



# Smart Safety System for Roadside Rainwater Electrification

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## Abstract

Waterlogging on roads during heavy rainfall is a major cause of fatal electric shock incidents in urban and semi-urban areas. Exposed or damaged electrical infrastructure — including street light poles, underground cables, and transformer junction boxes — can energize standing rainwater, creating a lethal hazard invisible to pedestrians and motorists. This mini project presents the design and implementation of a Smart Safety System for Roadside Rainwater Electrification that continuously monitors the electrical potential of accumulated roadside water and triggers instant protective actions when electrification is detected. The system uses a soil/water conductivity sensor and voltage sensing probes deployed at road edges and neareration during storms and is housed in a weather-proof IP65-rated enclosure

## Keywords

Roadside electrification hazard · Rainwater electrical safety · IoT-based hazard detection · Leakage current sensing · Smart relay isolation · Water-level monitoring · Urban infrastructure safety · Embedded systems · Real-time alert system ·

## Introduction

Electricity and water are two of the most essential resources in modern civilization, yet their inadvertent combination is responsible for hundreds of fatalities every year. In many developing and emerging nations, monsoon seasons bring not only relief from heat but also a deadly hazard — the electrification of rainwater pooling on roads due to faults in the electrical distribution network.

When electrical cables develop insulation faults, or when water enters junction boxes and transformer cavities, leakage current flows into the ground and subsequently into standing water on road surfaces. To an unsuspecting pedestrian or animal, this water appears no different from safe floodwater. The shock received when contact is made can be instantly fatal due to the full body path of the current from feet through vital organs to ground.



Traditional protection systems such as Earth Leakage Circuit Breakers (ELCBs) and Ground Fault Circuit Interrupters (GFCIs) protect equipment and indoor wiring but do not adequately address the outdoor, distributed, and weather-exposed nature of roadside electrical infrastructure. The proposed Smart Safety System bridges this gap by providing an active, real-time, autonomous monitoring and alerting solution specifically designed for roadside environments.

This project integrates low-cost embedded electronics, wireless communication, and renewable energy into a cohesive system that can be deployed at high-risk locations such as road sides near electrical poles, substation boundaries, and areas prone to flooding. The system is designed to be scalable, low-maintenance, and affordable for large-scale municipal

## Problem Statement & Motivation

### 2.1 Problem Statement

Design and implement a smart embedded system capable of detecting electrification in roadside accumulated rainwater, providing immediate local alerts, and notifying relevant authorities to prevent fatal electric shock incidents.

### 2.2 Motivation

The following documented scenarios motivate the urgency of this system:

- In June 2023, multiple pedestrians in Mumbai, India, died after stepping into electrified floodwater near a damaged underground cable.
- Annual monsoon fatality data reveals that between 40-60% of flood-related deaths in South Asia involve electrification rather than drowning.
- Electrical departments receive delayed, informal reports about cable faults via social media or phone calls, creating dangerous lag times.
- Stray animals and children are particularly vulnerable as they are less cautious near water accumulations.
- Existing solutions such as manual inspection and simple fuse-based protection are inadequate for real-time, autonomous protection.

## Objectives

- To design a compact, low-cost embedded system to continuously monitor electrical voltage in roadside accumulated water.
- To generate an immediate local alarm (buzzer + LED warning lights) upon detection of dangerous voltage levels

## Key Component Details

**Voltage Sensing Probes:** The probes are fabricated from 304-grade stainless steel rods (6 mm diameter, 15 cm length) to resist corrosion in long-term outdoor deployment. The inter-electrode spacing of 10 cm ensures sensitivity to both AC and DC leakage currents in the 50-500 mA range that constitutes the lethal zone for humans.

**SIM800L GSM Module:** This module supports AT command-based SMS transmission. A pre-programmed phone number (electrical department control room) receives an alert message formatted as: 'ALERT: Rainwater Electrification detected at [Location ID]. Voltage: [X]V AC. Time: [HH:MM]. Take immediate action.' A SIM card with active SMS plan is inserted into the module.



Relay Module: The 5V opto-isolated relay can switch up to 250V AC / 10A loads. In installations where the system is wired in series with the pole's supply circuit, triggering this relay disconnects the faulty section automatically.

### 7.1 Microcontroller Firmware

The firmware is developed in the Arduino IDE using C/C++ and is structured into initialization, sensing loop, decision logic, and alert subroutines.

### 7.2 Algorithm Flowchart (Description)

The algorithm follows these sequential steps:

- Step 1 — System Initialization: Configure ADC, GSM module (AT commands), LCD, relay, and LED pins. Load stored threshold voltage from EEPROM.
- Step 2 — Sensor Read: Sample ADC input from voltage divider at 500 ms intervals. Compute RMS value from 20 samples.
- Step 3 — Threshold Comparison: If computed voltage > SAFE\_THRESHOLD (default: 12V RMS), proceed to alert. Else, reset alert flag and display 'SAFE' on LCD.
- Step 4 — Debounce Check: Start a 3-second timer. If voltage remains above threshold for the full 3 seconds, confirm as genuine hazard. Else, ignore transient.
- Step 5 — Local Alert: Activate buzzer, flash LEDs at 2 Hz, display 'DANGER: [X]V' on LCD.
- Step 6 — GSM Alert: Send pre-formatted SMS to stored emergency contacts via SIM800L. Retry up to 3 times if send fails.
- Step 7 — Relay Trip: Activate relay to disconnect suspected faulty circuit branch (if relay mode enabled).
- Step 8 — Log Event: Write timestamp, measured voltage, and alert type to SD card CSV log file.
- Step 9 — Wait for Reset: System remains in alert state until manually reset or voltage drops below safe threshold for 10 seconds continuously.

### Conclusion

The Smart Safety System for Roadside Rainwater Electrification is an effective solution to prevent accidents caused by electric current leakage in rainwater. By continuously monitoring roadside drains using voltage sensors, the system automatically disconnects the power supply through relay and RCCB when danger is detected. At the same time, alert messages are sent to the concerned authorities for quick action. This system reduces the risk to pedestrians and animals, minimizes human intervention, and improves public safety during rainy seasons. Hence, the proposed system is reliable, cost-effective, and suitable for smart city and urban safety applications.