International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 03 | March - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

# Design and Implementation of Transmission Line Safety System (Line to Line and Line to Ground) Fault Detection

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ABSTRACT –

Transmission lines play a vital role in delivering electrical power from generation stations to consumers. However, these lines are exposed to environmental conditions that may cause faults such as Line-to-Line (L- L) and Line-to-Ground (L-G) faults. These faults can lead to excessive current flow, which may damage electrical equipment and interrupt power supply. This project presents a transmission line safety system designed to detect such faults quickly and protect the power network. The system continuously monitors the line current using sensors. When the current exceeds the normal limit, an overcurrent relay detects the fault and sends a signal to the circuit breaker to isolate the faulty section. By disconnecting the affected part of the transmission line, the system helps prevent equipment damage and improves the reliability of the power supply. The proposed system provides a simple, fast, and effective solution for transmission line fault detection and protection.

Keywords: Transmission line, Fault detection, Line-to-line fault, Lineto- ground fault, Overcurrent relay, Circuit breaker, Power system safety

## I. INTRODUCTION

.Electricity is one of the most important forms of energy used in modern life. It is required for homes, industries, hospitals, communication systems, and transportation. The electrical power system is responsible for generating, transmitting, and distributing electricity to consumers. A typical power system consists of three main parts: generation, transmission, and distribution.

Transmission lines play a very important role in the power system because they carry electrical energy from generating stations to substations over long distances. These lines are usually installed outdoors and are exposed to environmental conditions such as wind, rain, lightning, and temperature changes. Because of these conditions, faults may occur in the transmission lines.

The most common faults in transmission systems are Line-to- Line (L-L) faults and Line-to-Ground (L-G) faults. A Line-toLine fault occurs when two conductors come into contact with each other, while a Line-to-Ground fault occurs when a conductor touches the ground or any grounded object. These faults cause a sudden increase in current in the transmission line.

Excessive current can damage electrical equipment such as transformers, generators, and circuit breakers. It may also cause is very important to detect these faults quickly and disconnect the faulty section from the rest of the power system.

This research focuses on designing a transmission line safety system that can detect Line-to-Line and Line-to-Ground faults. The system monitors the current in the transmission line using sensors. When the current exceeds the safe limit, an overcurrent relay sends a signal to the circuit breaker to isolate the faulty section. This improves the reliability and safety of the electrical power system.

## II. LITERATURE REVIEW :

Several researchers have studied transmission line fault detection systems.

**Seada Hussen Aden (2020**): studied different types of transmission line faults and explained the importance of fast fault detection to maintain power system reliability.

**A. R. Abhishek et al. (2021) :** explained the working of overcurrent relays for detecting abnormal current during fault conditions. Their research showed that relays can effectively protect electrical equipment.

**P. Kumar and S. Singh (2022)** : discussed different protection techniques used in transmission lines and emphasized the need for simple and low-cost fault detection systems.

**Porlaje et al. (2024):** proposed a machine learning based fault detection system using algorithms such as KNN and Decision Tree. Their results showed improved fault detection accuracy.

**Kabir et al. (2025):** developed a system using Artificial Neural Networks (ANN) to detect and classify transmission line faults based on voltage and current data.

**Electrosal (2024):** proposed an IoT-based fault detection system using Arduino that can send real-time information about faults in the transmission line.

These studies show that fast and reliable fault detection is essential for maintaining the stability and safety of the electrical power system.

III. OBJECTIVE OF THE STUDY:

The main objective of this research is to design a system that can detect faults in transmission lines and protect the electrical power system.

- The specific objectives are:
- To study different types of faults in transmission lines.
- To detect Line-to-Line faults in the power system.
- To detect Line-to-Ground faults in the power system.
- To monitor the current flowing through the transmission line continuously.
- To protect electrical equipment from excessive current.
- To improve the safety and reliability of the transmission system .

IV. PROBLEM STATEMENT : Transmission lines are responsible for carrying electrical power from power plants to substations and consumers. Since these lines are installed outdoors and cover long distances, they are exposed to environmental conditions such as storms, lightning, falling trees, and insulation failure.

Because of these factors, faults such as Line-to-Line and Lineto- Ground faults can occur in the transmission line. When these faults happen, a very large current flows through the system.

This excessive current can damage electrical equipment, reduce system reliability, and cause power outages. In severe cases, it may also lead to fire hazards and equipment failure.

Therefore, there is a need for a system that can quickly detect these faults and isolate the faulty section of the transmission line to protect the power system.

V. METHODOLOGY :

The methodology of this project focuses on designing a system to detect Line-to-Line (L-L) and Line-to-Ground (L-G) faults in transmission lines and protect the electrical power system. The system works by continuously monitoring the current and voltage conditions of the transmission line.

First, electrical power flows through the transmission line from the source to the load. A current sensor or current transformer (CT) is used to measure the current flowing through the line, while a voltage sensor measures the voltage level of the system.

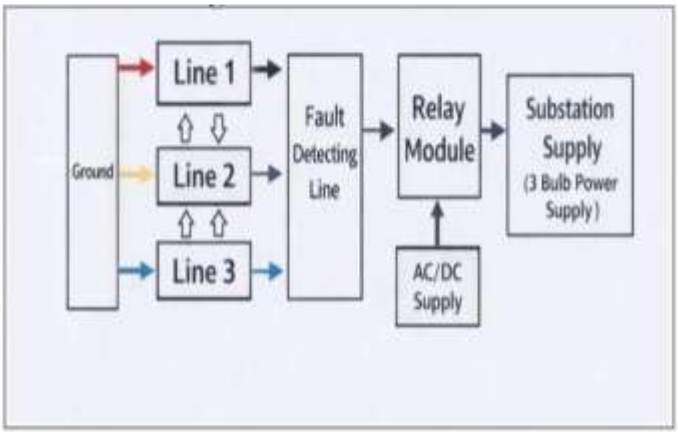
The measured current and voltage signals are sent to the control unit or microcontroller. The control unit continuously compares the measured values with predefined safe limits. Under normal operating conditions, the current remains within the safe range.

When a fault occurs, such as a Line-to-Line fault or Line-to Ground fault, the current in the transmission line increases suddenly and the voltage may drop. The control unit detects this abnormal condition and identifies it as a fault.

Once the fault is detected, an overcurrent relay is activated. The relay sends a signal to the circuit breaker, which disconnects the faulty transmission line from the rest of the power system. This process happens very quickly, helping to protect electrical equipment from damage.

By continuously monitoring the transmission line and quickly isolating the faulty section, the proposed system improves the safety, reliability, and stability of the electrical power system.

BLOCK DIAGRAM :




The block diagram represents : the working of the transmission line fault detection system used to detect Line-to-Line (L-L) and Line-to-Ground (L-G) faults.

The system consists of three transmission lines (Line 1, Line 2, and Line 3) that carry electrical power from the source to the substation supply. Under normal conditions, electrical power flows through all three lines and the load, represented by three bulbs, receives power normally.

The fault detecting line unit continuously monitors the condition of the transmission lines. It checks the electrical parameters of the lines to identify abnormal conditions such as excessive current or voltage imbalance.

If a Line-to-Line fault occurs, two transmission lines come into contact with each other, causing a sudden increase in current. Similarly, if a Line-to-Ground fault occurs, one of the transmission lines touches the ground, creating an unbalanced condition in the system.

When such faults are detected, the fault detecting unit sends a signal to the relay module. The relay module then activates and isolates the faulty line from the system to prevent damage to electrical equipment.

The AC/DC power supply provides the required DC power for the relay module and the control circuit. After the fault is isolated, the remaining healthy lines continue to supply power to the substation load.

Thus, the system helps in quick fault detection, protection of electrical equipment, and maintaining the reliability of the power system.

## VI. RESULT AND DISCUSSION:

The proposed transmission line fault detection system was tested under different operating conditions to evaluate its performance. The system successfully detected both Line-to-Line (L-L) faults and Line-to-Ground (L-G) faults.

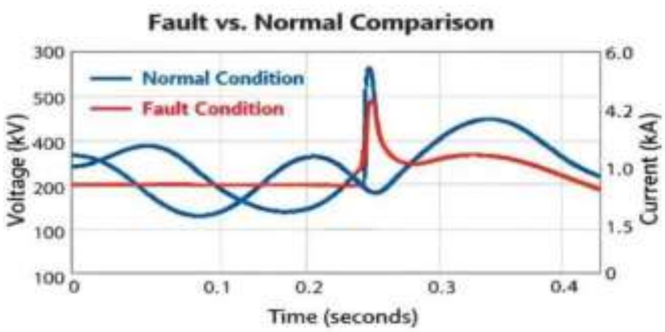
During normal conditions, the current and voltage waveforms remained stable and balanced in all three transmission lines. However, when a fault occurred, the system detected a sudden increase in current and a drop in voltage.

In the case of a Line-to-Line fault, two transmission lines came into contact with each other, which caused a large current flow between the lines. The fault detection unit quickly identified this abnormal condition and activated the relay module.

Similarly, during a Line-to-Ground fault, one of the transmission lines touched the ground, creating an unbalanced condition in the system. The system detected the fault and isolated the faulty line using the relay module.

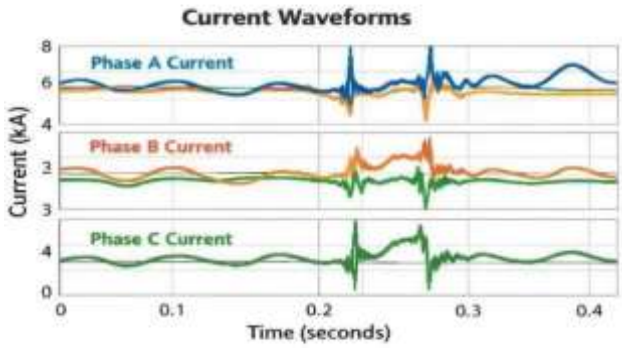
The results show that the proposed system can quickly detect faults and protect the power system from damage. This improves the reliability and safety of the transmission network.

## VII. FIGURE EXPLANATION :



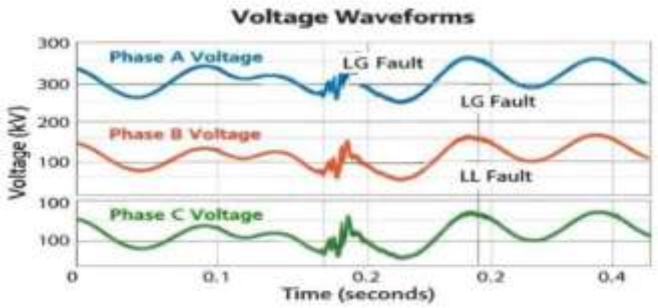

1 . Figure (a)): Current Waveforms

This figure illustrates the current behavior of the three phases during normal and fault conditions. In normal operation, the current remains relatively stable and sinusoidal. When a fault occurs, large current spikes appear due to the sudden decrease in system impedance, resulting in excessive current flow through the affected phase.




2. Figure (a): Voltage Waveforms

This figure presents the voltage waveforms of the three phases (Phase A, Phase B, and Phase C) in a three-phase power system. Under normal operating conditions, the voltages follow a smooth sinusoidal pattern, indicating a balanced system. Around 0.18 seconds, disturbances appear in the waveforms due to the occurrence of a Line-to-Ground (LG) and Line-to-Line (LL) fault. These faults cause noticeable voltage dips and waveform distortions, indicating instability in the system.




3. Figure (c): Fault vs. Normal Comparison

This graph compares the electrical characteristics of the system during normal operation and fault conditions. The normal condition shows steady voltage and current patterns, while the fault condition results in voltage sag and a sharp increase in current magnitude. This comparison highlights the impact of faults on the stability of the power system

**Comparison Table**

| Condition | Voltage (kv) | Current (kA) | Detection Time (s) |
|---|---|---|---|
| Normal | 230 | 0.8 | – |
| LG Fault | 120 | 4.5 | 0.03 |
| LL Fault | 150 | 5.2 | 0.025 |

4. Figure (d): Comparison TableThis table summarizes the main electrical parameters under different operating conditions. It indicates that during normal operation the

system voltage is around 230 kV with a current of approximately 0.8 kA. In contrast, LG and LL faults cause voltage reduction and a significant increase in current. The table also shows the fault detection time, demonstrating the ability of the protection system to detect and respond to faults rapidly.

## VIII. ADVANTAGES

- The proposed transmission line fault detection system has several advantages.
- It can detect faults quickly and accurately.
- It helps protect electrical equipment from damage.
- It improves the reliability of the power system.
- The system is simple and cost-effective.
- It helps reduce power outages by isolating faulty lines quickly.

## IX. APPLICATION :

- The proposed system can be used in different areas of electrical power systems.
- Transmission line protection systems
- Power system monitoring and control
- Substation protection systems
- Smart grid technology
- Electrical power network safety systems
- This system helps engineers detect faults quickly and maintain a reliable power supply.

## X. ACKNOWLEDGMENTS :

The authors would like to express their sincere gratitude to the faculty members of the Electrical Engineering Department for their valuable guidance and support during the completion of this research work. The authors also thank the institution for providing the necessary facilities and resources to successfully carry out this project.

## XI. CONCLUSION:

This research presented a transmission line fault detection system for detecting Line-to-Line and Line-to-Ground faults. The system continuously monitors the current and voltage in the transmission line.

When a fault occurs, the system detects the abnormal condition and activates the relay module to isolate the faulty transmission line. This helps prevent damage to electrical equipment and ensures the safe operation of the power system.

The results show that the proposed system provides a simple, effective, and reliable solution for transmission line fault detection and protection.

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