Design & Implementation of Three Phase Fault Detection And Protection

A Project report is submitted in partial fulfillment of the requirements for the award of Degree of Bachelor of Science in Electrical and Electronic Engineering.

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DECLARATION

This is to certify that this project and thesis entitled "Design & Implementation of Three Phase Fault Detection and Protection" is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on 12 Jun 2023.

Signature of the candidates

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APPROVAL

The project and thesis entitled "**Design & Implementation of Three Phase Fault Detection and Protection"** Submitted by **MD Rajib Howlader**, ID No: ID #: 201-33-5312, Session: Fall 2023 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering** in January-2024

Signed

For, Amj Ahmad

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Dedicated
To

My Supervisor and My Parents
With
Love and Respects

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ACKNOWLEDGEMENT

First of all, we give thanks to Allah or God. Then we would like to take this opportunity to express our appreciation and gratitude to our project and thesis supervisor **Senior Lecturer Khyrun Nesa Nesha, of Department of EEE** for being dedicated in supporting, motivating and guiding us through this project. This project can't be done without his useful advice and helps. Also thank you very much for giving us opportunity to choose this project.

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ABSTRACT

The project involves creating an automatic tripping mechanism for the three-phase transmission system. In the event of a transient fault, the project's output resets, however in the event of a permanent malfunction, the output obtains the permanent trip state. Several problems can occur in a three-phase power supply system that serves industrial and residential consumers. These failures are the result of some defects, which can be transient or permanent. These flaws could cause significant damage to the electricity system. This can disrupt power delivery and cause a halt in numerous industries connected to the grid. In a three-phase electrical system, these faults are categorized as LG (Line to Ground), LL (Line to Line), and 3L (Three lines). This system may solve such a problem by automatically identifying the failure and disconnecting the system from the power source, preventing large-scale damage to system components. The system automatically distinguishes between a brief disruption and a permanent malfunction, and cuts the supply accordingly for a short or lengthy period of time.

CHAPTER 1
INTRODUCTION

1.1 Introduction

While the electrical lines are being repaired, unplanned negative events for linemen have grown in recent months due to a breakdown in communication between the maintenance team and the electrical substation. Distribution errors are more common and much outweigh transmission side losses in terms of magnitude. According to the survey, 80% of customer service outages were caused by faults with the distribution network. This method addresses the problem and ensures the lineman's safety. To ensure the safety of the power system, power line faults must be discovered and detected. The proposed solution delegated responsibility for managing the ON/OFF status of power lines to Line Man. Linemen or maintenance personnel can turn on and off electricity because the job is so well-organized. As a result, in the event of an electrical malfunction, the power supply can be repaired quickly before the electricity supply to a specific line is turned on. To improve accuracy and reliability, various protection mechanisms are used in conjunction with contact methods. Overvoltage and under voltage faults, line to ground and three phase short circuit faults are all examples of fault overload solid faults.

The EB is responsible for the majority of distribution line fault detection and warning, as well as automatic notifications to the Electricity Board (EB) and transmission line error detection. The lineman will next disconnect the electricity supply from the transmission line. This method works well without the need for human interaction and requires significantly less time and money.

1.2 Problem Statement

We ran into a number of issues while working on this project, including issues with one Arduino, code, accurate data, voltage and current monitoring, and more. Even in the face of exceptional challenges, the fault finding and defense project will not be surpassed. Even if it is successful, the instrument and technique will still need to be updated.

1.3 Objectives

Another advantage of this type of transmission line fault detection is its capacity to track and safeguard a sensed object. Create a low-cost, widely applicable gizmo.

- To decrease fault-related outages and enhance customer service continuity. to examine the detection of three-phase circuit errors.
- To study how protected transmission and distribution line.
- To assist others.
- To keep the system stable.
- Deactivates the entire system through an automated procedure.

1.4 Applications of this project.

- It can be utilized by industries to safeguard their machinery.
- Apply in the substation.
- Application in fault detection of distribution and transmission lines.
- A three-phase induction motor was safeguarded.

1.5 Literature Review

The transmission of power from the generating station to the load centers is the most important aspect of the distribution system's transmission lines. Bangladesh's electricity system generates voltage at 6.6 kV, 11 kV, or 13.6 kV, transfers voltage at 66 kV, 132 kV, 230 kV, or 400 kV, and distributes voltage at 11 kV, 400 v, or 230 v.As a result, power system experts have been prime targets for fault discovery since the distribution and transmission system was built.

1.6 Research Methodology.

The method was adopted after taking into account two aspects of the project. The project module is broken into various sub-sections. Every module is divided into itself. Starting with the voltage sensor, the current sensor, voltage measurement, high voltage failure, low voltage failure, overload defect, short circuit defect, and imbalance fault diagnosis are all performed in sequence. This configuration allows relays and sensors to work with ease. These relays and sensors are used to assess fault diagnosis, and the results are then used to generate three-phase circuit instructions with an Arduino UNO. It is a processor capable of receiving and transmitting analog and digital signals. The purpose of this project is to determine whether the circuit will experience no damage if a relay fails (low voltage, excessive voltage, overload, or unbalance) for whatever cause. Finally, we laid the groundwork for the project.

1.7 Project Outline

Here we show the project outline in bellow:

In Chapter 1, We briefly examine this initiative and its value in our daily lives.

In Chapter 2, We discuss here the literature review of on our proposed system.

In Chapter 3, We will provide a brief summary of all the hardware components that we use in this project.

In Chapter 4, We present our project's outcome, output, and advantage.

In Chapter 5, We present consolation, and some recommendations.

CHAPTER 2

Literature Review

2.1 Introduction

This chapter addressed the literature discussion that was done previously in different country or different university anywhere of world.

2.2 Related Research

Research in the area of three-phase fault detection systems is critical for ensuring the reliable and efficient operation of power systems. Three-phase faults are common in electrical power systems and can lead to severe consequences if not detected and mitigated promptly. Here are some key aspects and related research areas in three-phase fault detection systems:

Traditional Methods: Research may focus on conventional methods like overcurrent protection, distance protection, and differential protection for three-phase fault detection.

Advanced Methods: Explore advanced techniques such as wavelet transform, neural networks, fuzzy logic, and artificial intelligence for more accurate and faster fault detection.

Digital Signal Processing (DSP) Techniques: Investigate the use of DSP techniques to process signals and extract relevant information for fault detection. This includes algorithms for filtering, feature extraction, and pattern recognition.

Transient Analysis: Study the transient behavior of power systems during three-phase faults. Transient-based approaches can provide insights into the characteristics of faults and aid in the development of effective detection algorithms.

Machine Learning and Artificial Intelligence: Explore the application of three-phase fault detection. This may involve the use of supervised and unsupervised learning algorithms to analyze system data and identify fault patterns.

2.3 Compare and Contrast

Comparing and contrasting various three-phase fault detection systems involves evaluating their features, advantages, and limitations. Here's a comparison based on different aspects:

Conventional Methods: Pros: Well-established, reliable, and widely used.

Cons: May have limitations in accurately detecting certain types of faults or adapting to dynamic system conditions.

Advanced Methods (e.g., AI and ML): Pros: Can adapt to dynamic system conditions, provide faster detection, and may offer improved accuracy.

Cons: Require extensive training data, may be computationally intensive, and could pose challenges in interpretability.

Traditional Methods: Pros: Generally provide quick response times.

Cons: Response time may be affected in complex power system configurations.

Advanced Methods: Pros: Can potentially offer faster response times, especially in dynamic and complex power system scenarios.

Cons: Computational complexity may lead to delays in certain cases.

Conventional Methods: Pros: Typically exhibit good sensitivity and selectivity for known fault types.

Cons: May struggle with identifying less common or evolving fault scenarios.

Advanced Methods: Pros: Can be designed to adapt and learn from various fault scenarios, potentially improving sensitivity to different fault types.

Cons: May be prone to false positives or require continuous updates to account for evolving fault patterns.

2.4 Summary

A three-phase fault detection system is an essential component of electrical power systems to identify and mitigate faults promptly, ensuring the reliability and stability of the system. Here's a summary of key aspects:

Purpose: Three-phase fault detection systems are designed to identify and locate faults in three-phase power systems, which could lead to disruptions, equipment damage, or compromise the overall stability of the electrical grid.

Detection Techniques: Conventional methods such as overcurrent, distance, and differential protection are well-established for three-phase fault detection.

Advanced techniques, including artificial intelligence, machine learning, and digital signal processing, offer improved adaptability and accuracy in detecting faults.

Response Time: Traditional methods generally provide quick responses, while advanced methods may offer faster detection, especially in dynamic and complex power system scenarios.

Sensitivity and Selectivity: Conventional methods exhibit good sensitivity and selectivity for known fault types.

Advanced methods can be prone to false positives.

Adaptability: Traditional methods are suited for stable power system configurations but may require manual adjustments when the system changes.

Advanced methods can adapt to changes in the power system configuration and evolving fault characteristics but may need continuous training and updates.

Robustness: Conventional methods are generally robust and proven in various power system conditions. Advanced methods can offer robustness in dynamic and complex power system conditions but may face challenges in situations not well-represented in training data.

the choice of a three-phase fault detection system depends on the specific requirements of the power system, considering factors such as reliability, adaptability, cost, and the level of sophistication needed for fault detection. As power systems evolve and incorporate smart grid technologies, there is an increasing trend towards adopting advanced methods that can harness the benefits of modern data analytics and artificial intelligence for enhanced fault detection and response.

CHAPTER 3
HARDWARE DEVELOPMENT

3.1 Introduction

An effective and reliable Three-Phase Fault Detection System is a crucial component within electrical power systems, playing a pivotal role in maintaining the stability, integrity, and optimal performance of the grid. This system is designed to swiftly identify and locate faults occurring in the three-phase power distribution, ensuring prompt mitigation to prevent potential disruptions, equipment damage, and overall system instability. The primary objective of a Three-Phase Fault Detection System is to monitor the power system continuously, detecting abnormalities such as short circuits or faults that may compromise the integrity of the system. By identifying these faults in their early stages, the detection system enables swift intervention, preventing cascading failures and minimizing downtime.

3.2 System Design and Components

Circuit Diagram

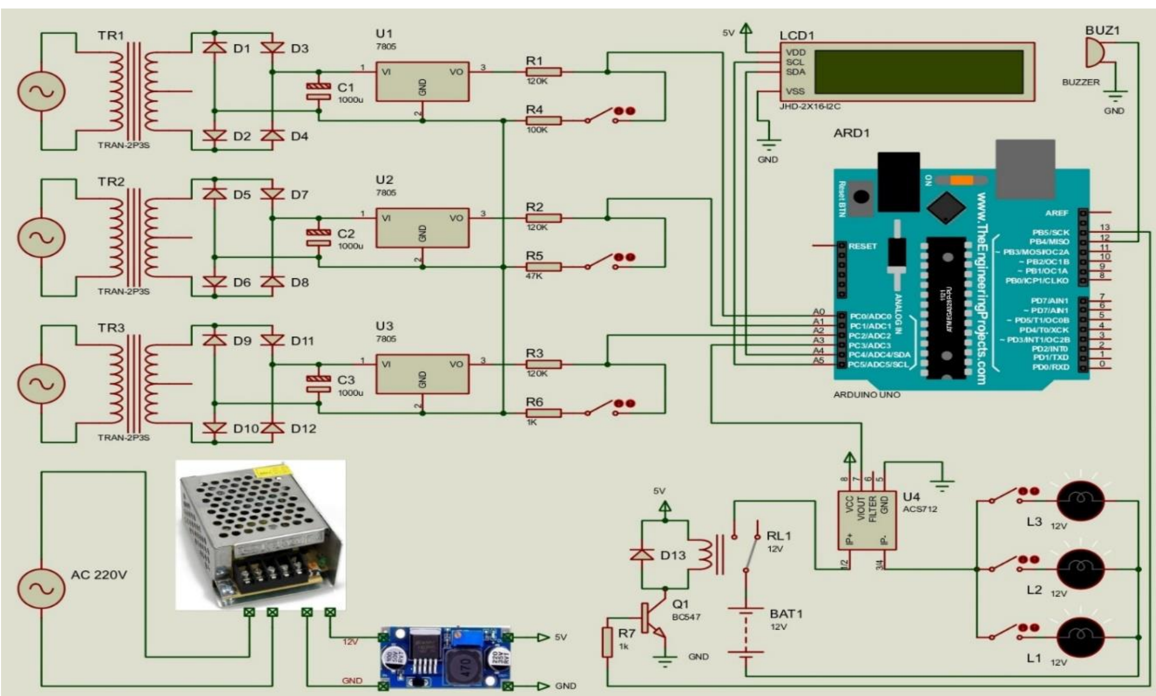

Fig. 3.1 Circuit diagram of this project

Project Flowchart

Here we show the block Diagram of our proposed system in bellow:

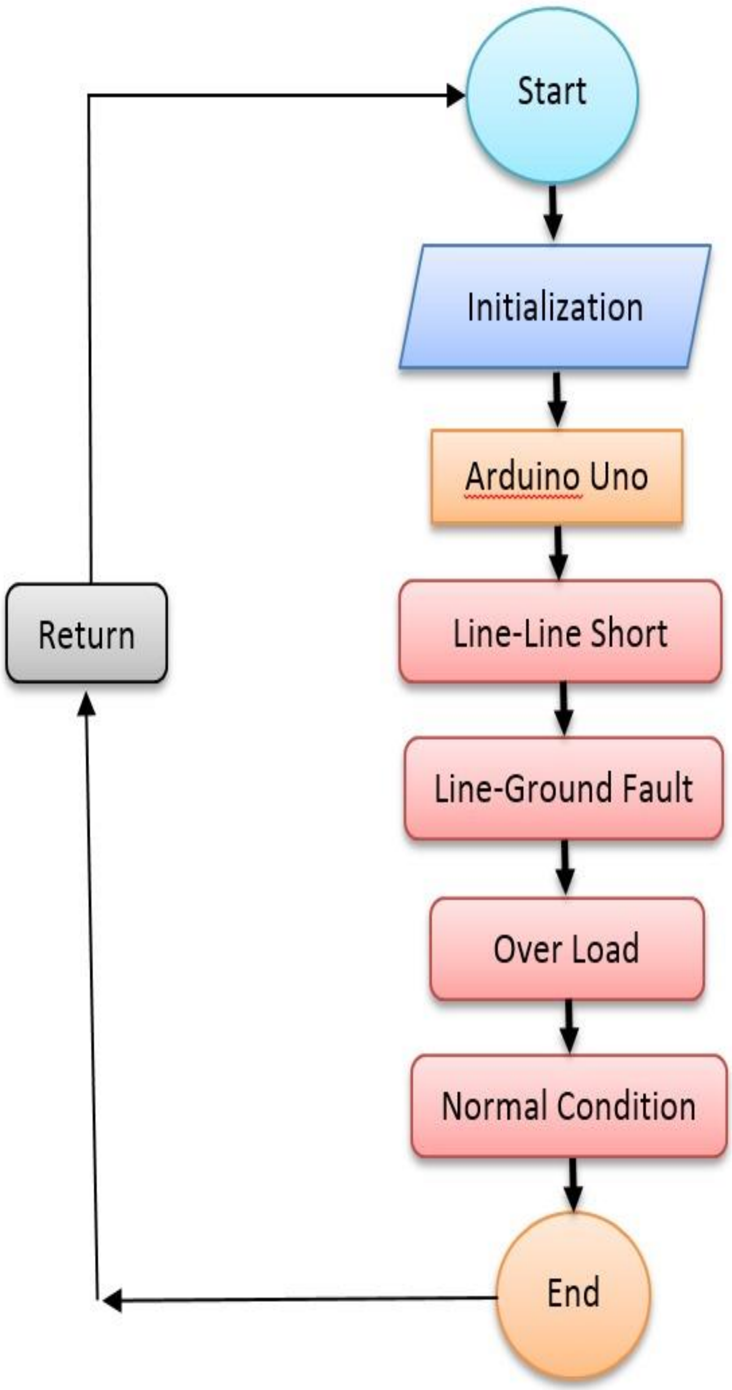

Fig. 3.2 Flow Chart

Here we need to use this listed component to complete this one:

Table II: Components List

S/L	Components Name	Quantity
01	Arduino Uno	1
02	12V SMPS	1
04	Current Sensor ACS712	1
05	Transformer	3
07	Buzzer	1
09	Relay	1
10	Capacitor	3
11	DC Bulb	3
12	Bulb Holder	3
13	Switch	3
14	Diode 5408	4
16	2 Pin	1
17	Sun Board	Needed
18	Wire	Needed

3.2.1 Arduino Uno

Arduino uno is a microcontroller of our system that will control this total operation of our system. It has an ICSP header, a reset button, a 5volt coax connector, 14 digital and 6 analog input/output pins, a USB port, and a crystal oscillator operating at 16 MHz. It also has an ICSP header, a reset button, and a 5-volt power socket. It may be programmed using a Type B USB port and the Arduino IDE (Integrated Development Environment).

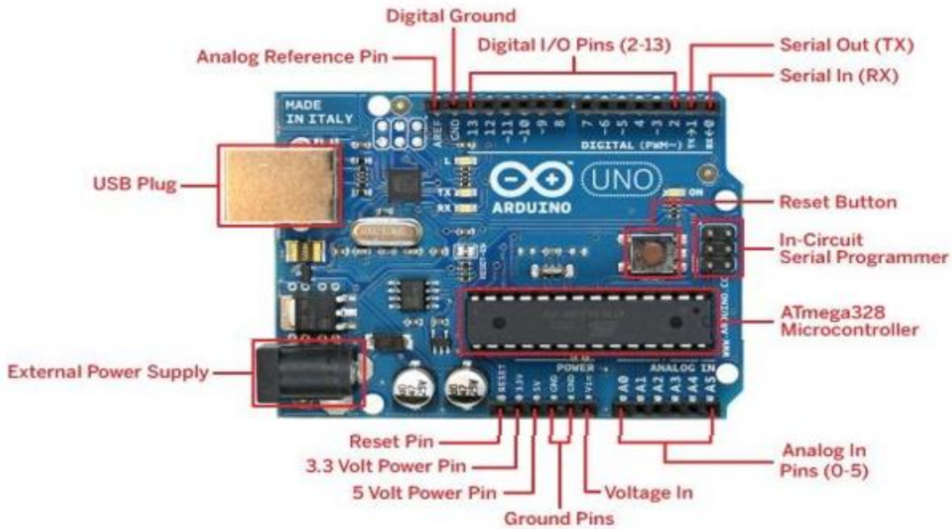

Fig. 3.3 Arduino UNO

3.2.2 12V SMPS

The usage of switched mode power supplies eliminates the problems of linear power supplies, such as poorer efficiency, the requirement for large-value capacitors to prevent ripples, and bulky, expensive transformers.

Figure 3.4: SMPS (12V, 5A)

Knowing that the transistor used in LPS is used to control the voltage drop while the transistor in SMPS is used as a controlled switch makes it simple to understand how SMPS operates.

3.2.3 Current Sensor ACS712

A device that senses and produces a signal proportionate to the current flowing through a cable is called a current sensor. When a current flows via a wire or in a circuit when the conductor carrying the current is encircled by a magnetic field, voltage drops happen. These two phenomena are used in the construction of modern sensors. An analog voltage, current, or even digital output could be the signal that is generated. An ammeter's computed current can be processed in a data gathering device for additional evaluation or control, or it can be represented by the output signal.

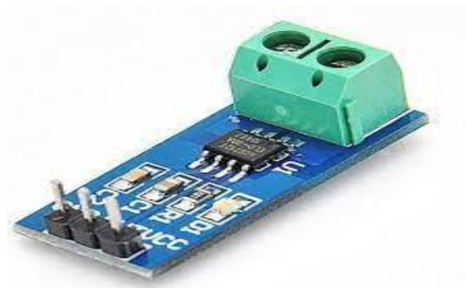

Fig. 3.5 ACS712 Current Sensor

3.2.4 Transformer

An electric transformer is a passive device used to convert electrical power between one or more circuits. One winding, often known as a spiral, is powered by an alternating electrical source. An alternating current running continuously through the coil creates a flux around it. If a component of this alternating stream comes into contact with the second winding, it will link. The AC voltage is altered to either increase or decrease. The transformer has a tapped core secondary winding and primary windings rated for 220 volts. We can use this project. Transformer from 220 to 9 volts.

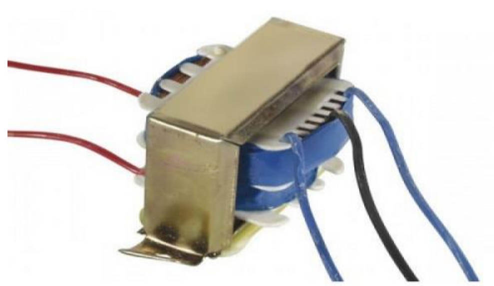

Fig. 3.6 Transformer

Features of o-12V 600mA Transformer:

I. Iron core type.

II. Current gain is 300mA.

Application of o-12V 300mA Transformer:

I. Works as High Current Gain.

II. This transformer basically transfers 220V ac to 0-9V.

III. It has two windings

3.2.5 Buzzer

Electric bells, buzzers, and alarms are available in a variety of features and pricing. This project's buzzer generates enough alarm noise to be used in a fire alarm system. This buzzer operates at 5 to 12 volts. We only had a 12-volt supply on the board, so a louder buzzer would have been perfect, but their working voltages are high.

Figure 3.7: Typical buzzer arrangement.

3.2.6 Relay

A switch powered by electricity. Although many relays use electromagnets to mechanically actuate switches, solid-state relays use a different functioning principle. Relays are used when a single signal is needed to control several circuits or when complete electrical isolation between the controlled and uncontrolled circuits is required. The first relays functioned as amplifiers on long-distance telegraph lines, replicating and retransmitting signals from one circuit to another. Early computers and telephone exchanges typically used relays to execute logical tasks.

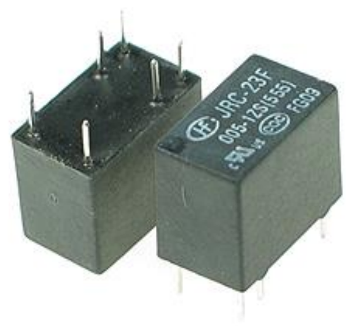

Figure 3.8: Electromagnetic relays

3.2.7 Capacitor

A capacitor, or passive electrical component, is an equipment that stores anomalous energy in the form of a waveform. Two conducting boards and a condenser are separated by a dielectric. Plates with plaques, on the other hand, correspond to plates with defined surface dimensions. The dielectric constant is divided by the compounds. We may use a capacitor in this project to eliminate pulses. Converting pulse setting DC to pure DC was used.

Fig. 3.9 Capacitor

Symbol:

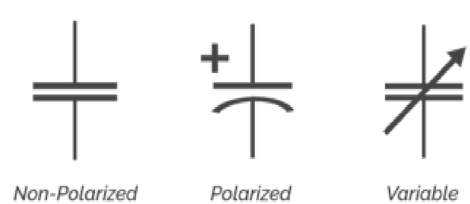

Fig. 3.10 Symbol of Capacitor

3.2.8 Diode

The diode is an electrical element with two terminals that conducts current preferentially in one direction (asymmetric conductivity); in one direction, it has a high resistance (preferably infinite), while in the other, it has a low resistance (ideally zero). A diode vacuum tube, also known as a thermionic diode, consists of a two-electrode vacuum tube, a heated cathode, and an electron fluid plate that connects the cathode and plate.

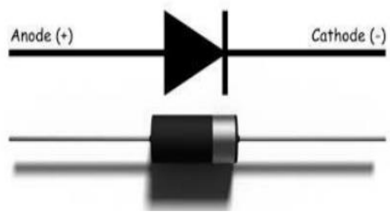

Fig. 3.11 Diode

3.2.9 Male Female jumper wire

Wires are utilized to link all devices. It also connected to all electrical circuits. A wire is a conductor that links two electric circuits or devices.

Fig. 3.12 connecting wire

3.3 Design Specification

Designing a Three-Phase Fault Detection System involves specifying the requirements, features, and functionalities that the system should possess to effectively detect and respond to faults in a power distribution network. Below is a generalized set of design specifications for a Three-Phase Fault Detection System.

- It can measure the line to line fault

- It can measure the line to GND fault
- It can define the over load value in ampere

3.4 System Analysis

System analysis of a Three-Phase Fault Detection System involves a comprehensive examination of its components, functionalities, and performance characteristics. Here is an overview of the key aspects to be considered in the system analysis, here I use different types of resistor with different value and for every single short circuit for each line with another line it will send different types of values to arduino and Arduino will read the value and calculate the ration and showing a fault that occurred in our system. I show here seven fault like, R-Y short Circuit, R-B Short Circuit, Y-B Short circuit, Y-R Short Circuit, B-Y Short circuit, B-R short Circuit, Red line broken, Yellow Line Brocken, Blue Line Brocken and Over Load detection.

3.5 Summery

In this chapter, we will look at all of the components of three-phase fault detection. We will complete the project by properly using all of these components while sustaining the fault. In this chapter, we go over in detail the description and operation of each hardware component.

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Project Picture

The transmission line is the main component of the power system. The highest number of power transmission lines. The modern world has dramatically increased power demands, and the transmission line's principal duty is to transport electricity from the source area to the distribution system. The increased expectation of fewer power outages has resulted in a confrontation between production restrictions. As a result, this project is pretty useful for daily life.

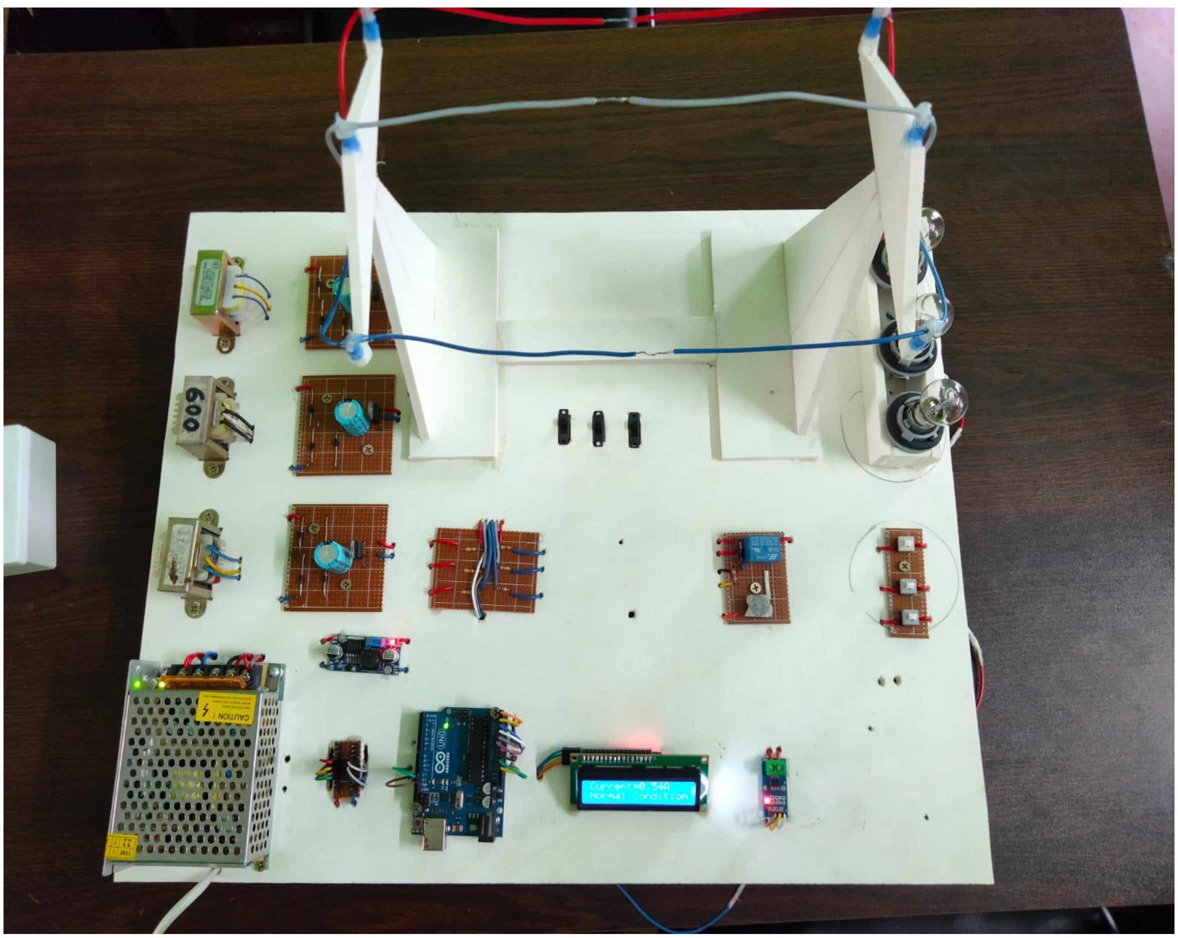

Fig. 4.1 Final project Overview

4.2 Outcome Analysis and Discussions

The goal of this technique is to protect the transmission line fault. Overload, overcurrent flow, short circuit faults, and other flaws can occur in transmission lines. The amount of current flow that we make through the current sensor in this project is conveyed to an Arduino processor by transforming the analog signal into a digital one. The Arduino CPU then sends a high digital signal to the relay, completing the procedure. Next, the signal connects the relay to itself. The Arduino will then send the digital signal to the Display driver, allowing us to monitor the current flowing over the transmission line. If there was an excess of current flowing across the transmission line, Arduino output a low signal to the relay. When an Arduino sends a signal to the display, we can see which problems are associated together, such as overload, overcurrent imbalance, and so on. The relay and Arduino connection are not in use. The relay is activated, turning off the circuit. The transmission cable then has no voltage or current. As a result, we locate the load for each load in the distribution line. This entire task was accomplished via the Arduino app.

Fig. 4.2: Normal condition with no load on

Fig. 4.3: Normal Condition with One Load On

Fig. 4.4: Normal Condition with Two Load On

Fig.4.5: Over load

Fig. 4.6: R line Broken

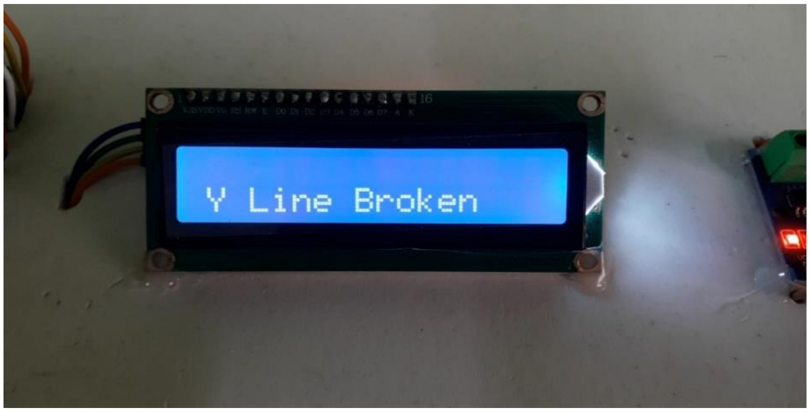

Fig. 4.7: Y Line Broken

Fig. 4.8: B Line Broken

Fig. 4.9: R-B Short Circuit

Fig. 4.10: B-Y Short Circuit

Fig. 4.11: R-Y-B Short Circuit

CHAPTER 5

CONCLUSION

5.1 Resources and Cost Management

Table III: Components Cost Analysis

Serial No	Name	Quantity	Unit Price	Price(BTD)
1	Arduino UNO	1	750	850
2	Current Sensor (ACS712)	1	100	900
3	Relay Module 5V,250V,10A	1	150	150
4	Display Unite 16*2	1	250	250
5	Buzzer 5V	1	30	30
6	Diode 4007	1	5	5
7	Capacitor (1000 µF, 470 µF)	4	5	20
8	Resistor (10k, 2k, 471Ω)	3	5	10
9	DC Bulb	3	30	90
10	Board Holder	3	50	150
11	Transformer (230v-9V,300mA)	1	80	80
12	Switch	3	15	45
13	SMPS (12V,5A)	1	350	350
14	Male Female jumper Wire	Required	50	50
15	Board	1	220	220
16	Others	Required	500	500
Total Cost				3700

5.2 Lesson Learned

An Arduino-based Three-Phase Fault Detection System can provide valuable lessons and insights into the challenges and opportunities associated with implementing fault detection in power systems. Here are some key lessons learned from such a system:

Integration Challenges: Integrating the Arduino platform with power system components and sensors can be challenging. Ensure compatibility between Arduino and power system components. Consider the need for signal conditioning and the appropriate interfaces to capture real-world electrical signals accurately.

Sensor Selection and Calibration: The choice of sensors, such as current transformers and voltage sensors, significantly affects the system's accuracy. Thoroughly calibrate and validate sensors to ensure accurate measurements. Consider the impact of sensor limitations on fault detection precision.

Real-Time Processing Limitations: Arduino platforms may have limitations in processing real-time data, especially in complex power systems. Consider the computational demands of fault detection algorithms. Evaluate the real-time processing capabilities of the Arduino platform and explore optimization techniques.

Limited Processing Power for Advanced Algorithms: Implementing advanced fault detection algorithms (e.g., machine learning) may be constrained by the limited processing power of Arduino. Strike a balance between algorithm complexity and computational resources. Explore edge computing solutions or offload computation to external devices if needed.

Communication Challenges: Establishing communication interfaces for data exchange with external devices or control systems can be complex. Choose communication protocols carefully and ensure compatibility with other components. Consider the reliability and speed requirements of data exchange in fault detection scenarios.

Power System Modeling Complexity: Modeling a three-phase power system accurately for fault detection can be intricate. Invest time in understanding power system modeling principles. Use simulation tools to validate the accuracy of the system's response to simulated faults.

System Robustness and Reliability: Arduino-based systems may face challenges in achieving the robustness required for fault detection in diverse and dynamic power system environments. Conduct thorough testing under various conditions to assess the system's reliability. Implement redundancy or fail-safe mechanisms where possible.

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