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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

OPTION: ELECTRICAL TECHNOLOGY

FINAL YEAR PROJECT

DESIGN AND IMPLEMENTATION OF TRANSMISSION LINE FAULTS DETECTOR

Final Year project submitted in partial fulfillment of the requirement for award of Advanced Diploma in Electrical Technology

Submitted By:

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Kigali, November2024

DECLARATION A

I, NSHIMIYIMANA Thierry hereby declare that this I own original work and not duplication of any similar academic work. It has therefore not been previously or concurrently submitted for any other degree, diploma or other qualification to ULK or any other institution. All materials cited in this paper which are not my own have been duly acknowledged.

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Signature: ………………………………………..

Date: …………./……………/……..

DECLARATION B

I certify that the candidate under my supervision carried out the work reported in this research project and it has submitted with my approval as the ULK Polytechnic institute supervisor.

The supervisor's name: Eng. BIRALI Steven

Signature………………………… ……………………………

Date ……………………………… …………………………………..

DEDICATION

This project is dedicated to my family and mentors, whose unwavering support and encouragement have been instrumental in guiding me through every challenge. To my teachers and peers, who have fostered my curiosity and passion for renewable energy, I owe deep gratitude for their wisdom and insight. Finally, I dedicate this work to all those committed to advancing sustainable solutions for a cleaner, greener future, in the hope that this contribution may inspire further efforts toward environmental preservation and energy independence.

ACKNOWLEDGEMENT

I would like to express my appreciation to Almighty God for life he offered to me during all this time, and I thank everyone who contributed to the successful achievement that are observed at this stage of my life.

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I grateful thanks all lecturers of electrical and electronics engineering department for their efforts in providing us the required knowledge.

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Am highly indebted to our teachers and lecturers from primary schools, until the UPI for the knowledge they provided to me.

I owe deep gratitude to families for materials, financial and moral support.

My acknowledgements go to everyone who supported me in my everyday lives to reach this moment.

To all my friends who contributed positively to accomplish this research.

Am really expressing my heartfelt thanks to all of them.

ABSTRACT

Abstract Transmission line is the most important part of the power system. Transmission lines a principal amount of power. the major role of a transmission line is to transmit electric power from the source area to the distribution network. The exploded between limited production, and a tremendous claim has grown the focus on minimizing power losses. Losses like transmission loss and also conjecture factors as like as physical losses to various technical losses, another thing is the primary factor it has a reactive power and voltage deviation are momentous in the long-range transmission power line. In essentially, fault analysis is a very focusing issue in power system engineering to clear fault in short time and re-establish power system as quickly as possible on very minimum interruption. However, the fault detection that interrupts the transmission line is itself challenging task to investigate fault as well as improving the reliability of the system. The transmission line is susceptible given all parameters that connect the whole power system. This paper presents a review of transmission line fault detection.

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LIST OF ABBREVIATIONS

ADC: Analog to digital converter

CT: current transformer

LCD: liquid crystal display

LED: light emitting diode

LL: line-to-line

LLG: line-to-line-to- ground   faults.

MDF: Medium Density Fiberboard

PCB: printed circuit board

SLG: single-line-to-ground

TTL: Transistor Transistor Logic

CHAPTER I: GENERAL INTRODUCTION

1.1 INTRODUCTION

Introduction regarding the distribution system, transmission lines perform the most important part that is to transfer electric power from the generating station to load centers. Since the development of the distribution and transmission system, power system engineers have been an object for locating and detecting faults. As long as the fault detected in short duration, it provides a good service for protecting the apparatus as well as an open way for disconnecting the part where this incident happened at fault, and with the help of this, it gives safe way to the system from any damages. So, it is needed to detect the fault otherwise due to fault it causes any disturbance which further tough time to the interconnected system that based on limitations.

1.2 Background of the Study

Power Transmission Systems: Power transmission systems are integral to modern electrical grids, responsible for transporting electrical energy from power generation sources such as power plants or renewable energy facilities—to distribution networks that deliver electricity to end-users. Transmission lines are designed to operate over long distances and at high voltages to minimize energy losses and maximize efficiency.

Faults in Transmission Lines: Transmission lines are prone to faults due to various factors including environmental conditions, mechanical failures, and accidental damage. Common types of faults include:

- Short Circuits: Occur when a line comes into contact with itself or another conductor, creating a path of low resistance that can lead to excessive current flow and potential damage.
- Open Circuits: Happen when a line breaks or disconnects, leading to an interruption in power flow.
- Line-to-Ground Faults: Involve a conductive path between a transmission line and the ground, which can cause significant operational disruptions.

1.3. Statement of Problem

Transmission lines are critical components of power systems, responsible for the delivery of electricity from generation sources to distribution networks and ultimately to consumers. Due to their extensive length and exposure to environmental conditions, transmission lines are susceptible to faults such as short circuits, open circuits, and line-to-ground faults. Prompt and accurate detection of these faults is crucial for maintaining the reliability and stability of the power grid, minimizing downtime, and ensuring the safety of both infrastructure and personnel.

Problem Description:

- ❖ This can result in prolonged outages and increased risk of damage to equipment and infrastructure.
- ❖ Transmission lines are vital for the transportation of electricity from power plants to distribution networks. Faults in these lines can lead to power outages, equipment damage, and safety hazards. Timely detection and diagnosis of faults are essential to maintain a reliable power supply.

Solution description:

- ❖ The proposed solution for the transmission line faults detector aims to provide at real-time monitoring system that accurately identifies and localizes faults in transmission lines.
- ❖ By leveraging advanced sensor technologies, data analytics, and machine learning, the system enhances the reliability and efficiency of power transmission.

1.4. Main Objectives of Project

The main objective of a transmission line faults detector is to accurately identify, locate, and classify faults in electrical transmission lines to ensure reliability and safety in power systems.

Quickly detect abnormal conditions or faults, such as short circuits or open circuits, in the transmission line.

Determine the precise location of the fault along the transmission line to facilitate rapid repairs and minimize downtime.

Differentiate between types of faults (e.g., single-phase, double-phase, and three-phase faults) to assist in appropriate remedial action.

1.5. Specific Objectives of Project

- ❖ To design an efficient and robust automatic fault detection and location system for overhead and underground power transmission lines.
- ❖ To reduce response time needed to rectify and save expensive transformers from damage or theft which usually occurs during longer power outages.
- ❖ To increase productivity of technical crews since the time needed to locate faults will be minimized.

1.6. Research Objectives

The aim of this research is to develop a device used to detect faults in the line and isolate the connected system or instrument connected to it. The primary objective of this research is to develop an advanced transmission line faults detector that improves the reliability, accuracy, and cost-effectiveness of fault detection systems.

1.7. Research Question

1. What are the most effective methods for achieving real-time fault detection in high-voltage transmission lines?"
2. How can advanced signal processing techniques be employed to enhance the detection of transient faults in transmission lines?"
3. What are the most effective approaches for classifying different types of faults in transmission lines using real-time data?"

1.8. Scope and Limitation

SCOPE

- ❖ Differentiating between types of faults (e.g., line-to-ground, line-to-line, or three-phase faults).

- Functionality across various types of transmission lines (e.g., overhead vs. underground) and voltage levels.

Limitations

- The system might incorrectly identify non-fault conditions as faults, leading to unnecessary maintenance or disruptions.
- The time taken to detect and locate faults might not always be fast enough to prevent damage or outages, especially in very long transmission lines.

1.9. SIGNIFICATION OF STUDY

The significance of studying transmission line fault detectors is profound, impacting various aspects of electrical power systems and broader societal and economic factors. Here's a detailed breakdown of why this research is important:

- Effective fault detection minimizes the duration of power outages by quickly identifying and isolating faults, which ensures a more reliable power supply to consumers.
- Reducing the likelihood of electrical faults reaching dangerous levels lowers the risk to maintenance personnel and emergency responders working on the grid.
- Fault detection systems enable more precise identification of issues, leading to targeted maintenance and repairs, thus optimizing resource allocation and reducing maintenance costs.

1.9. 1.Organization of the Study

This study is structured into five main chapters:

Chapter 1 is General Introduction: this Introduces the project, covering the Background, Problem Statement, research objectives, question, limitation, Scope and Significance.

Chapter 2 is Literature Review. This review relevant literature, discussing key concepts and components like multifunction relays while providing theoretical perspectives and related studies

Chapter 3 is Research Methodology: this outlines the Research Design, population, sample, size, instruction for Data Collection, and procedures for Analysis, along with ethical considerations and limitation.

Chapter 4 is the system Design and Implementation. This details the design and implementation of transmission line faults detector process, including calculation drawing, specification, cost estimations, and practical execution project

Chapter 5 is Conclusion and Recommendations: this summarizes findings, draws conclusion, and provides recommendations for system improvement and suggestions for further research.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

In the transmission line, the fault is comprised of ten parts that could interrupt in the three-phase system, single line to ground, line to line fault, double phase to ground and the last one is three phase faults. A single line to ground fault occurs when it makes contact with the ground during the occurrence of fault the impedance.

2.2. Ideas from Authors

John **D. Glover**: In his works on power system analysis, Glover discusses the importance of transmission line monitoring and fault detection methods, including impedance-based techniques.

- **Power System Protection Literature**: Authors like **Ramasamy** and **Murthy** have focused on the principles of protective relaying and fault analysis in transmission lines.

❖ Detection **Techniques**:

- **Impedance-Based Methods**: Many experts, such as **V. K. Mehta**, have explored techniques using impedance measurements to identify fault locations.
- **Wavelet Transform Methods**: Researchers like **S. M. S. R. Murthy** have studied the application of wavelet transforms for analyzing transient signals caused by faults, providing a time-frequency analysis approach.

❖ Smart **Grid Technologies**:

- **Smart Sensors**: Experts like **H. R. Pota** have discussed the role of smart sensors and real-time monitoring systems in enhancing fault detection capabilities within the smart grid framework.
- **Communication Technologies**: **R. M. K. Sinha** emphasizes the integration of communication technologies for rapid fault location and identification.

- Artificial **Intelligence Applications**:

  - **Machine Learning Techniques**: Researchers like **N. A. Al-Mansoori** have investigated the use of machine learning algorithms for predicting and diagnosing transmission line faults based on historical data.
  - **Pattern Recognition**: Authors such as **H. P. B. Hegde** have explored pattern recognition techniques for identifying fault types and locations through analyzed data.

- Real-**Time Monitoring Systems**:

  - **Phasor Measurement Units (PMUs)**: Experts like **A. G. Phadke** discuss the role of PMUs in providing real-time data for fault detection and system stability analysis.
  - **SCADA Systems**: Literature on Supervisory Control and Data Acquisition (SCADA) systems often highlights how these systems can facilitate effective monitoring and fault management.

- Case **Studies and Practical Implementations**:

  - **Field Studies**: Authors often publish case studies demonstrating successful implementations of fault detection systems in various utilities, showcasing real-world applications and outcomes.

  - **Ideas for Future Research**

1. **Integration with Smart Grids**:

   Combining fault detection with smart grid technologies can improve system resilience and efficiency by providing real-time data and automated responses.

2. **Predictive Maintenance**:

   Integrating fault detection with predictive maintenance approaches allows for early identification of potential issues and reduces unexpected failures.

2.3. Theoretical Perspectives

1. Relay

is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof. Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal. Relays were first used in long-distance telegraph circuits as signal repeaters: they refresh the signal coming in from one circuit by transmitting it on another circuit.

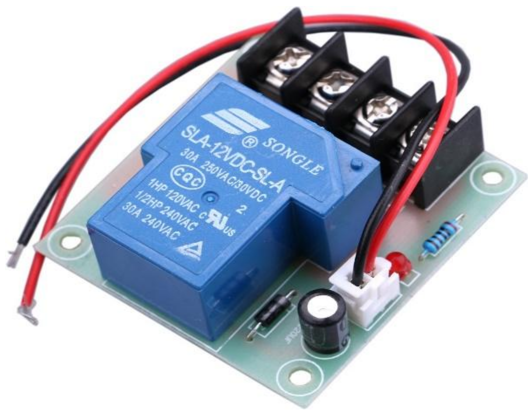


FIGURE.2. 1.RELAY

2.LCD Display

The liquid crystal display (LCD) panel is designed to project on-screen information of a microcomputer onto a larger screen with the aid of a standard overhead

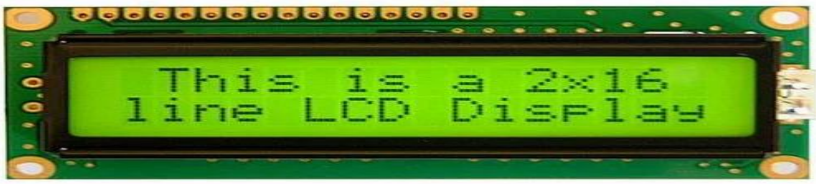


FIGURE.2. 2.LCD

3.Switches:

Switches offer a way to manage the flow of electrical current to various loads. A key feature of a switch is its ability to either allow or interrupt the current flow based on the operator's needs. Many electric switches operate by creating an air gap between two contacts to break the circuit.

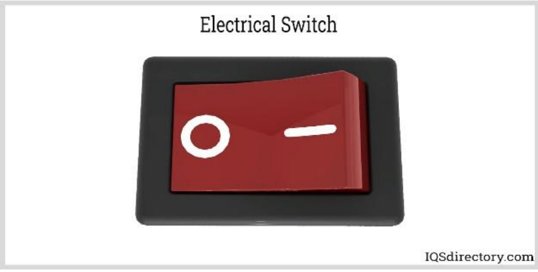


FIGURE.2. 3.SWITCH

4. Arduino Nano

1) **Arduino Nano** is a small, complete, flexible and breadboard-friendly Microcontroller board, based on **ATmega328p**, developed by Arduino.cc in Italy in 2008 and contains 30 male I/O headers, configured in a **DIP30 style**.
2) **Arduino Nano Pinout** contains 14 digital pins, 8 analog Pins, 2 Reset Pins & 6 Power Pins.
3) It is programmed using **Arduino IDE**, which can be downloaded from the Arduino Official site.
4) Arduino Nano is simply a smaller version of Arduino UNO, thus both have almost the same functionalities.
5) It comes with an **operating voltage of 5V**, however, the input voltage can vary from **7 to 12V**.
6) Arduino Nano's **maximum current rating is 40mA**, so the load attached to its pins shouldn't draw a current more than that.
7) Each of these Digital & Analog Pins is assigned with multiple functions but their main function is to be configured as **Input/Output**.
8) Arduino Pins are acted as **Input Pins** when they are interfaced with sensors, but if you are driving some load then we need to use them as an Output Pin.
9) Functions like **pin Mode ()** and **digital Write ()** are used to control the operations of digital pins while **analog Read ()** is used to control analog pins.

10) The analog pins come with a total **resolution of 10-bits** which measures the value from 0 to 5V.

11) Arduino Nano comes with a **crystal oscillator of frequency 16 MHz** It is used to produce a clock of precise frequency using constant voltage.

12) There is one limitation of using Arduino Nano i.e. it doesn't come with a **DC power jack**, which means you cannot supply an external power source through a battery.

13) This board doesn't use standard USB for connection with a computer, instead, it comes with **Type-B Micro USB**.

14) The tiny size and breadboard-friendly nature make this device an ideal choice for most applications where the size of the electronic components is of great concern.

15) **Flash memory is 16KB or 32KB** that all depends on the Atmega board i.e. Atmega168 comes with 16KB of flash memory while Atmega328 comes with a flash memory of 32KB. Flash memory is used for storing code. The 2KB of memory out of total flash memory is used for a bootloader.

16) The **SRAM memory of 2KB** is present in Arduino Nano.

17) Arduino Nano has an **EEPROM memory of 1KB**.

18) You can download Arduino Nano Datasheet by clicking the below button:

FIGURE.2. 4.ARDUINO NANO

5. Transformer

transformer, device that transfers electric energy from one alternating-current circuit to one or more other circuits, either increasing (stepping up) or reducing (stepping down) the voltage. Transformers are employed for widely varying purposes; e.g., to reduce the voltage of conventional power circuits to operate low-voltage devices, such as doorbells and toy electric trains, and to raise the voltage from electric generators so that electric power can be transmitted over long distances.

1. **Transformer Ratio Formula**

The turns ratio of a transformer relates the number of windings on the primary coil (Np) to the number of windings on the secondary coil (Ns):

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

- Np = Number of turns in the primary coil
- Ns= Number of turns in the secondary coil
- Vp = Voltage on the primary side
- Vs = Voltage on the secondary side

$$\frac{I_s}{I_p} = \frac{N_p}{N_s} = \frac{V_p}{V_s}$$

FIGURE.2. 5.TRANSFORMER

6. Potentiometer

A **potentiometer** is a three-terminal variable resistor used primarily to control voltage within a circuit. It functions by varying the resistance through the movement of a wiper along a resistive element. The two outer terminals of the potentiometer are connected to a fixed resistive track, while the third terminal, known as the wiper, slides along the resistive track as it is adjusted. This adjustment changes the ratio of resistance between the two sections of the track, effectively dividing the input voltage between them. Potentiometers are commonly used as voltage dividers, allowing users to control devices such as volume knobs in audio equipment or to fine-tune voltages in electronic circuits. By varying the position of the wiper, the output voltage can be precisely adjusted between the input voltage levels, making it a useful tool in many applications.

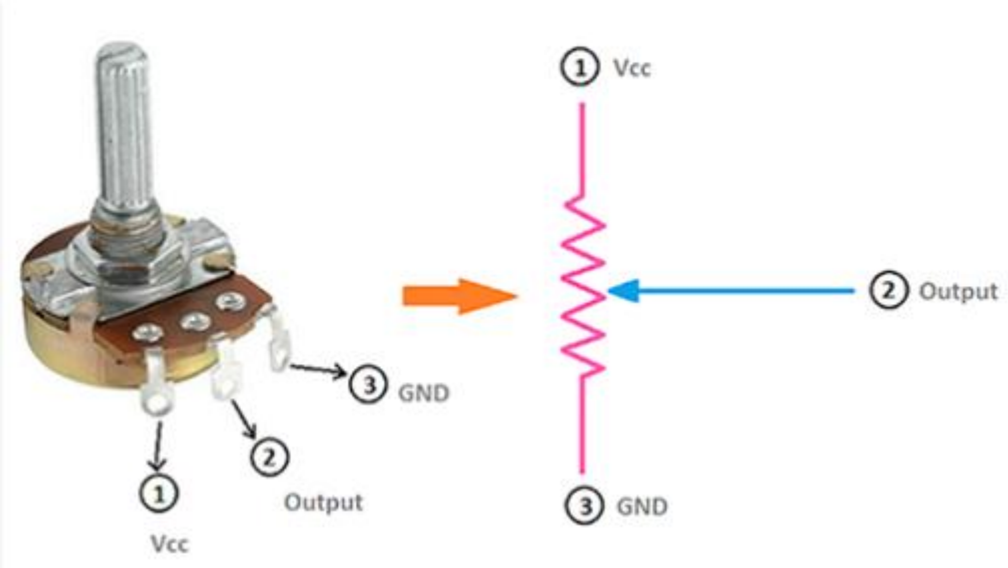


FIGURE.2. 6. POTENTIOMETER

7. NOT GATE

A **NOT gate**, also known as an **inverter**, is a basic digital logic gate that outputs the opposite, or inverse, of its input. If the input is high (logic 1), the output will be low (logic 0), and if the input is low (logic 0), the output will be high (logic 1). This gate is fundamental in digital circuits, where signal inversion is often required.

In practical applications, a NOT gate can be implemented using an **IC** (integrated circuit). One common IC that contains NOT gates is the **7404 IC**, which houses six independent NOT gates. Each gate on the IC can invert an individual input signal. The IC operates by applying a power supply (typically 5V for TTL logic) and using the gate's input and output pins to process signals. NOT gates are crucial in creating complex logic circuits and are often used in microcontrollers, signal processing, and control systems to manage logical conditions by inverting input signals.

8. Pcb Printed Circuit Board

A **Printed Circuit Board (PCB)** is a crucial component in modern electronics, providing the physical platform for connecting and supporting electronic components. A PCB consists of a flat, rigid substrate, usually made from fiberglass or other non-conductive materials, onto which conductive pathways, or **traces**, are etched. These traces serve as electrical connections between components, replacing traditional wire connections and allowing for more compact and reliable designs. Components such as resistors, capacitors, ICs, and transistors are soldered to the board, creating a functional electronic circuit.

PCBs can be **single-sided**, with components and traces on one side, or **double-sided**, where both sides are used for components and connections. **Multi-layer PCBs** have multiple layers of conductive traces sandwiched between insulating layers, allowing for even more complex circuits in compact spaces. PCBs are essential in virtually all modern electronic devices, from consumer electronics like smartphones and computers to industrial equipment and automotive systems, offering advantages in efficiency, durability, and ease of manufacturing.

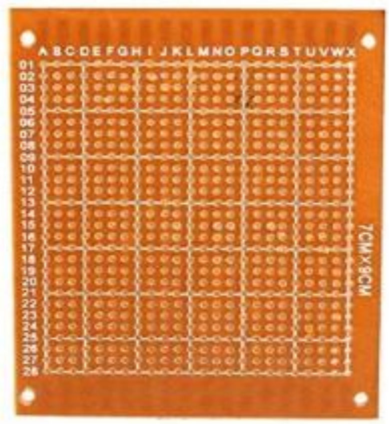


FIGURE.2. 7.PCB

9. LAMP

A **lamp** is an essential electrical device that converts electrical energy into light, typically used for illumination purposes in homes, industries, and various electronic applications. Lamps come in various forms, such as **incandescent bulbs**, **fluorescent lamps**, **halogen bulbs**, and **LEDs (Light Emitting Diodes)**, each offering different efficiencies, lifespans, and lighting characteristics. The traditional incandescent lamp works by passing electricity through a filament, which heats up and emits light due to thermal radiation. However, more modern options like LEDs are more energy-efficient, producing light through electroluminescence, a process where electricity excites semiconductor materials to emit photons.

FIGURE.2. 8.LAMP

10. Lamp Socket

A **lamp socket** is the part of a lamp that holds the bulb in place and provides the electrical connections needed to light the bulb. It's sometimes called a **lamp holder** or **light socket**. These sockets are designed to fit specific types of bulbs, such as **Edison screw** bulbs, **bayonet** bulbs, or **pin** bulbs, depending on the design and regional standards. The socket includes electrical contacts that connect to the bulb's base and to the power supply through wiring.

There are different types of lamp sockets based on their size, voltage, and the type of bulb they are designed for, such as:

1. **E26/E27**: Common for household use with screw-in bulbs (Edison sockets).
2. **GU10**: For spotlights and recessed lighting.
3. **B22**: Bayonet sockets, often used in regions like the UK and India.
4. **G4/G9**: Pin-type sockets for small halogen or LED bulbs.
5. **E12/E14**: Smaller Edison screw sockets often used in chandeliers or decorative lighting.

Lamp sockets can also be made from various materials like ceramic, plastic, or metal, depending on the temperature and safety requirements of the fixture.

FIGURE.2. 9.SOCKET

11. MDF

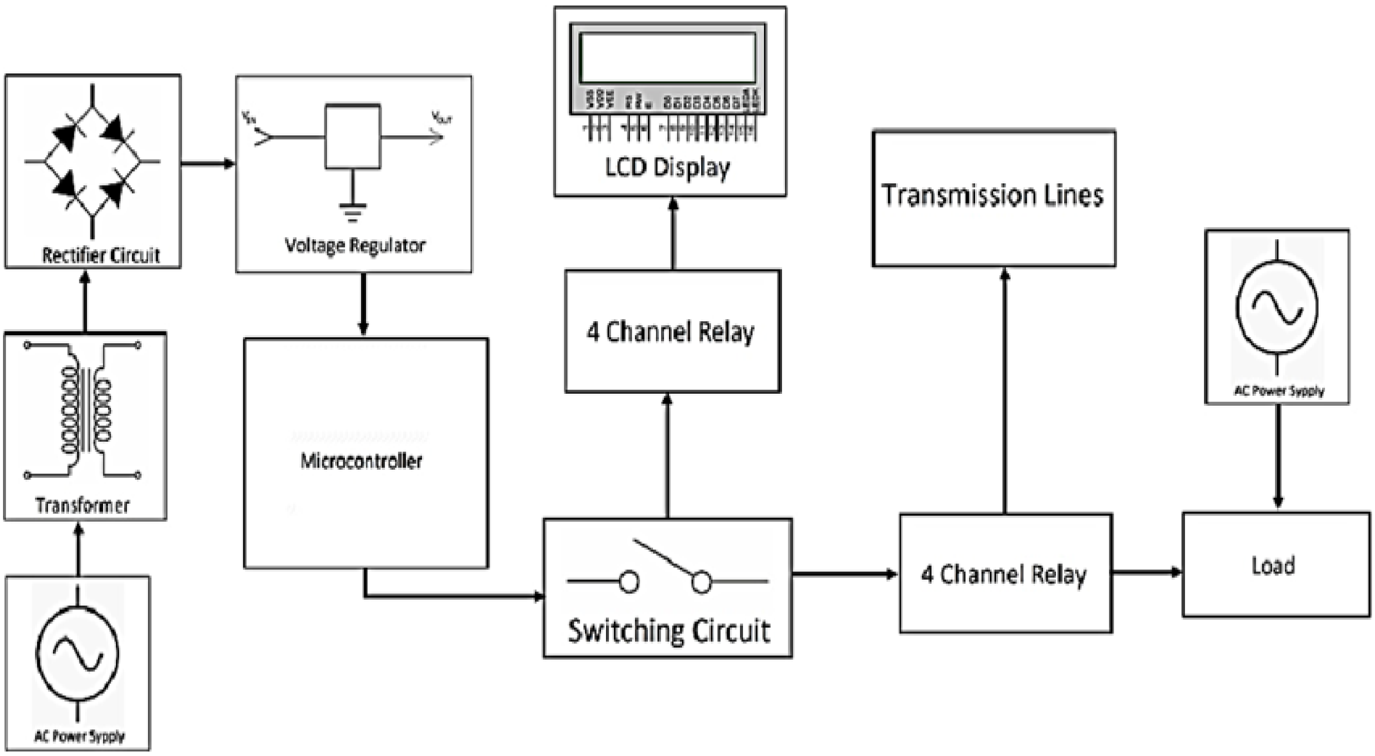
MDF refers to **Medium-Density Fiberboard** with a thickness of **2.12 millimeters**. MDF is an engineered wood product made from wood fibers that are bonded together with resin under high pressure and heat. It is known for its smooth surface, uniform consistency, and versatility in a wide range of woodworking projects.

FIGURE.2. 10.MDF

2.4. Related Study

Transmission line fault detection is a crucial area in power system engineering, aiming to ensure the reliable operation of electrical grids. Here's a summary of some key aspects and related studies in this field:

- ✓ These occur when there's a direct connection between two conductors or between a conductor and the ground. Common types include single-line-to-ground (SLG), line-to-line (LL), and line-to-line-to-ground (LLG) faults.
- ✓ These involve a break or disconnection in the transmission line, leading to a loss of current flow
- ✓ These methods estimate the fault location by analyzing the impedance of the line. Techniques such as the reactance-based method and the distance relay are commonly used.
- ✓ These methods detect faults by analyzing the traveling waves generated when a fault occurs. This includes the use of wavelet transforms and the characteristics of fault-generated transients.
- ✓ These relays measure the impedance between the relay location and the fault. They are effective in determining the distance to the fault but may face challenges in complex networks.



CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter outlines the methodology used for developing and evaluating a transmission line fault detector system. The research methodology provides a structured approach to the system design, development, testing, and analysis. It includes the research design, population, sampling techniques, research instruments, validity, and reliability, data gathering procedures, data analysis, and ethical considerations. The purpose of this research is to design and test a system capable of detecting faults in transmission lines efficiently to improve the reliability of power systems.

3.2 Research Design

The study adopts an **experimental research design**, which is appropriate for testing new technological systems. The research is conducted in two phases:

1. **System development**: This involves designing the hardware and software for the fault detection system, including sensors, relays, and signal processing algorithms.
2. **System testing**: The fault detection system will be tested in both simulated and real-world environments to measure its effectiveness in identifying and localizing faults in transmission lines.

The research also involves both **quantitative** (system performance data) and **qualitative** (expert feedback) approaches to analyze the effectiveness of the system.

3.3 Research Population

The population for this study includes:

1. **Transmission lines** of various voltage ratings (low, medium, and high voltage lines) which are subject to different types of faults.
2. **Power substations** that are responsible for monitoring and protecting the transmission lines.
3. **Technical experts** such as engineers and technicians involved in power system maintenance and fault detection.

3.4 Sample Size

The sample size consists of:

1. **Transmission lines**: Approximately **10-15 transmission lines** from different geographic locations and with varying voltage levels will be selected for testing.
2. **Fault scenarios**: The system will be tested against **50-100 simulated**, **scenarios**, covering different types and severities of faults.
3. **Technical personnel**: Feedback will be gathered from **10-15 technical experts** with experience in fault detection and power system maintenance.

3.5 Sample Procedures

1. **Transmission lines**: **Purposive sampling** will be used to select transmission lines of varying configurations and locations to ensure comprehensive testing of the system.
2. **Fault scenarios**: A mix of **simulated and real faults** will be induced or analyzed from historical fault data. **Random sampling** will be used for fault scenario selection to ensure diverse testing conditions.
3. **Technical personnel**: A **purposive sampling** technique will be used to select engineers and technicians based on their expertise and experience in fault detection and system maintenance.

3.6 Sampling Procedures

The sampling procedure ensures diversity in both the physical and technical aspects of the transmission lines and fault scenarios. The sample selection will follow the principles of:

1. **Purposive sampling**: This will be used for selecting a diverse set of transmission lines (urban, rural, different voltage levels) and technical personnel who have in-depth knowledge of fault detection systems.
2. **Random sampling**: For fault scenario testing, random sampling will be used to avoid bias and ensure the system is tested in a wide range of conditions.

3.7 Research Instruments

1. **Hardware Components**:

- ✓ **Current and voltage sensors**: To monitor transmission line parameters in real-time.
- ✓ **Relays**: For system protection and signaling during fault occurrences.
- ✓ **Signal processing units**: To analyze sensor data and detect faults.
- ✓ **Communication modules**: To transmit fault data to remote monitoring stations.
- ✓ Custom algorithms to process the data from sensors and classify fault types.

2. **Questionnaires and Interviews**: To gather feedback from the technical experts who monitor and maintain the transmission lines and fault detection systems.

3.8 Choice of the Research Instruments

The choice of instruments is guided by the need to accurately detect and diagnose faults in transmission lines. The hardware instruments (sensors, relays, communication modules) are selected based on their compatibility with power systems, precision, and reliability. Software tools like proteus professional 8.17 is chosen for their robustness in simulating power systems and their ability to model faults in real-time. Questionnaires and interviews provide qualitative feedback on the system's usability and performance from the perspective of technical experts.

3.9 Validity and Reliability of the Instruments

1. **Validity**: The validity of the research instruments will be ensured by using **standardized hardware and software** components that are widely used in power systems for fault detection. Simulations will be benchmarked against real-world fault data to ensure that the system performs as expected.
2. **Reliability**: The reliability of the fault detection system will be tested by repeatedly subjecting the system to various fault conditions. Consistent results across multiple trials will confirm the reliability of the system. The reliability of feedback from technical personnel will be established by conducting the study across a range of experts and analyzing consistent themes in their responses.

3.10. Data Gathering Procedures

- ✓ **Data from hardware and software**: The fault detection system will generate data on fault occurrences, such as the time of detection, type of fault, and the location of the fault. This data will be recorded in real-time and stored for later analysis.
- ✓ **Simulations**: Fault scenarios will be simulated using software tools, and the system's response will be recorded. Variables such as fault detection time and accuracy will be measured.
- ✓ **Expert feedback**: Data from questionnaires and interviews will be gathered to understand the system's ease of use, reliability, and potential areas for improvement.

3.11. Data Analysis and Interpretation

- ✓ **Quantitative data analysis**: The performance data from the system will be analyzed using
- ✓ **Qualitative data analysis**: Feedback from technical experts will be analyzed using **thematic analysis** to identify common issues, strengths, and recommendations for system improvement.
- ✓ **Comparative analysis**: The performance of the developed system will be compared with existing fault detection systems to evaluate its effectiveness.

3.12. Ethical Considerations

- ✓ **Informed consent**: All participants, including technical experts, will be informed about the purpose of the research, the procedures involved, and their right to withdraw at any time without penalty.
- ✓ **Confidentiality**: All data, particularly any proprietary information from power systems, will be anonymized to ensure confidentiality. Personal information from the technical experts will also be kept confidential.
- ✓ **Safety**: Since the research involves testing on electrical transmission systems, appropriate **safety measures** will be followed to prevent harm to personnel and equipment. All tests involving live systems will adhere to standard safety protocols to mitigate risks.

CHAPTER 4: DESIGN AND IMPLEMENTATION OF TRANSMISSION LINE FAULTS DETECTION

4.0. Introduction

This part contains with both experimental results discussions and system analysis design and implementation

4.1. Calculations

Transmission line calculations are essential for understanding how electrical signals propagate along conductors, particularly in high-frequency circuits, power systems, or telecommunications. These calculations are used to determine parameters such as voltage, current, impedance, and power flow along a transmission line. Here's a breakdown of key concepts and methods used in transmission line calculations:

Characteristic Impedance (Z_0):

- A transmission line has an inherent impedance called the characteristic impedance, Z0 which is independent of the length of the line. It is defined as:

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

equation (1)

- where:
  - R = Resistance per unit length (ohms)
  - L= Inductance per unit length (Henries)
  - G = Conductance of the dielectric per unit length (siemens)
  - C = Capacitance per unit length (farads)
  - ω = Angular frequency of the signal (radians/sec)

Propagation Constant (γ):

- The propagation constant, γ determines how signals attenuate and phase-shift along the line. It is defined as:

$$\gamma = \alpha + j\beta = \sqrt{(R + j\omega L)(G + j\omega C)}$$

equation(2)

where:

- α = Attenuation constant (Np/m)
- β = Phase constant (radians/m)

Reflection Coefficient (Γ):

- When there is an impedance mismatch at the end of the transmission line, part of the signal is reflected back. The reflection coefficient is given by:

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

equation (3)

where ZL is the load impedance, and Z0 is the characteristic impedance.

Voltage Standing Wave Ratio (VSWR):

- The VSWR is a measure of how well the transmission line is matched to the load impedance. It is related to the reflection coefficient by:

$$\text{VSWR} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

equation (4)

Impedance Transformation:

- Along a transmission line, the input impedance at a point lll away from the load is transformed based on the distance and wavelength:

$$Z_{\text{in}}(l) = Z_0 \frac{Z_L + jZ_0 \tan(\beta l)}{Z_0 + jZ_L \tan(\beta l)}$$

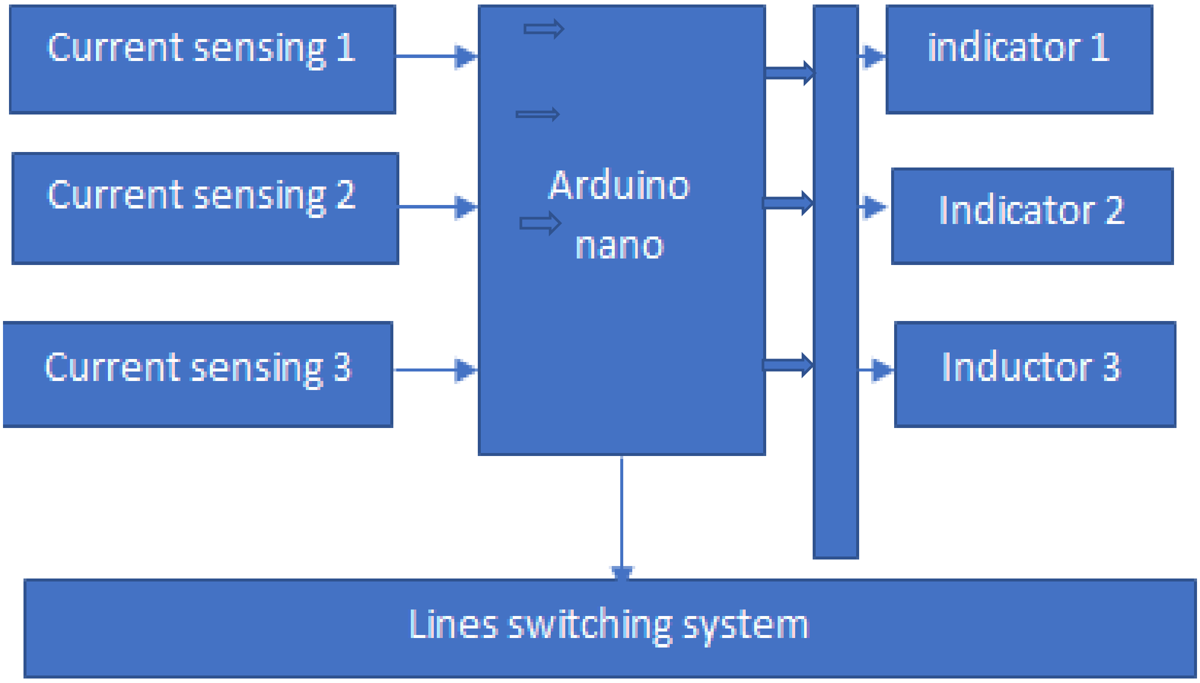
equation (4)

where l is the length of the transmission line from the load.

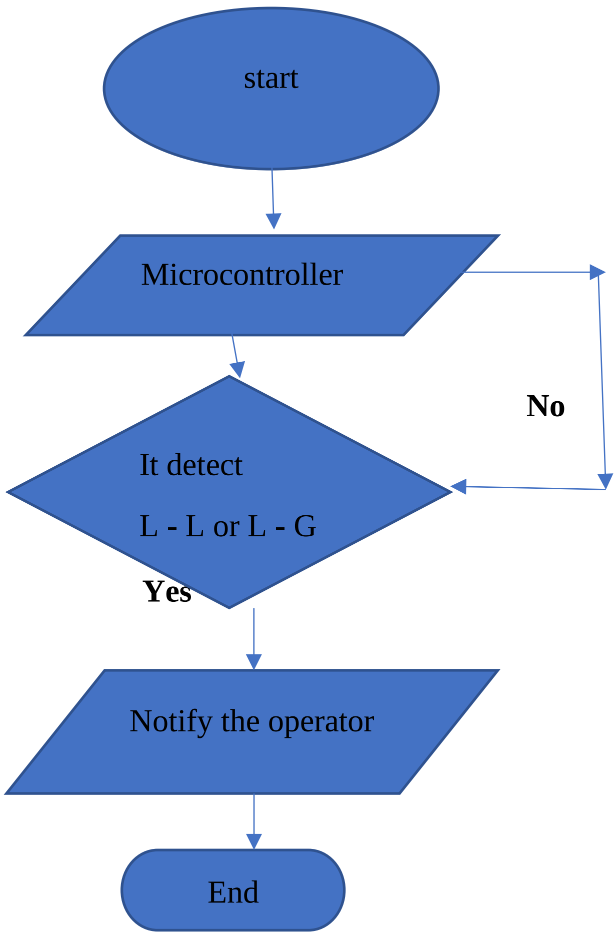
Lossless Transmission Line:

- For high-frequency applications where Rand G are negligible, the transmission line is often assumed to be lossless, simplifying calculations. The characteristic impedance and propagation constant simplify to: $Z_0 = \sqrt{\frac{L}{C}}, \quad \beta = \omega\sqrt{LC}$
  equation (5)

4.2. SYSTEM BLOCK DIAGRAM



4.3. FLOWCHART



If Yes, the lights are OFF.

If No, the lights are still ON.

4.4. Project Circuit Diagram

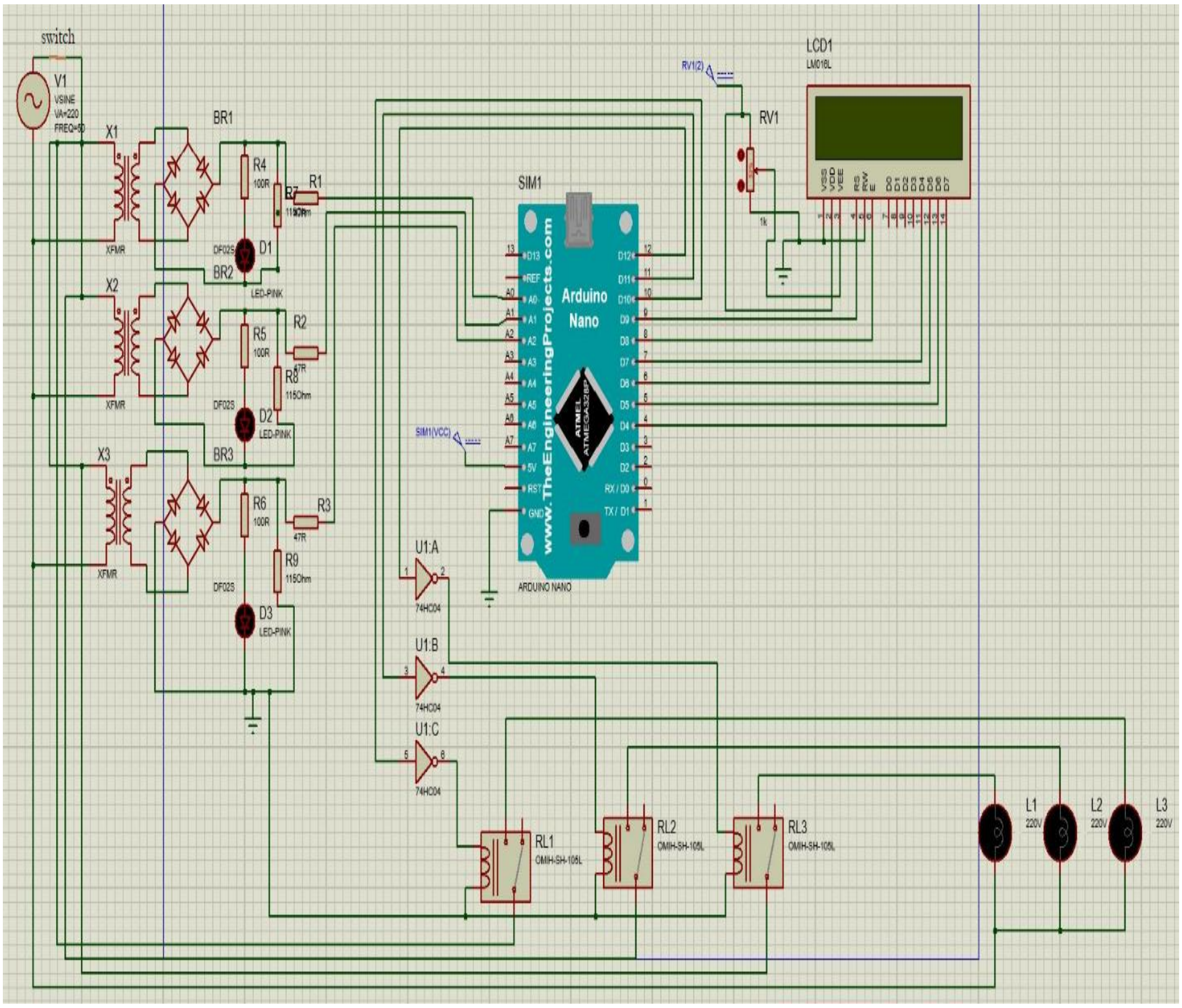


Figure.4. 1.PROJECT CIRCUIT

4.4.1. Working Principle

1. System configuration:

- ✓ **Transformer Placement**: The CTs are installed around the conductors of each phase (A, B, and C) of the transmission line. The PT is connected to measure the phase voltage.
- ✓ **Arduino Connections**: The outputs from the CTs and PTs are fed into the Arduino Nano's analog input pins. The Arduino will convert these analog signals into digital values for processing.

2. **Signal measurement**:

- ✓ **Current Measurement**: The CTs provide a scaled-down version of the line current. The output from the CT is usually an AC signal proportional to the actual current flowing in the line.
- ✓ **Voltage Measurement**: The PT measures the voltage across the line or phases, providing a proportional AC voltage signal.

3. **Analog to digital conversion**:

- ✓ The Arduino Nano has built-in ADC (Analog to Digital Converter) channels that convert the analog signals from the CTs and PT into digital values.
- ✓ These digital values represent the instantaneous current and voltage at the time of measurement.

4. **Data processing**:

- ✓ The Arduino code continuously reads the current and voltage values from the CTs and PT.
- ✓ **Real-time Analysis**: The code calculates the RMS (Root Mean Square) values of the current and voltage for each phase.
- ✓ **Symmetrical Components**: The Arduino can implement algorithms to compute positive, negative, and zero sequence components. This helps identify imbalances in the three-phase system.

5. **Fault detection logic**:

- ✓ **Threshold Settings**: Predefined thresholds for current and voltage are set based on the system's normal operating conditions.
- ✓ **Fault Criteria**: The Arduino checks for the following conditions:
  - o **Overcurrent**: If the measured current in any phase exceeds a set threshold, it may indicate a fault.
  - o **Voltage Imbalance**: Significant deviations in voltage between phases can indicate a fault condition.
  - o **Zero Sequence Current**: A significant zero-sequence current suggests a ground fault.
- ✓ The Arduino can use conditional statements to determine if a fault condition exists.

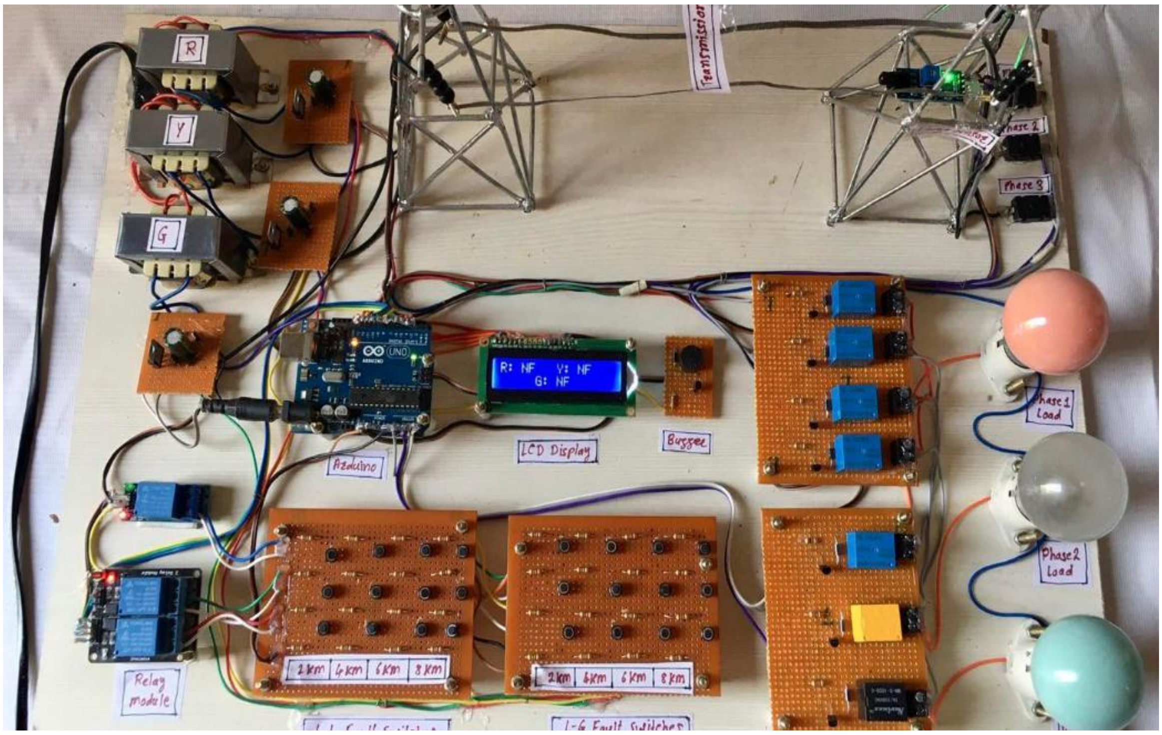
6. **Fault type identification**:

- ✓ Based on the measured values, the Arduino can differentiate between types of faults:
  - o **Single-phase to Ground Fault**: Indicated by high zero-sequence current.
  - o **Phase-to-Phase Fault**: Noted by current imbalances between two phases.
  - o **Open Circuit Fault**: Detected by a drop in current in one phase without a corresponding voltage drop.

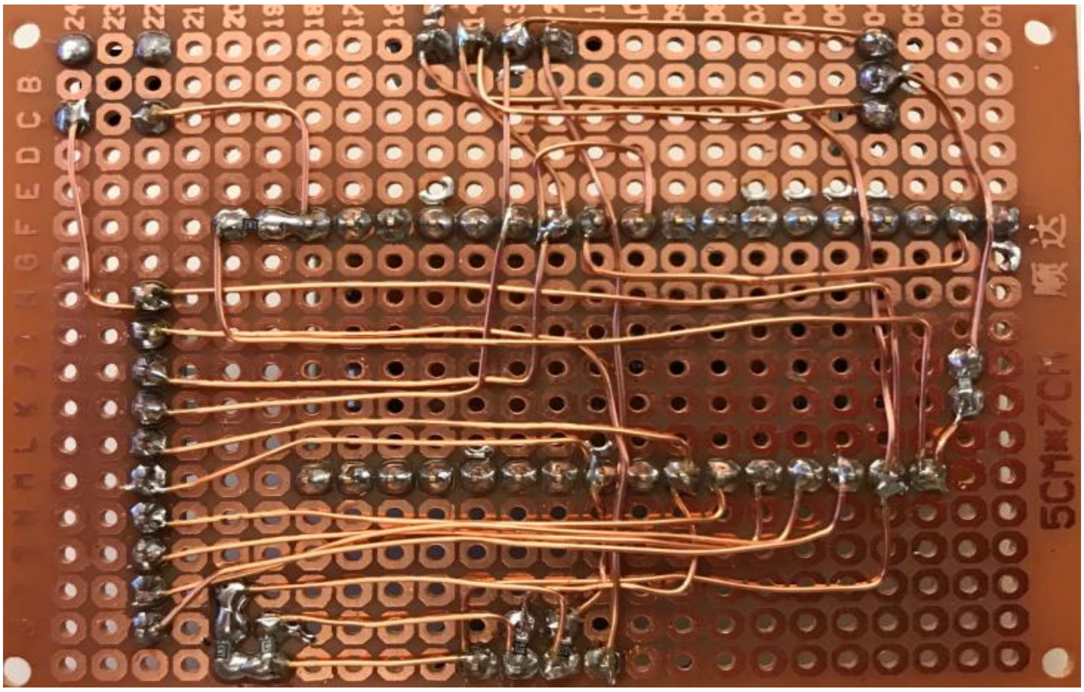
7. **Protection action**:

- ✓ If a fault is detected, the Arduino can trigger an alarm (Lamp indicator) and activate relays or circuit breakers to disconnect the faulty section of the transmission line.
- ✓ Optional: Display the fault type or status on an LCD screen for easy monitoring.

4.5. Implementation of the Project



Project picture



4.6. Specifications

When designing a transmission line faults detector, several specifications must be considered to ensure effective operation and reliability. Here are the key specifications typically included:

- Ability to measure a range of voltages (0-400 kV).
- Capability to measure fault currents, typically in the range of 1 A to several kA.
- Support for standard power frequencies (50/60 Hz) and higher frequencies for transient analysis.

TABLE.4. 1.TABLE OF MATERIALS SPECIFICATION

No	Component	specification
1	Relay	• trigger Voltage (Voltage across coil): 12V DC · • Trigger Current (Nominal current): 100mA · • Maximum AC load current: 7A @ 250/125V AC ·
2	LCD Display	• Operating Voltage: 4.7V to 5.3V. • Operating Current 1mA (without backlight) • Can display (16x2) 32 Alphanumeric Characters.
3	Arduino nano	• DC Current per I/O Pin: 20 mA (recommended) • Flash Memory: 32 KB (0.5 KB used by bootloader) • SRAM: 2 KB • EEPROM: 1 KB • Clock Speed: 16 MH
4	Transformer	• The input voltage the transformer is designed to operate with (e.g., 120V, 240V).

		• The output voltage the transformer provides (e.g., 12V, 24V). • **VA (Volt-Amperes)**: The maximum power the transformer can handle, often denoted in VA or kVA. • **Operating Frequency**: The frequency of the AC supply (e.g., 50Hz, 60Hz).
5	Potentiometer	• The total resistance, usually expressed in ohms (Ω), such as 1kΩ, 10kΩ, 100kΩ, etc. • The acceptable deviation from the nominal resistance value, typically expressed as a percentage (e.g., ±5%, ±10%).
6	PCB	• **Dielectric Constant**: Relevant for high-frequency applications (typically around 4.0 for FR-4). • **Number of Layers**: Options include single-sided, double-sided, or multi-layer (e.g., 4-layer, 6-layer).
7	lamp	**Power Consumption**: The electrical power the lamp uses, measured in watts (W). • **Measured in Kelvin (K)**: Indicates the color of the light (e.g., warm white ~2700K, cool white ~4000K, daylight ~5000K).
8	Lamp socket	• **Body Material**: Common materials include plastic, ceramic, or metal (for heat resistance). • **Contact Material**: Usually brass, nickel-plated for conductivity and corrosion resistance.

9	MDF	• **Operating Voltage**: The maximum voltage the socket can handle (e.g., 120V, 240V • **Fibers**: Made from wood fibers, adhesive, and additives, bonded under heat and pressure. • **Wood Species**: Typically made from a mix of hardwood and softwood fibers. • **Density Range**: Usually between 600 kg/m³ and 800 kg/m³ (37 to 50 lb/ft³), depending on the specific product.

4.7. COST ESTIMATION

TABLE.4. 2.TABLE OF COST ESTIMATION

Component	**Quantity**	**Cost in Rwf**
Arduino	**1**	**15000**
Transformer	**3**	**27000**
Lamps	**3**	**6000**
Socket	**3**	**1500**
LCD	**1**	**12000**
Potentiometer	**2**	**2000**
Wire	**10 m**	**8000**
PCB	**1**	**3000**
Current sensor	**3**	**30000**
Total		**104500**

CHAPTER 5. CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

The development and deployment of transmission line faults detectors represent a significant advancement in the management of electrical grids. By prioritizing safety, efficiency, and reliability, these systems contribute to a more resilient energy infrastructure, ultimately benefiting consumers and utility providers alike. Continuous improvement and adaptation to emerging technologies will be essential for maximizing the potential of these systems in the future.

5.2. RECOMMENDATIONS

Maintain through documentation of all procedures, settings, and compliance with industry regulations to ensure accountability and facilitate audits.

By following these recommendations, organizations can enhance the effectiveness and reliability of their transmission line faults detection systems, ultimately leading to a more resilient power infrastructure

5.3. SUGGESTION FOR FURTHER STUDY

Conduct studies on the social implications of fault detection technologies, including community perceptions, stakeholder engagement, and the impact on service delivery.

By pursuing these areas of study, researchers and practitioners can contribute to the ongoing improvement of transmission line faults detection systems, enhancing their effectiveness and integration into modern power infrastructures

REFERENCES

1. Evgeny Tsykunov, Luiza Labazanova, Akerke Tleugazy, and DzmitryTsetserukou. "Swarmtouch: Tactile interaction of human with impedance-controlled swarm of nano-quadrotors". In: 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE. 2018, pp. 4204–4209.

2. Francisco das Chagas Fernandes Guerra and Wellington Santos Mota. "Current transformer model". In: IEEE Transactions on Power Delivery 22.1 (2006), pp.187–194. In: IEEE Communications magazine 31.4 (1993), pp. 92–100.

3. Kieran M Corcoran. "When Does the Buzzer Sound: The Nonstatutory Labor Exemption in Professional Sports". In: Colum. L. Rev. 94 (1994), p. 1045.

4. Moe Rahnema. "Overview of the GSM system and protocol architecture".

5. Nagarajan R, S Sathishkumar, K Balasubramanian, C Boobalan, S Naveen, and N Sridhar. "Chopper fed speed control of DC motor using PI controller". In: IOSR-Journal of Electrical and Electronics Engineering (IOSR-JEEE) 11.3 (2016), pp. 65–69.

6. Nitin Jain, Aniruddha Dongariya, and Ajay Verma. "Critical evaluation of several kinds of task scheduling systems for partnership amongst data transmission". In: 2017 international conference on information, communication, instrumentation and control (ICICIC). IEEE. 2017, pp.1– 4.

7. Pei Zhang, Fang Xing Li, and Navin Bhatt. "Next-generation monitoring, analysis, and control for the future smart control center". In: IEEE Transactions on Smart Grid 1.2 (2010), pp. 186–192.

8. PJ Patel, DP Thakkar, LN Gupta, VB Patel, V Tripathi, NP Singh, UK Baruah, et al. "A regulated power supply for accelerator driven system". In: Proc. IAEA. 2009, pp. 1–8.

9. Poorani Ramachandran, Vijay Vital, and Gerald Thomas Heydt. "Mechanical state estimation for overhead transmission lines with level spans". In: IEEE Transactions on Power Systems 23.3 (2008), pp. 908–915.

APPENDICES

```
#include <LiquidCrystal.h>

const int ct1Pin = A0;

const int ct2Pin = A1;

const int ct3Pin = A2;

const int ptPin = A3;

float current Threshold = 10.0;

float voltageThreshold = 220.0;

void setup () {

  Serial. Begin (9600);

}

void loop () {

  float current1 = analogRead(ct1Pin);

  float current2 = analogRead(ct2Pin);

  float current3 = analogRead(ct3Pin);

  float voltage = analogRead(ptPin);

  current1 = (current1 * 5.0 / 1023.0);

  current2 = (current2 * 5.0 / 1023.0);

  current3 = (current3 * 5.0 / 1023.0);

  voltage = (voltage * 5.0 / 1023.0);
```

```
  if (current1 > current Threshold || current2 > current Threshold || current3 >
current Threshold) {
    Serial.println("Overcurrent detected!");
  }
  if (voltage < voltageThreshold) {
    Serial.println("Voltage dip detected!");
  }
  Delay (1000);
}
```