

Three Phase Transmission Line Fault Detection System

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Abstract - The power system is divided in three section like generation, distribution and Transmission. Various types of fault is occur in this system it should isolate. In this module we include the Arduino UNO, ULN2003, Relay to drive the relay, Resistor, LCD display, Moving switches to create fault. As per the Programming of Arduino UNO when we create the fault across any line LCD displayed the output as "Fault occurred in that particular line (i.e. R,Y,B) at the distance (2km,4km,6km,8km)". The output which shows displayed on the LCD display is depends on where we create a fault and in which line.

KeyWords: Three-Phase Transmission Line, Fault Detection, Arduino Uno, Fault Location, Line-to-Ground (L-G) Fault, Line-to-Line (L-L) Fault, Relay Protection, LCD Display, Power System Protection, Impedance-Based Fault Detection, Transmission Line Monitoring, Electrical Safety.

1.INTRODUCTION

As we see in our surroundings, faults occurring in transmission lines are very common, especially during the rainy season, and they can be very dangerous to both human life and electrical equipment. The electrical power system is continuously growing in size and complexity in the areas of generation, transmission, and distribution. Due to this increasing complexity, the possibility of faults also increases, resulting in economic losses and reducing the reliability and stability of the power system. Therefore, it is essential to detect and clear faults as quickly as possible. If faults are not cleared in time, they may lead to complete blackout or grid failure. Generally, about 70% to 90% of faults in overhead transmission lines are temporary and occur due to lightning, storms, heavy rainfall, flashovers, insulation failure, tree branches, and environmental conditions. These faults are harmful to society because they interrupt the power supply, damage electrical equipment, reduce system efficiency, and may create hazardous situations. Common transmission line faults include line-to-ground (L-G), line-to-line (L-L), double line-to-ground (L-L-G), and three-phase faults. Hence, a reliable fault detection system is necessary to improve the safety, reliability, and efficiency of the electrical power system. In this project, a prototype model of a "Three-Phase Transmission Line Fault Detection System" is developed. Faults are created manually using switches to simulate

different fault conditions on the transmission line. Since the impedance of a transmission line increases with its length, different combinations of resistors are used to represent different fault distances for each phase. The "Arduino Uno" acts as the main controller of the system. A regulated DC power supply is provided to the control circuit using a transformer, rectifier, filter, and voltage regulator. Recent studies have shown that Arduino-based transmission line fault detection systems provide an effective and low-cost solution for identifying faults, estimating their location, and protecting power systems. Kumar (2024) developed a three-phase transmission line fault detection system using an Arduino Uno, where the controller continuously monitored voltage variations through its analog input pins. The system detected Line-to-Line (L-L) and Line-to-Ground (L-G) faults, displayed the fault status on an LCD, and activated relay modules to disconnect the faulty section, thereby preventing equipment damage.

2.LITERATURE SURVEY

[1] H. Saadat (2002) explained the fundamentals of power system analysis, including transmission line parameters, fault analysis, and protection methods. The book provides the theoretical foundation for transmission line fault studies.

[2] J. Lewis Blackburn and T. J. Domin (2014) discussed modern protective relaying principles and digital protection techniques for detecting various transmission line faults with high accuracy and reliability.

[3] B. Ravindranath and M. Chander (1977) presented different power system protection schemes and emphasized relay coordination for minimizing equipment damage during faults.

[4] A. R. Bergen and V. Vittal (2000) described methods for power system monitoring and fault analysis, highlighting the importance of rapid fault location in maintaining system stability.

[5] A. G. Phadke and J. S. Thorp (2008) introduced synchronized measurement technology using Phasor

Measurement Units (PMUs) for accurate fault detection and transmission line monitoring.

[6]. M. Kezunovic (2011) reviewed intelligent monitoring systems and digital relays for smart grid applications, focusing on automated fault diagnosis and protection.

[7] A. Yadav and A. Swetapadma (2015) presented a comprehensive review of transmission line fault location techniques using impedance-based and travelling-wave methods, discussing their advantages and limitations.

[8] S. R. Samantaray (2009) proposed wavelet transform techniques for transmission line fault classification, improving detection accuracy under different fault conditions.

[9] R. N. Mahanty and P. B. Gupta (2004) developed an ANN-based fault classification system capable of identifying different transmission line faults with improved speed and precision.

[10] S. M. Brahma (2004) investigated fault location algorithms for transmission lines using synchronized voltage and current measurements, achieving accurate fault distance estimation.

[11] Atmel Corporation (2015) introduced the ATmega328P microcontroller architecture, widely used in Arduino Uno for embedded monitoring and control applications due to its simplicity and reliability.

[12] Arduino (2021) provided an open-source embedded platform that enables real-time sensing, signal processing, relay control, and LCD interfacing for low-cost protection systems.

[13] M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay (2017) explained practical interfacing of sensors, LCDs, relays, and microcontrollers, supporting the implementation of embedded fault detection systems.

[14] Animesh Kumar, "Three Phase Transmission Line Fault Detection Using Arduino," International Journal for Research in Applied Science and Engineering Technology (IJRASET), vol. 12, no. 5, pp. 4169–4183, May 2024.

- Design a prototype model of a three-phase transmission line using resistor networks.
- Provide a regulated 5 V DC power supply to the Arduino Uno and other components.
- Simulate transmission line faults manually using switches.
- First, a prototype model of a three-phase transmission line was constructed using resistor networks to simulate the impedance of an actual transmission line. Different resistor values were selected to represent different transmission line distances of 2 km, 4 km, 6 km, and 8 km, following the approach described by Metkar et al. (2023), where fault distance estimation is achieved by measuring changes in line resistance.
- Connect the fault detection circuit to the analog input pins of the Arduino Uno.
- Continuously monitor the voltage and resistance values using the Arduino.
- Identify the faulty phase (R, Y, or B) and estimate the fault location based on resistance.
- Display the fault phase and distance on the 16×2 LCD display.
- Activate the relay to disconnect the faulty line from the power supply.
- Detect fire using a flame sensor and trip all relays during emergency conditions.
- Restore normal operation after the fault is cleared and the system is reset.

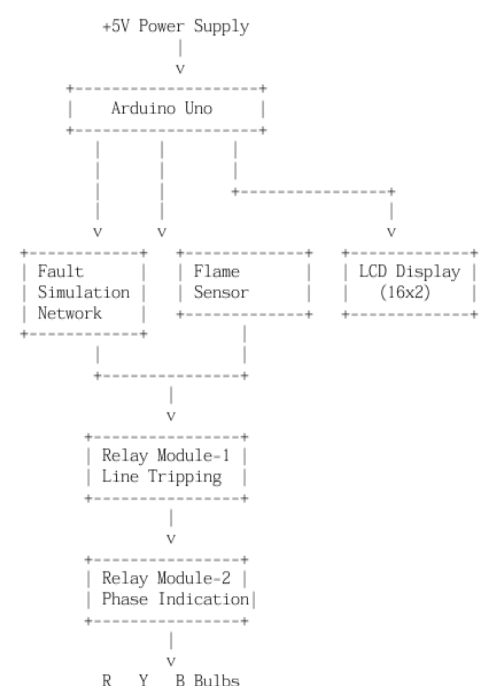


Fig.1 Flowchart for Three Phase Transmission Line Fault Detection System

3.METHODOLOGY

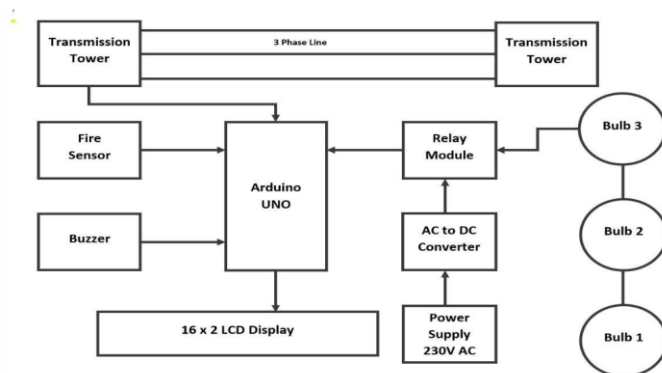


Fig.2 Block Diagram for Three Phase Transmission Line Fault Detection System

1. **Three-Phase Transmission Line-** The three-phase transmission line represents the power transmission path between two transmission towers. Faults are manually created using switches to simulate real transmission line fault conditions. The resulting fault signals are sent to the Arduino Uno for fault detection and location.
2. **Arduino Uno-** The Arduino Uno acts as the central controller of the system. It continuously monitors the transmission line, processes the input signals, identifies the faulty phase, estimates the fault location, and controls the relay module, LCD display, and buzzer based on the detected fault.
3. **Fire Sensor-** The fire sensor is installed near the transmission tower to detect fire hazards. When fire is detected, it sends a signal to the Arduino Uno, which immediately disconnects the transmission line by operating the relay module and activates the buzzer for safety.
4. **Buzzer-** The buzzer provides an audible alarm whenever a transmission line fault or fire is detected. It alerts the operator about the emergency condition for quick action.
5. **16 × 2 LCD Display-** The LCD display shows the fault information in real time. It displays the faulty phase (R, Y, or B) and the estimated fault distance, allowing the operator to identify the fault location easily.
6. **Power Supply (230 V AC)-** The 230 V AC power supply is the primary source of electrical energy for the system. It supplies power to the AC-to-DC converter.
7. **AC-to-DC Converter-** The AC-to-DC converter converts the 230 V AC input into a regulated DC voltage required for operating the Arduino Uno, relay module, LCD display, fire sensor, and other electronic components.

8. **Relay Module-** The relay module receives control signals from the Arduino Uno. When a fault is detected, it disconnects the faulty transmission line from the power supply, thereby protecting the connected load and preventing further damage.
9. **Bulb 1, Bulb 2, and Bulb 3 -** The three bulbs represent the R, Y, and B phases of the transmission line. During normal operation, all bulbs remain ON. When a fault occurs in any phase, the corresponding bulb turns OFF, indicating that the faulty phase has been isolated by the relay module.

4.HARDWARE

Our proposed system uses an “Arduino Uno, regulated power supply, resistor network, fault switches, relay module, 16 × 2 LCD display, fire sensor, buzzer, and bulbs”. The resistor network is used to simulate the transmission line impedance, while the fault switches are used to create different fault conditions. The Arduino Uno continuously monitors the transmission line, detects the faulty phase, calculates the fault location, and displays the information on the LCD. The relay module disconnects the faulty transmission line to protect the load, while the fire sensor detects fire hazards and the buzzer provides an audible alarm during emergency conditions.

The list of hardware components required is:

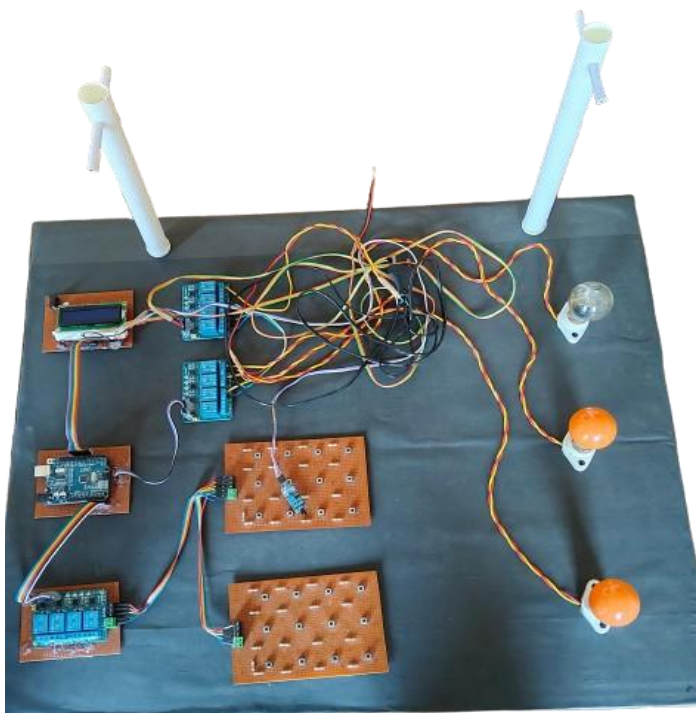
- Regulated Power Supply (RPS)
- Arduino Uno
- Resistor Network
- Fault Switches
- 16 × 2 LCD Display
- Relay Module
- Fire Sensor
- Buzzer
- Bulb 1, Bulb 2, and Bulb 3

1. **Regulated Power Supply (RPS)-** Provides a stable and regulated DC voltage to the Arduino Uno, relay module, LCD display, fire sensor, and other electronic components, ensuring reliable operation of the system.
2. **Arduino Uno-** Acts as the main controller of the system. It receives input signals from the transmission line and fire sensor, processes the data, detects the faulty phase and fault location, controls the relay module, and displays the fault information on the LCD.
3. **Resistor Network-** Represents the impedance of the transmission line. Different resistor values simulate different transmission line lengths, enabling the Arduino to estimate the fault location accurately.
4. **Fault Switches-** Used to create different transmission

line fault conditions manually. When a switch is operated, it simulates a fault on the corresponding phase, allowing the system to detect and locate the fault.

5. 16 × 2 LCD Display- Displays the fault status, faulty phase (R, Y, or B), and the estimated fault distance, providing real-time information to the operator.
6. Relay Module- Acts as an electrically operated switch. It disconnects the faulty transmission line from the power supply whenever a fault or fire condition is detected, protecting the connected load.
7. Fire Sensor- Continuously monitors the transmission tower area for fire. When fire is detected, it sends a signal to the Arduino Uno, which trips the relay and disconnects the transmission line to prevent further damage.
8. Buzzer- Provides an audible alarm whenever a fault or fire is detected, alerting the operator to take immediate action.
9. Bulb 1, Bulb 2, and Bulb 3- Represent the R, Y, and B phases of the transmission line. Under normal operation, all bulbs remain ON. When a fault occurs in a particular phase, the corresponding bulb turns OFF, indicating that the faulty phase has been isolated.

5.RESULT



6.ADVANTAGES AND DISADVANTAGES

Advantages

1. Enhances system safety by rapidly isolating faulty transmission lines, reducing the risk of electrical fires and equipment damage.
2. Minimizes damage to transmission line equipment by detecting faults at an early stage.
3. Reduces operational and maintenance costs by minimizing outage duration and repair time.
4. Provides real-time fault information on the LCD display, enabling quick action by operators.
5. Improves the reliability and stability of the power transmission system.
6. Offers a simple, low-cost, and easy-to-implement fault detection solution using Arduino Uno.

Disadvantages

1. The prototype is suitable only for laboratory-scale applications and requires modification for practical transmission systems.
2. Fault detection accuracy may be affected by electrical noise and electromagnetic interference.
3. Changes in transmission line parameters and operating conditions can affect fault location accuracy.
4. Arduino Uno has limited memory and processing capability for advanced protection algorithms.

7.FUTURE SCOPE

- Upgrade the Arduino Uno to a high-speed ARM or DSP-based controller for faster and more accurate fault analysis.
- Implement an automatic auto-reclosure mechanism to restore power after temporary faults.
- Integrate impedance-based fault distance calculation for precise fault location.
- Add IoT or GSM technology for remote monitoring and instant fault notifications.
- Incorporate self-health monitoring to detect failures in sensors and protection circuits.
- Develop the system for real-time high-voltage transmission line applications.

8.CONCLUSION

The proposed Three-Phase Transmission Line Fault Detection System using Arduino Uno provides a simple, reliable, and cost-effective solution for detecting transmission line faults and estimating their location. The system identifies the faulty phase, displays the fault information on an LCD, and automatically isolates the faulty line using a relay to protect the transmission system. The integration of a fire sensor further enhances system safety by preventing damage during fire hazards. The prototype demonstrates fast fault detection, improved protection, and reliable operation, making it suitable for educational purposes

and as a foundation for developing advanced transmission line protection systems.

9. REFERENCES

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