RESEARCH ARTICLE OPEN ACCESS

Transformer Line Fall Detection and Alert System for Agricultural Land Using Sensors and GSM

Sahana S, Vidhya A, Vismayaa H, Yazhini R

Department of Electronics and Communication Engineering,

Anjalai Ammal Mahalingam Engineering College, Kovilvenni, India

Guided by: Mrs. Pavithra ME Assistant professor

Abstract:

Rural agricultural areas face severe safety risks due to fallen electrical conductors caused by weather conditions, pole damage, or aging power lines. This paper proposes a dual-post automated detection and alert system that deploys voltage and current sensors at two distribution line posts. Post 2 (field unit) monitors line voltage using a ZMPT101B sensor; when voltage drops to or below 50 V it transmits a fault signal to Post 1 (transformer unit) via serial communication. Post 1 triggers an automatic relay-based power cut-off and dispatches SMS alerts to farmers via GSM. The system also detects energy theft by comparing current readings between the two posts. A 16×2 LCD and buzzer provide local status indication at each post. Laboratory testing confirmed reliable fault detection, timely SMS notification, and effective power isolation.

Keywords — Fallen conductor detection, serial communication, GSM alert, ZMPT101B voltage sensor, SCT-013 current sensor, Arduino Nano, energy theft detection, rural power safety, automatic power cut-off.

I. Introduction

Electrical safety in rural and agricultural areas remains a critical concern in developing nations. Distribution lines passing through agricultural land are prone to mechanical damage due to storms, aging infrastructure, and accidental contact with farming equipment. When a live conductor falls on the ground or farmland, it poses severe electrocution hazards to farmers and livestock.

Traditional circuit breakers handle overload and short-circuit faults but often fail to detect high-impedance faults caused by fallen conductors on dry soil or crops, leaving the line energized and dangerous.

The proposed dual-post system deploys Arduino Nano nodes at Post 2 (field) and Post 1 (transformer). Post 2 monitors line voltage and current; on detecting a voltage drop below 50 V, it sends a fault character to Post 1 via SoftwareSerial. Post 1 cuts off power via relay, sends dual SMS alerts via GSM, and detects energy theft by comparing current at both posts.

The paper covers: Section II — Literature Review, Section III — Proposed Methodology, Section IV — Component Specifications, Section V — System Modules, Section VI — Program Implementation, Section VII — Results, Section VIII — Conclusion.

II. Literature Review

Several researchers have explored fault detection for distribution lines. Singh and Bisht [1] used soft computing to detect evolving faults in compensated transmission lines, improving early fault identification. Al-Sultan and Avci [2] incorporated voltage sag analysis to enable faster and more accurate fault protection.

Liang et al. [3] combined PLC and residual neural networks with advanced hardware sensing, significantly improving cable fault classification. Behera et al. [4] demonstrated IoT-based real-time monitoring with reduced fault response times. Kanwal and Jiriwibhakorn [5] showed that ANFIS and neural networks outperform conventional relay methods in fault detection, classification, and localization.

The proposed system builds on these findings with a low-cost, hardware-centric dual-node architecture suited for rural Indian agricultural settings.

TABLE I
SUMMARY OF LITERATURE REVIEW

Reference Title	Author(s)	Year	Key Finding
Soft computing for evolving faults in compensated lines	Singh & Bisht	2025	Soft computing detects incipient and evolving faults effectively.
Fault protection with voltage sag analysis	Al-Sultan & Avci	2025	Voltage sag improves fault detection speed and accuracy.
Cable fault detection using PLC and neural networks	Liang et al.	2025	PLC and ResNet improve cable fault classification.
Fault detection in transmission line using IoT	Behera et al.	2024	IoT sensors enable real-time monitoring and fast response.
Advanced fault detection and localization: comparative study	Kanwal & Jiriwibhakorn	2024	ANFIS and neural networks outperform relay-based methods.

III. PROPOSED METHODOLOGY

The system uses a dual-post architecture where Post 2 monitors the field line and Post 1 manages the transformer-end control and alert logic.

A. Post 2 — Field Sensing Unit

Post 2 monitors AC line voltage using a ZMPT101B sensor and line current using a SCT-013 sensor via EmonLib. When voltage drops to or below 50 V, it transmits character '1' to Post 1 via SoftwareSerial to signal a fault. Under normal conditions it transmits '2'. A local LCD and buzzer provide field indication.

B. Post 1 — Transformer Control Unit

Post 1 polls SoftwareSerial for incoming characters. On receiving '1' it de-energizes the relay, sounds the buzzer, updates the LCD to 'FAULT DETECTED', and calls sendSMS() to send dual SMS alerts. On receiving '2' it restores the relay and shows 'NORMAL'. It also detects energy theft when $Irms1 \geq Irms2 + 1$ A.

C. Data Logging

Post 1 streams CSV data (Voltage, Irms1, Irms2, Status) over its USB serial port for real-time PC logging and analysis.

IV. COMPONENT SPECIFICATIONS

Table II summarizes the key specifications of all system hardware components.

TABLE II
COMPONENT SPECIFICATIONS

Component	Function	Specification	Supply
ZMPT101B	Measures AC RMS line voltage	0–250 V AC, pin A1/A0	5 V DC
SCT-013	Measures RMS line current (EmonLib)	0–30 A, factor 111.1	5 V DC
Arduino Nano	Microcontroller — acquisition and control	16 MHz, 8-bit AVR	5 V DC
SoftwareSerial	Inter-post fault signal link	9600 baud, pins 10/11	5 V DC
Relay Module	Automatic power cut-off at Post 1	250 V / 10 A, pin 12	5 V DC
GSM Module	SMS alerts to farmers/authorities	Quad-band, pins 8/9	3.3–5 V
16×2 LCD	Real-time status display at each post	16×2 char, pins 7-2	5 V DC
Buzzer	Audible fault and theft alert	Active buzzer, pin 13/12	5 V DC

V. SYSTEM MODULES

The system is divided into four functional modules.

A. Sensing Module

The ZMPT101B voltage sensor and two SCT-013 current sensors are managed by EmonLib. All sensors are calibrated at startup with a -20 V offset correction for voltage and a factor of 111.1 for current.

B. Inter-Post Communication Module

Post 2 writes '1' on fault and '2' on normal via SoftwareSerial at 9600 baud. Post 1 polls the buffer each loop cycle to update system state. The wired serial link is used in the current prototype and can be replaced by ZigBee for wireless deployment.

C. Transformer Control Module

On receiving a fault signal, Post 1 immediately de-energizes the relay (pin 12) to cut power. The relay re-energizes on a normal signal. Theft detection runs independently each loop iteration by comparing Irms1 and Irms2.

D. GSM Notification Module

The sendSMS() function sends two consecutive SMS messages to +919894727969 to ensure delivery. The GSM module uses AT commands over SoftwareSerial. The LCD shows 'Sending SMS...' then 'SMS SENT' on completion.

TABLE III
MODULE PROGRESS STATUS

Module	Objective	Progress Status	Next Steps
Sensor Module	Detect fallen conductors via voltage and current monitoring	ZMPT101B and SCT-013 calibrated and tested	Field-test under weather conditions
Data Acquisition	Collect and preprocess real-time electrical data	Microcontroller reads all sensors with offset correction	Improve noise filtering

Module	Objective	Progress Status	Next Steps
Inter-Post Communication	Transmit fault status from Post 2 to Post 1	SoftwareSerial link stable at 9600 baud	Extend range with ZigBee
Control and Alert	Isolate faulty lines and notify farmers via GSM	Relay cut-off and dual SMS alerts tested	Add multi-user notification

VI. Implementation and Program

The firmware is developed in the Arduino IDE and uploaded separately to each Arduino Nano. The complete source code for both posts is listed below.

A. Post 1 — Transformer Control Unit

Post 1 manages the relay, GSM, buzzer, LCD, and two current sensors. It receives fault signals from Post 2 via SoftwareSerial and performs energy theft detection.

```
#include <LiquidCrystal.h>
#include <SoftwareSerial.h>
#include "EmonLib.h"
#include <ZMPT101B.h>
#define SENSITIVITY 500.0f
LiquidCrystal lcd(7,6,5,4,3,2);
SoftwareSerial mySerial(10,11); // From Post 2
SoftwareSerial gsm(8,9);         // GSM module
EnergyMonitor emon1;
EnergyMonitor emon2;
ZMPT101B voltageSensor(A1, 50.0);
int relay=12, buz=13;
char incoming='*';

void setup() {
  pinMode(relay,OUTPUT); pinMode(buz,OUTPUT);
  digitalWrite(relay,LOW); digitalWrite(buz,LOW);
  Serial.begin(9600);
  mySerial.begin(9600); gsm.begin(9600);
  emon1.current(A0,111.1);
emon2.current(A2,111.1);
  voltageSensor.setSensitivity(SENSITIVITY);
  lcd.begin(16,2);
  lcd.print("POST 1 SYSTEM"); delay(1500);
  lcd.clear();
  digitalWrite(buz,HIGH);
digitalWrite(relay,HIGH);
  delay(500); digitalWrite(buz,LOW);
  Serial.println("Voltage,Irms1,Irms2,Status");
}

void loop() {
  int voltage=voltageSensor.getRmsVoltage()-20;
  double Irms1=emon1.calcIrms(1480);
  double Irms2=emon2.calcIrms(1480);
  String status="NORMAL";
  lcd.setCursor(0,0);
  lcd.print("V:"); lcd.print(voltage);
  lcd.setCursor(8,0);
  lcd.print("I:"); lcd.print(Irms1);
  if(mySerial.available())
incoming=mySerial.read();
  if(incoming=='1'){
    digitalWrite(relay,LOW); status="FAULT";
    digitalWrite(buz,HIGH);
    lcd.setCursor(0,1);
    lcd.print("FAULT DETECTED ");
    delay(2000); digitalWrite(buz,LOW);
    sendSMS("POST FALL DETECTED");
    incoming='*';
  } else
    if(incoming=='2'){ digitalWrite(relay,HIGH);
    status="NORMAL"; lcd.setCursor(0,1);
    lcd.print("NORMAL          ");
  }
  if(Irms1>=(Irms2+1)){ status="TH
    EFT"; digitalWrite(buz,HIGH);
    lcd.setCursor(0,1);
    lcd.print("THEFT OCCURED   ");
    delay(2000); digitalWrite(buz,LOW);
  }
  Serial.print(voltage); Serial.print(",");
  Serial.print(Irms1);   Serial.print(",");
  Serial.print(Irms2);   Serial.print(",");
  Serial.println(status);
  delay(1000);
}

void sendSMS(String msg){
  lcd.clear(); lcd.print("Sending SMS...");
  gsm.println("AT+CMGF=1"); delay(1000);
  gsm.println("AT+CMGS=\"+919894727969\"");
  delay(1000);
  gsm.print(msg); gsm.write(26); delay(3000);
  gsm.println("AT+CMGS=\"+919894727969\"");
  delay(1000);
  gsm.print(msg); gsm.write(26); delay(3000);
  lcd.clear(); lcd.print("SMS SENT");
  delay(2000);
}
```

B. Post 2 — Field Sensing Unit

Post 2 monitors voltage and current at the field pole. When voltage drops to or below 50 V it transmits fault character '1' to Post 1 and activates the local buzzer and LCD. Under normal conditions it transmits '2'.

```
#include <LiquidCrystal.h>
#include <SoftwareSerial.h>
#include "EmonLib.h"
#include <ZMPT101B.h>
#define SENSITIVITY 500.0f
LiquidCrystal lcd(7,6,5,4,3,2);
SoftwareSerial mySerial(10,11);
EnergyMonitor emon1;
ZMPT101B voltageSensor(A0, 50.0);
int buz=12;
int voltage=0;

void setup(){
  pinMode(buz,OUTPUT); digitalWrite(buz,LOW);
  Serial.begin(9600); mySerial.begin(9600);
  emon1.current(A1,111.1);
  voltageSensor.setSensitivity(SENSITIVITY);
  lcd.begin(16,2);
  lcd.print("POST 2 SYSTEM"); delay(1500);
  lcd.clear();
  digitalWrite(buz,HIGH); delay(500);
```

```
    digitalWrite(buz,LOW);
  }

  void
    loop(){ voltage=voltageSensor.getRmsVolta
    ge()-20; double Irms=emon1.calcIrms(1480);
    lcd.setCursor(0,0);
    lcd.print("V:"); lcd.print(voltage);
    lcd.setCursor(8,0);
    lcd.print("I:"); lcd.print(Irms);
    if(voltage<=50){
      mySerial.write('1');  // Fault signal
      digitalWrite(buz,HIGH);
      lcd.setCursor(0,1);
      lcd.print("NO VOLTAGE      ");
      delay(1000); digitalWrite(buz,LOW);
    } else {
      mySerial.write('2');  // Normal signal
      lcd.setCursor(0,1);
      lcd.print("NORMAL          ");
    }
    delay(1000);
  }
```

VII. Results and Output

The system was tested in a laboratory setup simulating fault conditions by reducing the AC supply voltage below 50 V at Post 2.

A. Hardware Setup

Fig. 1 shows the complete hardware prototype. The left board is Post 1 (transformer control unit) with LCD, current sensors, relay, and GSM module. The right board is Post 2 (field sensing unit) with LCD, ZMPT101B, and current sensor. The two blue serial interface boards at the centre link the two posts. The bulb on the left simulates the agricultural load and the white buzzer on the right provides audible alerts.

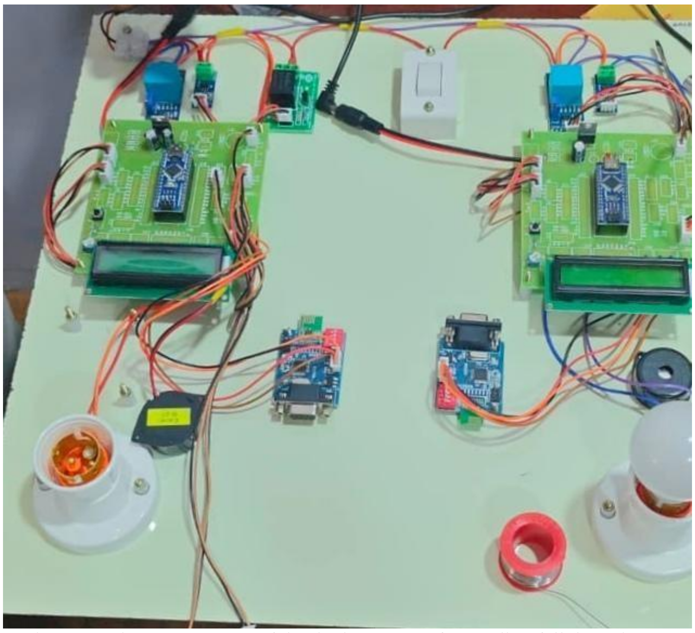

Fig. 1. Hardware prototype of the dual-post transformer line fall detection system.

B. LCD Display Output

Post 2 LCD Line 1 shows real-time voltage and current (e.g., "V:220 I:12.3"). Line 2 shows "NORMAL" when voltage > 50 V and "NO VOLTAGE" on fault. Post 1 LCD Line 2 shows "NORMAL" during normal operation, "FAULT DETECTED" on receiving '1', and "THEFT OCCURED" when Irms1 ≥ Irms2 + 1 A.

C. Buzzer and Relay Output

The Post 2 buzzer activates immediately on voltage drop. Post 1 buzzer activates on fault or theft detection and de-activates after 2 seconds. The relay de-energizes on fault (power cut-off) and re-energizes when a normal signal is received.

D. GSM SMS Alert

Two consecutive SMS messages are sent to the registered number to ensure delivery. Message text:

```
POST FALL DETECTED
```

E. CSV Data Log Output

Sample serial log under normal, fault, and theft conditions:

```
Voltage,Irms1,Irms2,Status
220,12.45,12.30,NORMAL
218,12.50,12.35,NORMAL
45,0.10,0.08,FAULT
221,12.48,11.20,THEFT
```

TABLE IV

System Output Summary

Condition	Post 2 LCD	Post 1 LCD	Post 1 Action
Normal Operation	NORMAL	NORMAL	Relay ON, silent, CSV: NORMAL
Conductor Fall (V ≤ 50 V)	NO VOLTAGE	FAULT DETECTED	Relay OFF, buzzer, SMS sent, CSV: FAULT
Theft (Irms1 ≥ Irms2+1)	NORMAL	THEFT OCCURED	Buzzer beep, CSV: THEFT

VIII. Conclusion

This paper presented a dual-post transformer line fall detection and alert system. Post 2 monitors voltage and current at the field pole and transmits a fault character to Post 1 via SoftwareSerial when voltage drops below 50 V. Post 1 cuts off power through a relay and sends dual SMS alerts via GSM. Energy theft detection compares current readings at both posts.

Laboratory testing confirmed reliable fault detection, timely SMS notification, and effective power isolation. Future work will focus on field deployment, replacing the wired serial link with ZigBee for wireless operation, integrating GPS-based fault location, and developing a mobile dashboard for centralized monitoring.

Acknowledgment

The authors thank the Department of Electronics and Communication Engineering, Anjalai Ammal Mahalingam Engineering College, Kovilvenni, for providing laboratory facilities. Special thanks to the project guide for continuous technical guidance.

REFERENCES

[1] S. K. Singh and V. S. Bisht, "Soft computing based approach for ascertaining evolving faults in compensated lines," 2025.
[2] M. Al-Sultan and I. Avci, "Advanced transmission line fault protection including the voltage sag," 2025.
[3] D. Liang et al., "Advanced sensing techniques for cable fault detection enhanced by PLC and residual neural networks," 2025.
[4] S. K. Behera et al., "Fault detection in transmission line by using IoT," 2024.
[5] S. Kanwal and S. Jiriwibhakorn, "Advanced fault detection, classification, and localization in transmission lines: A comparative study," 2024.
[6] Y. Wu et al., "Ubi-asthma: toward ubiquitous asthma detection using the smartwatch," IEEE Internet of Things Journal, vol. 10, no. 13, pp. 11576–11587, 2023.