
Most present systems rely on manual inspection or on a complaint from the public before the line is switched off. In remote areas the poles are spread over long distances, communication is poor, and the response can take hours. A system that detects the unsafe voltage, disconnects the supply and informs people automatically is therefore needed, as discussed in Section II.



Figure 1: Electrical hazard due to a fallen live wire

The objective of this work is to design and build a low-cost Smart Voltage Detection and Protection Box that performs real-time fault detection, automatic power disconnection and instant alerting. It uses an ESP32 microcontroller, a voltage sensor, a relay, a SIM800L GSM module and a buzzer, powered from a battery so that it keeps working when the mains fails. The rest of the paper is organised as follows. Section II reviews related work, Section III describes the proposed method, Section IV presents the results and Section V concludes the paper.

II . LITERATURE REVIEW

Work on electrocution prevention and fault detection that was studied for this project is summarised in Table I and discussed below.

Table I: Summary of related work

S.No	Authors	Method	Ref., Year
1	Gupta et al.	IoT smart shoe that senses the electric field on wet ground	[1], 2021
2	Zemaitis et al.	Study of causes and effects of electrical injuries	[2], 2025
3	Liu et al.	Shock fault diagnosis using BP-AdaBoost	[3], 2025
4	Anbumalar et al.	Line-break detection with fault location (FLI) algorithm	[4], 2020
5	This work	ESP32 voltage detection box with relay, GSM and buzzer	—

Gupta et al. proposed a smart shoe that senses the electric field around the user on wet surfaces and sends an alert to a mobile device or smart watch. The shoe warns only the person wearing it and cannot remove the hazard, whereas ordinary dielectric footwear only insulates and cannot detect danger [1]. Zemaitis et al. describe how voltage level, type of current, duration of contact and body resistance decide the severity of an electrical injury. They show that serious internal damage can occur even when external burns are small, which supports the need for early detection and prevention [2].
Liu et al. addressed shock faults in low-voltage distribution networks by extracting time and frequency features and classifying them with a BP neural network combined with AdaBoost. This improves accuracy over conventional protection devices, which are affected by noise and harmonics [3]. Anbumalar et al. used two control units, one at the pole and one at the distribution transformer. When the line voltage drops below a threshold, an alert is sent, the transformer unit trips the circuit breaker, and a fault location identification (FLI) algorithm finds the place of the fault [4].
It can be seen that existing work either only warns the user, concentrates on diagnosis, or needs a second unit at the transformer. This motivates a single compact box at the pole that detects the fault, cuts the supply, alerts the people concerned and warns the public on its own.

III . PROPOSED METHOD

System overview: The box is built around an ESP32 microcontroller connected to a voltage sensor, a relay module, a SIM800L GSM module and a buzzer, and the whole unit is powered from a battery. The block diagram is shown in Fig. 2. The sensor measures the electrical potential near the pole and passes it to the ESP32, which compares it with a preset threshold. The relay, the GSM module and the buzzer are triggered only when this threshold is crossed.

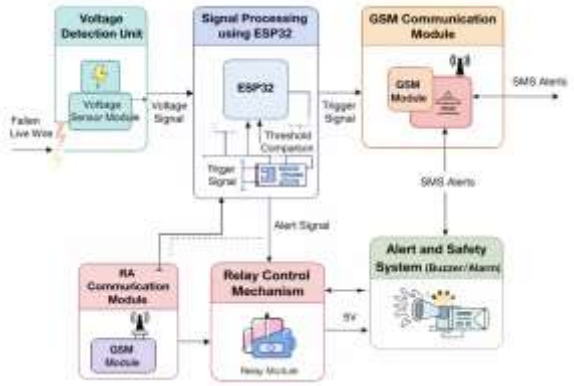


Figure 2: Block diagram of the Smart Voltage Detection System

Voltage detection unit: The voltage sensor module continuously measures the potential in the surroundings and detects any abnormal rise caused by a fallen live wire, grounding fault or leakage current. Its analog output is sent to the ESP32 at regular intervals, so that a sudden change is noticed at once.

Signal processing: The analog signal cannot be used directly, so the built-in ADC of the ESP32 converts it into digital values. The program compares each value with the safe threshold. If the value is below the threshold, the box keeps monitoring. If it is above, the ESP32 treats it as a fault and starts the protective actions. This decision takes only a few milliseconds.

Relay control: On a fault, the ESP32 sends a digital signal to the relay module, which acts as an electrically controlled switch and disconnects the supply from the affected line. Stopping the current is the most important action because it removes the cause of the hazard.

GSM alert: At the same time, the ESP32 sends AT commands over a serial (UART) link to the SIM800L module, which sends an SMS to the electricity board, linemen and nearby users. The message gives the nature of the fault, the pole identification and the power status. A sample message received from the prototype is shown in Fig. 3. GSM is used because it works in remote places that have no internet connection.

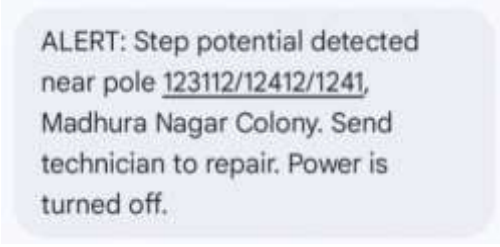


Figure 3: Alert message sent by the voltage detection box

Buzzer alarm: A buzzer connected to a digital pin of the ESP32 is switched on during a fault. It warns people in the vicinity so that they keep away from the danger zone, even if they do not have access to a mobile phone.

Operation: The activity diagram in Fig. 4 shows the working. After power on, the ESP32 sets up its pins, the serial link to the GSM module and the ADC, and the system checks that the GSM module has network, the relay is in its default state and the buzzer is off. The box then reads the sensor in a loop. If the voltage is unsafe, it activates the relay, sends the SMS and triggers the buzzer. It continues to monitor afterwards, and when the voltage returns to a safe level it can reset automatically or wait for a manual reset.



Figure 4: Activity diagram of system operation

Hardware and software: The components used are shown in Fig. 5. The program is written in Arduino C (embedded C/C++) in the Arduino IDE on Microsoft Windows. The IDE compiles the code, uploads it to the ESP32 and provides a serial monitor to check the sensor readings during testing. The ESP32 core, GSM and serial libraries are used for pin control, communication and AT commands. The sensor is calibrated so that false detections are kept to a minimum.



Figure 5: Components used: (a) ESP32, (b) voltage sensor, (c) SIM800L GSM module, (d) relay module and (e) buzzer

Comparison with existing methods: Table II compares the proposed box with the existing methods described in Section II.

Table II: Existing methods and the proposed method

Parameter	Existing methods	Proposed method
Detection	Manual or delayed	Real-time, automatic
Response time	Slow, depends on human reporting	Fast, handled by the ESP32
Power cut-off	Not automatic or delayed	Immediate, by relay
User alert	No direct alert	Instant SMS by GSM
Human intervention	High	Very low
Cost	Some systems are expensive	Low cost
Scalability	Limited	Easy for rural and urban areas



Figure 6: Hardware prototype of the voltage detection and protection box

IV . RESULTS AND DISCUSSION

The prototype was built with the ESP32, voltage sensor, GSM module, relay and buzzer mounted on a base board, as shown in Fig. 6 and Fig. 7. During normal operation the sensor reading stayed below the threshold, the box kept monitoring and no action was taken. To test fault detection, an abnormal condition was created by raising the input voltage above the threshold.



Figure 7: Experimental setup of the Smart Voltage Detection System

Functional verification: When the voltage crossed the threshold, the ESP32 identified the unsafe condition and the relay disconnected the supply. The SIM800L sent the SMS to the predefined numbers (Fig. 3) and the buzzer sounded, so the three protective actions took place together.

Performance: The response time is low because the ESP32 processes each reading within milliseconds before triggering the relay and the GSM module. The system separated safe and unsafe levels correctly once the sensor was calibrated, and it gave consistent results in repeated tests. It uses little power, and the battery backup keeps it running during outages.

Limitations: The accuracy depends on the sensor and its calibration, and SMS delivery depends on the availability of the GSM network. Heavy rain and extreme temperature may also affect the sensor. Numerical measurements of response time and detection accuracy are not reported in this paper and are planned as future work.

V . CONCLUSION

This paper presented a Smart Voltage Detection and Protection Box that detects unsafe voltage near electric poles and responds without human intervention. The ESP32 compares the sensor reading with a threshold, the relay disconnects the supply, the GSM module alerts the authorities and nearby users, and the buzzer warns the public. The prototype performed all three actions correctly when a fault was simulated. The box is low cost, easy to install and runs on battery backup, so it suits farms, cities, industrial areas, construction sites, public places and disaster-prone regions. Future work will add IoT cloud monitoring, GPS location of the faulty pole, LoRa or NB-IoT links as an alternative to GSM, a solar supply and machine learning for predicting faults, together with measured response time and accuracy figures.

VI . REFERENCES

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