# Transformer Monitoring and Protection System

**A Project and Thesis 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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**January 2023**

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This is to certify that this project and thesis entitled “**Transformer Monitoring and Protection System**” is done by the following student 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.

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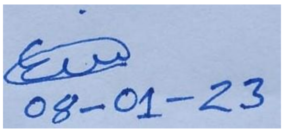


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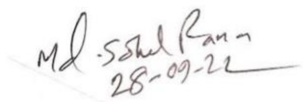


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# DEDICATION

# “Our Parents”

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# ABSTRACT

One of the most crucial pieces of equipment in the network of the power system is the transformer of the substation. Data collecting, condition monitoring, and automated regulating are significant difficulties in power systems due to the numerous transformers and varied components spread across a huge region. Designing a Transformer monitoring system is the goal of the project. The current monitoring system involves labor, which takes time, and it is challenging to foresee when defects may arise. In this project, we created a system that uses sensors to continually track the properties of the transformer, including the load current, voltage, and oil temperature. On the LCD, these values are continually presented. The relay tripping system is operational and an alarm system is triggered to warn if any irregularities in the transformer occur. The transformer will benefit from this system's smooth operation and early problem detection.

# CHAPTER-1
# INTRODUCTION

## 1.1 Introduction

The majority of power generation systems must be able to transport electricity from the power plant to the user's location as efficiently and dependably as feasible since most power generation systems are located far from the user's location. Delivering power through high-voltage power lines is the best approach, according to past studies. As a consequence, the transformer will increase the voltage of the power flowing from the power plant to a higher level before transferring it, such as 132 kV, 161 kV, or 400 kV. The electricity will be lowered to the rated low voltage once it reaches its destination for distribution to customers [1]. This shows that the transfer of power involves transformers significantly. When own generators are not accessible, transformers are essential step-up and step-down devices in power transmission lines in facility infrastructure companies, industries, hospitals, and municipalities. These transformer users commonly struggle with temperature regulation of the transformers, real-time operational data receipt, remote transformer monitoring, data collecting and analysis, and reducing the costs of manual maintenance. A transformer is a device that has static components. Its main function is to move electric energy from one circuit to another without any direct electrical connections. The power supply system commonly includes circuit breakers, fuses, and electromechanical relays to secure the power system, however it turns out that these devices are unstable. The bulk of currently performed commercial activities use manual monitoring of the performance of transformers, notably manual and routine on-site inspection of transformer stations for maintenance. Transformers can be used to either increase or decrease voltage, which is referred to as stepping up or down the voltage, respectively. In a transformer, a metal core is encircled by two wire coils, each with hundreds or thousands of turns. Both the incoming and departing electricity are handled by separate coils. An alternating magnetic field is created in the core by alternating current in the incoming coil, and this creates alternating current in the exiting coil.

**Figure1.1: A Distribution transformer**

Despite the fact that an electrical power transformer is a static object, internal stresses brought on by unusual system conditions must be taken into account. The following transformer faults commonly affect transformers:

1. Over current due to overloads and external short circuits,
2. Terminal faults,
3. Winding faults,
4. Incipient faults.

The transformer winding and its connection terminals experience mechanical and thermal strains as a result of all the aforementioned transformer problems. Thermal strains cause overheating, which ultimately harms the transformer's insulation system. Winding issues are brought on by deteriorating insulation. Overheating of the transformer can occur occasionally when the cooling system for the transformer fails. Consequently, the need for transformer protection measures is great.

Either earth faults or inter-turn faults are the most common winding defects in transformers. In transformers, phase to phase winding failures are uncommon. Electrical transformer phase failures can be caused by tap changer equipment malfunctions and bushing flash over. Whatever the issue, the transformer needs to be immediately separated in order to prevent a serious breakdown in the electrical power supply [2].

Internal flaws known as "incipient defects" provide no immediate threat. However, if these flaws are ignored and left unattended, they might develop into more serious ones.

Inter-lamination short circuits caused by insulation failure between core laminations, drops in oil level from oil leaks, and obstruction of oil flow pathways are the principal defects in this category. Overheating results from each of these flaws.

## 1.2Problem Statement

A through fault may cause the windings to migrate closer together and may result in a flash-over, which may result in a catastrophic failure of the transformer if the insulation system of the transformer is badly compromised.

Transformer failures can occur due to various causes.

- Dielectric Breakdown
- Winding distortion caused by short circuit withstand
- Excessive winding and core hot spot
- Electrical disturbances such as a through fault
- Deterioration of insulation's dielectric integrity
- Lightning
- Overload
- Inadequate Maintenance such as loose connections, insulating fluid leaks, cooling system failure
- Failure of accessories such as OLTCs
- Bushings

## 1.3 Objective

I. To monitor transformer real time input and output voltage, current and temperature.
II. To give protection for transformer during fault
III. To make an automatic temperature control system for transformer.

## 1.4 Application of this project

In order for the remaining section of the electrical power system to continue operating as intended without suffering more severe damage from fault current, power system protection seeks to isolate a malfunctioning component from the remainder of the active system.

Since their trip signal originates from the protection relay, circuit breakers essentially separate the malfunctioning system from the rest of the functional system and they instantly open in the event of a failure. No power system protection can prevent fault current from passing through the system, according to the fundamental protection precept; only by promptly removing the short circuit channel from the system can it halt the flow of fault current. For this quick disengagement, the protective relays need to satisfy the following functional requirements. the development of an embedded system that monitors the input voltage, load current, and oil temperature of the transformer and trips on its own when specified thresholds are exceeded. To obtain the optimal performance, implement the proposed real-time based monitoring and protection strategy.

## 1.5 Project Outline

- **Chapter 1**: Provides a brief overview of the transformer and report structure.
- **Chapter 2**: focuses on various transformer failure prevention schemes, different apparatus details.
- **Chapter-3:** Discussion on hardware development like circuit diagram, flow chart, block diagram etc.
- **Chapter-4:** Concludes the result of this project.
- **Chapter-5:** Conclusion and discussion of the project.

# CHAPTER 2
# LITERATURE REVIEWS

## 2.1 Introduction

The components of a transformer protection strategy are determined by the application size and relevance of the transformer in issue. In order to lessen the impacts of thermal stress and fault-induced electrodynamics forces, it is advised to make sure that the protection system utilized keeps the disconnection time in the case of a fault developing within the transformer to a minimum possible. Small distribution transformers can be sufficiently protected from a technical and budgetary standpoint by fuses or over current relays. This results in time-delayed protection to satisfy the need for downstream coordination. However, due to system operation/stability, maintenance cost, and outage length considerations, time-delayed fault clearing on bigger power transformers used in distribution, transmission, and generating applications is unsatisfactory.

## 2.2 Theoretical background

### 2.2.1 Transformer Health Protection Scheme

Proper safety precautions are required when there are transformer issues. In contrast to electromechanical relay types, which required multiple different relays, each with their own connections to perform a different function, the development of static relays established this as the standard for modern relays, which are now typically designed to provide all necessary protection elements in a single package [3]. Thus, the CT requirements are more onerous. Look at figure 2.1. Rapid response times, mobility, precision, reduced stress on the CTs, and greater programmability are all benefits of static relays. The basic protection configuration is depicted in the schematic figure 2.1 below, together with the relay, circuit breaker, voltage transformer, and current transformer (CT), which are required to protect the equipment used in power systems.

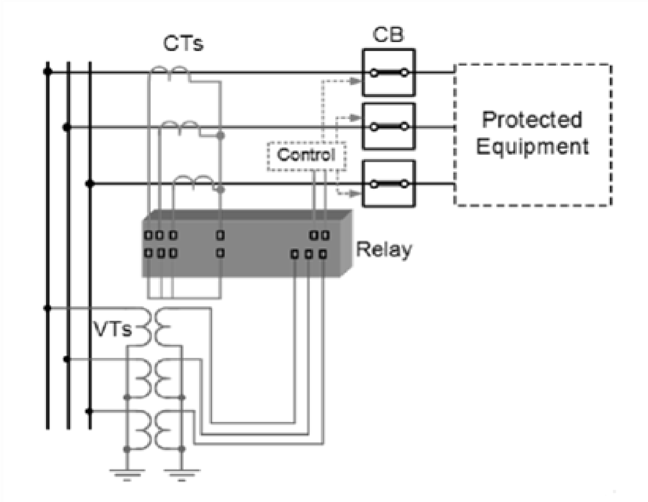


**Figure 2.1: Basic protection setup**

## 2.1.1 Current Transformer

The primary purpose of a current transformer is to reduce the fault current in the primary circuit to levels that the protection relays can regulate [8]. It provides a link between the primary circuit and the control circuit. High voltages from the primary circuit shouldn't be able to enter the control circuit. The relays are protected from excessive currents by the Protection CT's low saturation values. Although accuracy is often more critical than the ability to manage enormous magnetizing currents while turning on highly inductive loads while still being able to distinguish between inrush currents and fault currents, protection CTs must typically operate above the system's full load currents. The secondary current carries load when the primary current to which they are connected does not.

## 2.2.3 Potential transformer

An instrument transformer called a potential transformer (P.T.) is used in power systems for monitoring and protection reasons. In a power system, a potential transformer is primarily used to assess high alternating voltage.

Potential transformers are step-down transformers, meaning their primary winding has a large number of turns while the secondary has a smaller number. For the purpose of measuring high alternating voltage, the illustration depicts a conventional potential transformer. A P.T. is a well-designed step down transformer, as is seen from the illustration.

## 2.3 Component

### 2.3.1 Arduino Uno

The Arduino electronics platform's hardware and software are user-friendly. Examples of inputs that Arduino boards can read and translate into outputs include a finger on a button or a light weight on a detector. There are several types of Arduino, including:
Arduino UNO, Arduino MICRO, Arduino LEONARDO, Arduino NANO, Arduino ESPLORA, Arduino MINI. In this project we used Arduino UNO.

The ATmega328 microcontroller could work with the Arduino Uno board. A 16 MHz ceramic resonator, an ICSP header, a USB port, six analog inputs, a power connector, and a reset button are all included on the device. Additionally, it features 14 digital input/output pins, 12 of which are often utilized as PWM outputs. This covers any desirable validation that a microcontroller would need. To get started, all they require is a USB connection to connect to a computer. The Arduino Uno Board, which is unique from all other boards, will not use the FTDI USB-to-serial driver that is given to them.

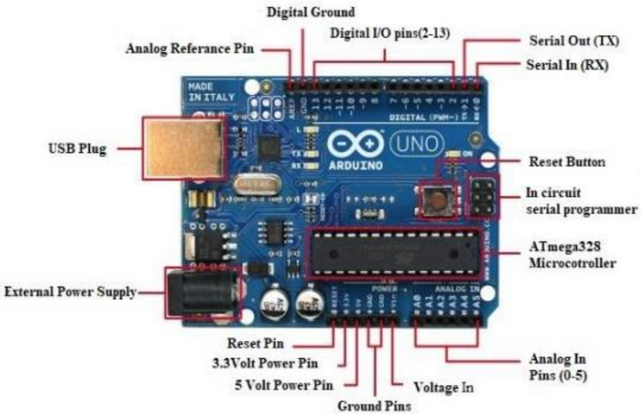


**Figure 2.2: Arduino Uno**

### 2.3.2 Current Measuring Unit

We have employed a method to monitor current flowing via a transmission line in this project. We connected a transmission line in series with a ceramic resistor with a very low resistance and high power. Because of its low resistance, it won't allow extremely high voltage to cross it, consuming very little power. Using an Arduino, we measure the voltage drop across it while current flows through it. The voltage drop is then divided by the resistance. Through the transmission line, it provides the most recent value. However, a CT is really employed to measure current.

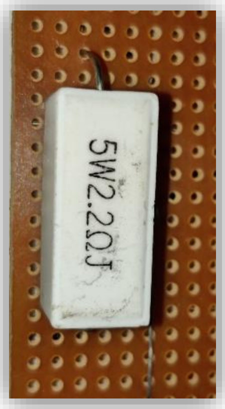


**Figure2.3: A very low resistance to measure current (CT)**

## 2.3.3 Relay

It is a LOW Level 12V single-channel relay control panel, and the channel requires 15-20mA to run the circuit. Can be used to monitor various high-current appliances and machines. On the AC 250V 10A, high-current relays are placed. It has a typical characteristic that a microcontroller may use directly [4].


**Figure2.4: Relay module**

## 2.3.4 LCD Display

Everywhere we walk, LED screens cross our minds. Time displays are used in computers, calculators, TVs, smartphones, and digital watches, among other devices. An LCD is a form of electronic display that produces a visible image using fluid crystal. The 162 LCD display is a widely used part in DIY projects and circuits, and it is a pretty simple gadget. The sixteen to two is converted into sixteen characters per line in two of these lines. A grid of 5 pixels is used to show each character on this LCD.

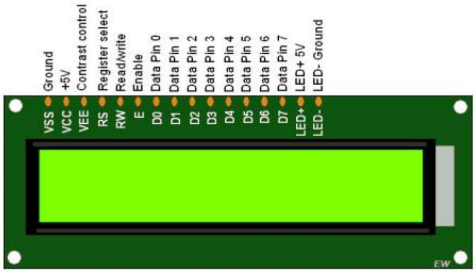


**Figure2.5: 16*2 LCD panel**

## 2.3.5 Resistor

A resistor is a passive electrical part with two ends that adds electrical resistance to circuits. Electronic circuits use resistors for a number of functions, such as transmission line termination, signal level adjustment, voltage division, biasing active components, and reducing current flow. As a motor control component or a test charge for generators, which can lose the bulk of their power as heat, high energy resistors can be utilized.

**Figure2.6: Resistor**

## 2.3.6 Transformer

A transformer functions using a simple idea. According to the electromagnetic induction hypothesis, an electromotive force will move through a loop as a result of the fluctuating magnetic flux. Such a fluctuating magnetic field may be easily produced with a coil and alternating EMF system. A conductor carrying electricity generates a magnetic field all around it using a coil. The magnetic field of the coil will alter over time as well. in the secondary winding, with the assistance of a ferromagnetic core. This fluctuating magnetic field will result in an EMF in the secondary coils due to electromagnetic induction. Every turn, the EMF in the main and secondary coils will be the same. The primary coil's EMF varies with each turn depending on the supplied input voltage. This only suggests that by doing fewer spins in the secondary than in the primary, the voltage may be reduced. The revere case's voltage can be increased.

Three of these single-phase transformers are utilized in three-phase transformers, but with a slightly altered coil configuration. The secondary and primary coils are situated close to one another. Two more of these windings are used in a three-phase transformer [5].

**Figure2.7:Transformer**

## 2.4.8 Diode

A vast variety of electrical devices employ diodes. In essence, a diode serves as an electrical one-way valve. The diode is made from a semiconductor, such silicon. Even if the silicon used is not pure, free electrons cannot exist in pure silicon. One section receives an n-type impurity, while the other receives a p-type impurity. As a result, the n-side of the diode has free electrons and the p-side has open electron sites. Because there are numerous electrons on the n-side, they naturally go to the hole that is available on the p-side, making the p-side border negatively charged and the n-side boundary somewhat positively charged. In other words, it might potentially hinder electron flow. We can connect the positive terminal to the p-side of the diode if the power source produces enough voltage to overcome the barrier potential. The electrons will be ejected from the system by the negative terminal. Electrons that have passed the potential barrier can go to nearby holes in the p-region even if they are low on energy and quickly populate the holes there thanks to the attraction of the positive terminal. The forward biasing of a diode is what causes this. For the most part, a diode serves as a one-way valve for the flow of electricity [6].

## 2.4.9 Capacitor

A capacitor is a device that stores the strange energy waveforms that passive electrical components emit. A dielectric substance separates the condenser from the two conducting boards. Where the dielectric constant splits the compounds, the plates whose extents precisely match the surface and totally disproportionally match the plates whose plaques. The capacitor may be used in this project to eliminate pulses. Pure DC was created by converting pulse-setting DC.

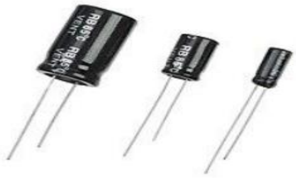

**Figure 2.8: Capacitor**

## 2.5 Summary

This chapter has covered the many transformer failure theories. Additionally, we spoke about every component we used for this project. By appropriately utilizing each of these components and preserving the flaw, we will complete the job.

# CHAPTER 3

# HARDWARE DEVELOPMENT

## 3.1 Introduction

We will introduce our hardware and circuit design in this chapter. The system's brain is a microcontroller that we utilized, the Arduino Uno. Additionally, the project's operating philosophy will be discussed.

## 3.2 Block Diagram

This is the system's block diagram. In the midst of our block diagram, we used a Arduino Uno. This module will regulate the entire system.

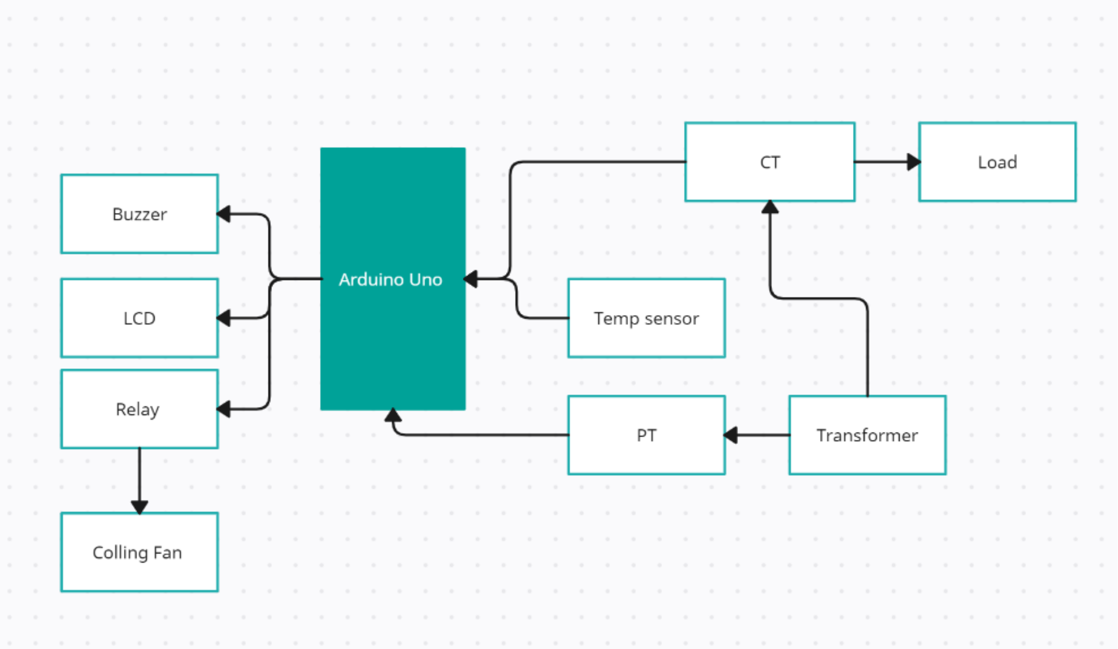


**Figure 3.1: Block diagram of proposed system**

The Arduino board serves as the plan's brain. Below is a description of each block's circuit. Three transducers are used in this type: a temperature transducer, a current transducer, and a voltage transducer. Analog transducers are used in these devices. An output signal or voltage is continuously produced by analog sensors, and it is generally proportional to the amount being measured. Using this technique, the transformer may be isolated from the source and defects caused by under voltage, overcurrent, and excessive winding temperature can be found.

## 3.3 Flow Chart Diagram of the Proposed Project

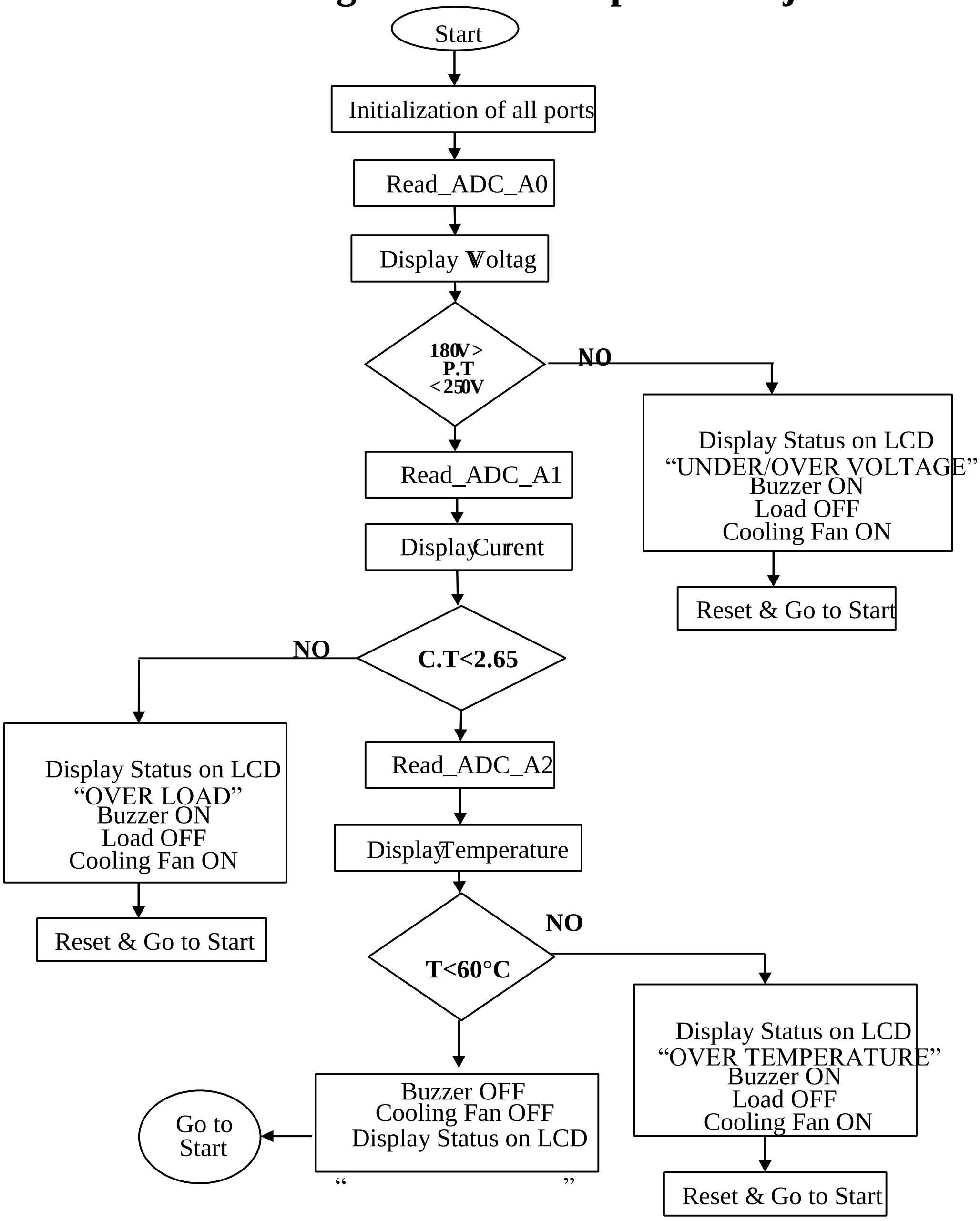


**Figure 3.2: Flow chart of this project**

## 3.2 Hardware Connection picture

An electrical device called a transformer may adjust voltage without changing frequency. Distribution transformers typically reduce voltage from 11 kV to 440 v. However, a transformer may malfunction, undergo insulation failure, or entirely fail due to faults and high load increases, which might result in a blackout. A safety system that continually monitors the transformer's operating parameters based on real-time data and displays those values on the LCD has been designed for this project.

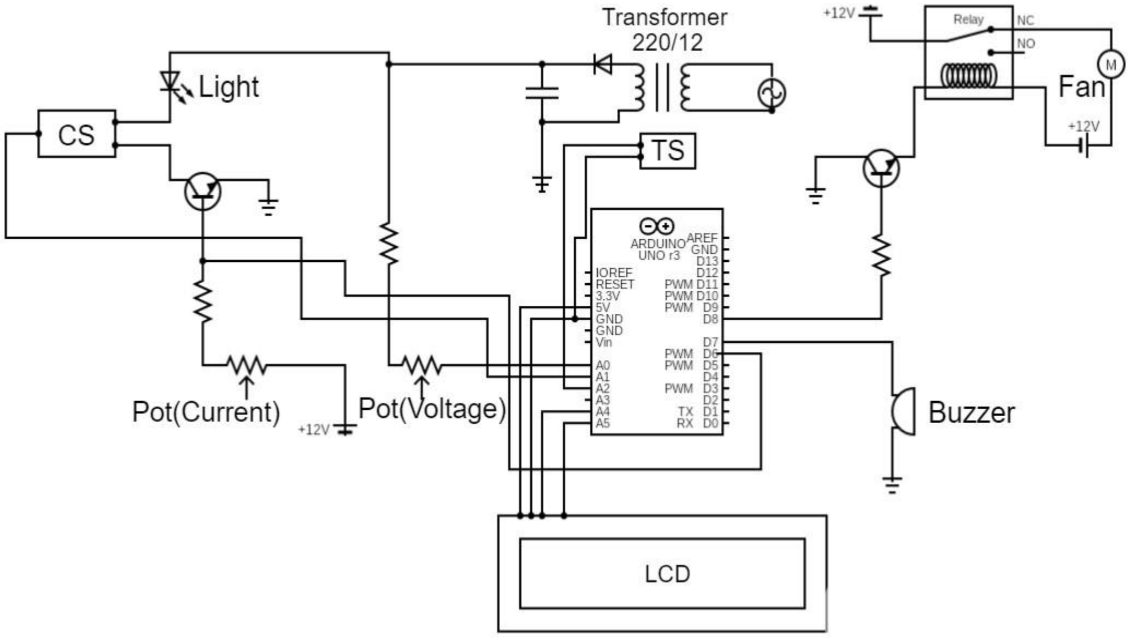


**Figure 3.3: Circuit diagram of this project**

We can see the transformer's continuous parametric data on the LCD monitor. In this project, the line currents are measured by a current sensor while the line voltage is stepped down using a P.T. for measuring reasons. The terminals of the transformer are connected in series and parallel, respectively, by C.T. and P.T. The temperature of the transformer oil is measured using temperature sensors. Relays control the tripping process. The microcontroller's analog to digital converter measures voltage, current, and temperature. The analog to digital converter converts analog voltage, current, and temperature quantities into equivalent digital values. Values are then compared to the controller's preset values in line with the code; If any parameter exceeds its limit, a relay would trigger the transformer. The proper driver circuit would activate a fan if the temperature rose over the predetermined point. On the LCD, the values for voltage, temperature, and current are shown.

## 3.6 Software Development

The Arduino software is used to implement the program. The implementation of software requires the programming of Arduino boards and sensor interfaces. The "C" programming language is used in the programming portion. As soon as the hardware circuit obtains power, it is initialized. The Arduino is connected to an LCD display that shows parameter values like voltage, current, and temperature.

## 3.6 Summary

The equipment utilized during this project's three phase transmission line fault is described in the next chapter. All of the equipment used in this plan is completely functioning and designed to function faultlessly. We attempt to describe the specifics of the hardware characterization employed in this chapter's work.

# CHAPTER 4
# RESULT

## 4.1 Introduction

Transformer monitoring is very important as it is a very expensive and sensitive equipment of a power system. In this project we made a system to protect transformer and monitor its parameter .depending upon transformer voltage current temperature the load can be controlled using this system .So a tabular form is given bellow which shows when the load will be active or inactive.

**Table II: Different Conditions**

| DETECTORS | STEPS | LCD | Load |
|---|---|---|---|
| VOLTAGE DETECTOR ( P.T ) | 180>V <250 | **NORMAL CONDITION** (With R.M.S. values) | ACTIVE |
| | V > 250 volt | OVER VOLTAGE | INACTIVE |
| | V < =180 volt | UNDER VOLTAGE | INACTIVE |
| CURRENT DETECTOR ( C.T ) | I < = 2.5 AMP | **NORMAL CURRENT** (With R.M.S. values) | ACTIVE |
| | I > 2.65 AMP | OVER LOAD | INACTIVE |
| TEMPERATURE DETEECTOR | 60 > T >30 | High TEMPERATURE | ACTIVE |
| | T>60 | Critical condition | INACTIVE |

## 4.2 Project Overview:

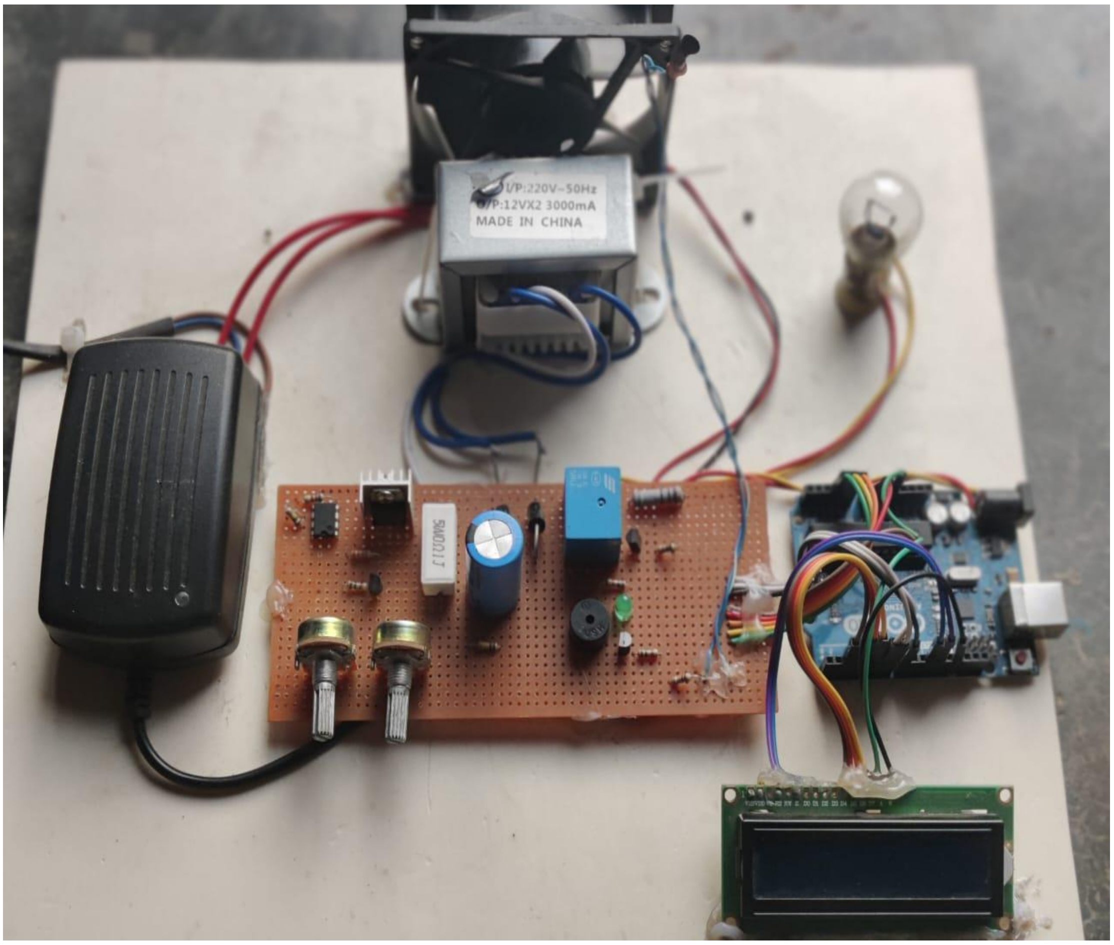


**Figure 4.1 : Overall setup of this project**

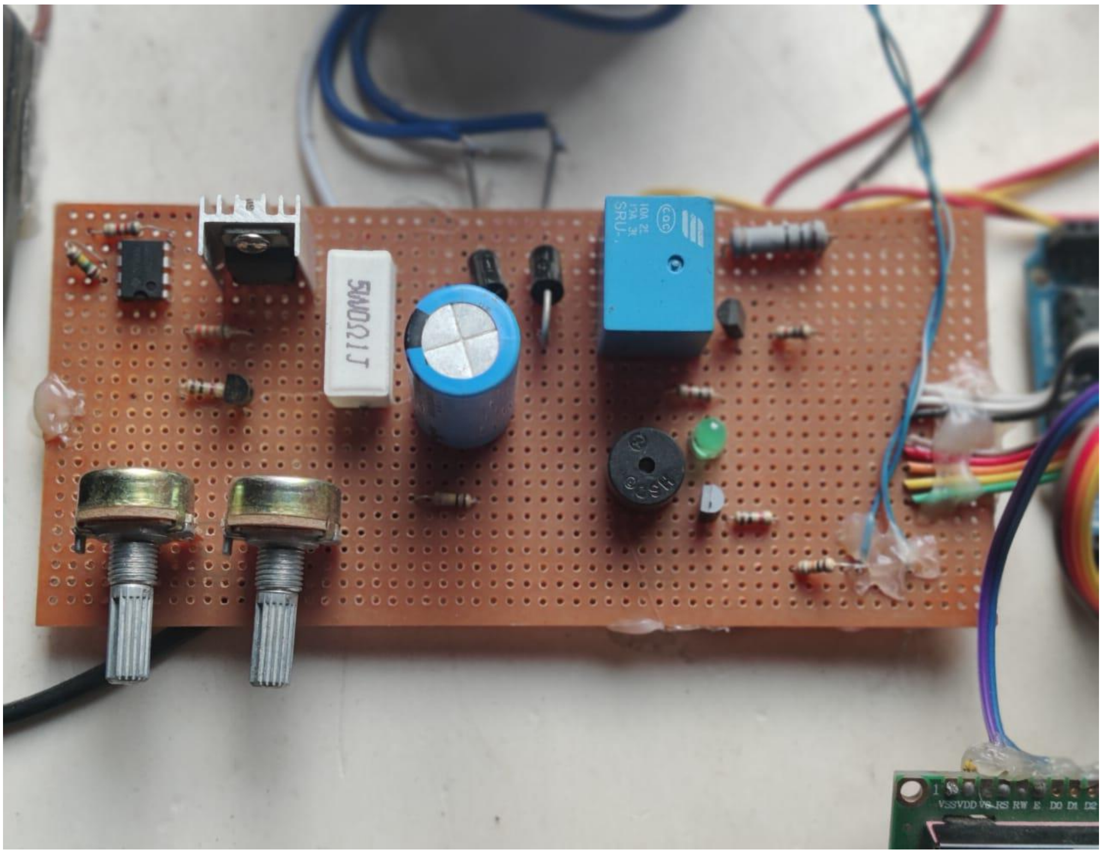

**Figure 4.2 : Control circuit (CT ,PT, Relay, Buzzer and Pot etc.)**


**Figure 4.3: Giving warning for high current**


**Figure 4.4: Over current and load get's cutoff**


**Figure 4.5: Over voltage (V>250) so load gets cutoff**


**Figure 4.6: Over temperate (T>60) load gets cutoff and colling fan is turned on**

## 4.3 Result

This project is designed to monitor and protect the transformer from different faults. Monitoring the voltage , current and temperature of transformer and by processing the data in Arduino we can give the transformer over voltage ,under voltage ,over current and over temperature protection .If the Arduino detect there is a problem in transformer it immediately send a signal to the relay to cut the transformer from the system.

# CHAPTER 5

# CONCLUSION AND DISCUSSION

## 5.1 Discussion

Monitoring the state of a transformer enables prompt intervention to halt a breakdown before it has disastrous consequences. The findings of this study reduce the difficulty of preventing transformer failure and prevent the need to replace the transformer.

## 5.2 Limitation of project

When we attempted to use this transformer protection system to offer protection against over voltage, under voltage, over load, and excessive temperature, we made a number of errors. We correctly perform a lot of procedures in our proposal, however there are currently certain limitations. The following is expanded with certain restrictions:

- As part of our safety system, we can only use this application to control and keep an eye on DC voltage and DC loads. Our equipment isn't nearly ready for commercial use.
- We use this Arduino Board to monitor and manage the entire system, but if we wanted to manage or operate it directly from the system, we would need to use a PLC or microcontroller to assure good operation for a long period.

## 5.3 Future scope

- The form of the research also permits early planning of severe power outages, which shortens the overall time for load reduction.
- Use this safety precaution to protect the power producing system as well.

## 5.4 Conclusion

Since transformers are the most important components of the power system, monitoring systems are necessary. Inconsistencies in its characteristics, such as load current, ambient temperature, under voltage, and overvoltage, must be watched out for. In order to offer safety and assure long life, a low-cost project that can be put on transformers was developed. Despite this, our technology is able to react rapidly to prevent the transformer from catastrophically collapsing. The findings of this study reduce the difficulty of preventing transformer failure and prevent the need to replace the transformer.

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