

DESIGN AND MODELING OF AN IOT BASED TRANSFORMER HEALTH MONITORING SYSTEM

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.

Submitted by

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DECLARATION

We declare that the project **Design and Modeling of an IOT Based Transformer Health Monitoring System** is our original work, completed in the laboratories of the Department of Electrical and Electronic Engineering at Daffodil International University as part of the requirements for the Bachelor of Science degree in Electrical and Electronic Engineering. This work has not been submitted for any other degree or qualification at this or any other institution. We have identified all risks associated with this research, obtained necessary ethical and safety approvals, and acknowledged our responsibilities and the rights of the participants involved.

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APPROVAL

The project entitled **Design and Modeling of an IOT Based Transformer Health Monitoring System** submitted by Md. Shoriful Islam Shuvo (201-33-1111), Partho Protim Paul (201-33-1056) has been done under my supervision and accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering** in **January, 2025**.

Signed


06/01/2025

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Dedicated
To
Our
Parents

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LIST OF ABBREVIATIONS

LED	Light Emitting Diode
LCD	Liquid Crystal Display
ESP-8266	Espressif Systems on a Chip microcontroller
CAN	Controller Area Network
ICC	Inter- Integrated Network

LIST OF SYMBOLS

Symbol	Name of the symbol
V/A	Voltage/ Amperes
I	Current
I_p & I_s	Primary current and secondary current
$^{\circ}\text{C}$	temperature
Ω	ohms
η	Efficiency
P_v	Primary voltage
V_s	Secondary voltage

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ABSTRACT

The paper focuses on **Design and Modeling of an IOT-based Transformer Health Monitoring System** designed to improve transformer reliability and lifespan by enabling real-time monitoring and predictive maintenance. Transformers, essential to power systems, are prone to failures that can cause costly repairs and service disruptions. Traditional manual or basic automated monitoring methods often fail to provide timely insights.

This system integrates sensors to measure parameters like temperature, humidity, load current, oil level, and voltage, with data transmitted to a cloud-based platform. Using IOT technology, data analytics, and machine learning, it detects abnormalities and predicts faults, allowing operators to take preventive actions. Alerts and reports are accessible via web or mobile apps, enabling quick responses.

The system reduces maintenance costs, extends transformer life, and enhances grid stability, making it vital for advancing smart grid infrastructure and energy management efficiency.

CHAPTER 1

INTRODUCTION

1 Background

Design and Modeling of an IOT based Transformer Health Monitoring System enhances the reliability of power transformers by providing real-time monitoring and predictive maintenance. Transformers are essential for power distribution, and their failure can cause significant disruptions and expenses. Traditional monitoring methods often fail to detect early warning signs of issues.

This system uses IOT technology to continuously track key parameters such as temperature, oil levels, voltage, and load current. Data is sent to a central cloud platform for analysis, enabling trend detection and fault prediction. Real-time alerts help operators address potential problems proactively, reducing downtime and maintenance costs.

1.2 Problem Statement

Transformers frequently endure heavy loads without consistent monitoring of critical parameters such as KVA demand, operating temperature, oil level, and moisture content, risking sudden breakdowns and revenue losses. Manual checks by technicians during peak hours contribute to inefficiencies. To enhance transformer operation, a modern power system necessitates accurate fault detection and real-time data monitoring. A microcontroller-based system offers real-time monitoring, quick fault detection, cost efficiency, and flexibility, underscoring the need for an IOT-based transformer monitoring system to ensure reliable power system performance

1.3 Objectives of the Study

The objectives of this project are:

- To study and design also construct about IOT Transformer Health Monitoring.
- To measure transformer health, like inside temperature, inside gas, oil limit and test the performance of the transformer health monitoring through IOT

1.4 Scope of the Study

This IOT-based transformer monitoring system optimizes transformer operation and reduces manual labor. It prevents catastrophic failures by continuously monitoring transformers, aiming to avoid sudden breakdowns. As a fully human-machine interface device, it operates without human intervention, providing real-time, accurate information on critical transformer conditions through sensors.

1.5 Research Questions

The text discusses the design and implementation of an IOT-based transformer health monitoring system, focusing on key monitoring parameters such as temperature, oil level, and vibrations. It evaluates suitable IOT technologies like Lora and Wi-Fi while addressing challenges in sensor integration under diverse environmental conditions. The importance of accurate sensors, real-time data acquisition, and effective communication protocols for secure data transmission is emphasized.

1.6 Methodology Overview

The IOT-Based Transformer Health Monitoring System is developed using a systematic approach that encompasses system design, hardware selection, and IOT module programming.

- The design phase focuses on key transformer health indicators, including temperature, oil level, humidity, load current, and voltage.
- Selected sensors comprise temperature sensors (DHT11), an ultrasonic oil level sensor, humidity sensors, and current and voltage sensors (ACS-712, ZMPT101B).
- The ESP-8266 microcontroller is chosen for its Wi-Fi capabilities to enable data collection and transmission.

Finally, the microcontroller is programmed to read sensor data and connect to a Wi-Fi network for cloud integration.

1.7 Implementation Schedule

Important activities and milestones, such as the phases of design, testing, and deployment, will be outlined in the implementation timeline. In order to guarantee that each step is finished on time, it will also assign resources and establish deadlines.

Phase/Task	Month					
	1-2	3-4	5-6	7-8	9-10	11-12
Project planning	✓					
Literature review		✓		✓		
Material Collection			✓	✓		
Frame Design					✓	
Testing					✓	
Final Documentation						✓

1.8 Structure of the Report

The IOT Based Transformer Health Monitoring System project involves two main phases: mechanical design and control system development. The mechanical design focuses on creating a durable structure through chassis design, material selection, and component integration, utilizing advanced modeling to ensure performance and usability. The control system phase employs a micro-controller with custom software for autonomous navigation and fire detection, allowing remote operation via laptops or phones. Feedback mechanisms will be integrated for real-time monitoring and adjustments, enhancing performance and safety.

CHAPTER 2

LITERATURE REVIEW

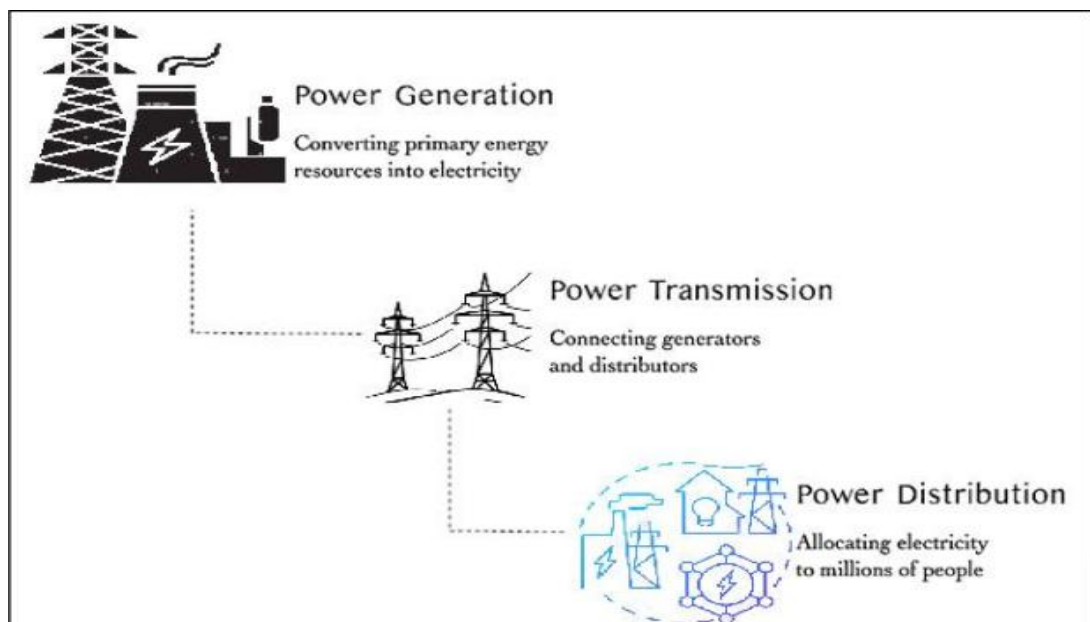
2.1 Introduction

This section primarily focuses on reviewing previous research in the field of monitoring parameters for distribution transformers, as well as providing a theoretical overview. The review explores various methods, technologies, and systems developed to enhance the reliability and efficiency of transformer monitoring. By examining existing approaches and identifying key advancements, this section lays the groundwork for understanding the current challenges and potential improvements in transformer monitoring techniques. [1]

2.2 IOT in Power Systems

The electric power industry (EPI) comprises three core areas:

- **Power Generation:** Converts primary energy sources (fossil fuels, renewables) into electricity.
- **Power Transmission:** Connects power generation facilities to distribution networks.
- **Power Distribution:** Delivers electricity to end-users, including homes, businesses, and industries.



2.2.1 Application of IOT in Power Generation:

The Internet of Things (IOT) is revolutionizing the power generation industry by improving data transfer between power plants and the grid, which enhances operational efficiency and reliability. IOT technologies, such as sensors and cameras, facilitate real-time monitoring of plant performance, enabling anomaly detection and predictive maintenance to reduce downtime and repair costs. Furthermore, IOT optimizes plant operations, leading to greater energy efficiency and lower costs, while also bolstering grid security by identifying potential threats. As IOT technology advances, its role in enhancing efficiency, security, and reliability in power generation is anticipated to increase

2.2.2 Application of IOT in Power Transmission:

The integration of Internet of Things (IOT) technology in power transmission is transforming the sector by facilitating real-time remote monitoring and control of power systems, which enhances operational efficiency, reliability, and safety while lowering maintenance costs. IOT applications monitor electricity flow, temperature, and pressure, helping to reduce power losses and quickly identify faults. This real-time data monitoring enables early detection of fluctuations, decreasing the risk of outages and safety hazards such as fires or explosions. Overall, IOT considerably improves the efficiency and reliability of power transmission systems, resulting in reduced operational and maintenance expenses. [2]

2.2.3 Application of IOT in Power Distribution

The application of Internet of Things (IOT) technology in power transmission is transforming the sector by enabling real-time monitoring and control of power systems, which enhances operational efficiency and reliability while reducing maintenance costs. IOT manages electricity flow, temperature, and pressure within the grid, minimizing power losses and facilitating prompt fault detection. By utilizing sensors and devices, IOT improves data accuracy and allows for proactive measures to prevent outages and safety hazards, such as fires and explosions. Overall, IOT significantly enhances the safety, efficiency, and cost-effectiveness of power transmission systems. [3]

2.3 Sensors for Transformer Monitoring

Transformers are essential components in electrical power systems, and their proper monitoring is crucial for ensuring reliable operation and preventing failures. Here are the main types of sensors used for transformer monitoring:

➤ **Temperature Sensors:**

RTDs (Resistance Temperature Detectors): These measure the temperature of transformer windings and oil, which helps in preventing overheating.

Thermocouples: Another type of temperature sensor used to detect temperature variations.

➤ **Thermal Cameras:** These are used for more extensive temperature monitoring, detecting hot spots in the transformer.

➤ **Oil Level and Temperature Sensors:**

Oil Level Sensors: These measure the oil level inside the transformer to ensure that cooling is adequate.

Oil Temperature Sensors: These measure the temperature of the insulating oil, which helps in understanding the transformer's operating condition and preventing overheating.

➤ **Gas Detection Sensors (DGA - Dissolved Gas Analysis):**

DGA Sensors: These sensors detect the presence of gases such as hydrogen, methane, and carbon monoxide in the oil, which indicate internal faults like arcing or overheating.

➤ **Load Current Sensors:**

Current Transformers (CTs): These sensors measure the current flowing through the transformer's primary and secondary windings, helping to assess the load and detect overloading conditions.

➤ **Voltage Sensors:**

Voltage Transformers (VTs): These sensors measure the voltage levels on both sides of the transformer, allowing for monitoring of any significant voltage fluctuations or imbalances.

➤ **Partial Discharge Sensors:**

These sensors detect partial discharge (PD) activity within the transformer, which is an early indication of insulation degradation or potential failure. [5]

2.4 IOT Architecture and Platforms

- **Traditional Systems:** Earlier transformer monitoring systems were primarily mechanical and required manual inspections, leading to delays in identifying faults.
- **IOT Approaches:** Current designs integrate sensors (temperature, vibration, gas, etc.) with IOT technologies, enabling real-time data collection and remote monitoring. For instance, a common architecture involves using microcontrollers (e.g., Arduino or Raspberry Pi) that collect data from sensors and send it to cloud platforms for analysis
- **Comparative Analysis:** Some literature emphasizes the integration of multiple sensor types for a holistic view of transformer health, while others prioritize specific sensors based on application needs.

2.4.1 Challenges and Limitations

- **Data Security and Privacy:** Concerns about data breaches and unauthorized access to sensitive operational data are common.
- **Network Reliability:** The dependency on reliable internet connections can be a significant drawback in remote areas.
- **Cost of Implementation:** Various studies highlight that while the operational efficiency improves, the initial setup costs can be prohibitive. [19]

2.4.2 Application Case Studies

- **Success Stories:** Several articles document successful implementations in diverse geographical regions, showcasing improved monitoring efficiency and reduced downtime.
- **Comparative Outcomes:** Some evaluations offer direct comparisons of traditional versus IOT-enabled monitoring, highlighting reduced maintenance costs and increased transformer life. [20]

2.5 Challenges and Trends in Transformer Monitoring

- **Data Overload and Interpretation:** Large volumes of sensor data make processing and analysis complex. Lack of standardization in data formats hinders integration.
- **Cost Constraints:** High initial setup costs and ongoing maintenance deter adoption.
- **Environmental and Operational Challenges:** Extreme conditions degrade sensor performance. Real-time fault diagnosis is complicated by load fluctuations and external events.
- **Cybersecurity Threats:** IOT-enabled systems are vulnerable to cyberattacks, requiring robust security.
- **Sensor Reliability and Maintenance:** Continuous operation in harsh environments leads to reliability issues and high maintenance demands.
- **IOT and Smart Sensors:** Real-time, wireless communication and self-diagnostic smart sensors revolutionize monitoring.
- **Cloud-Based Monitoring:** Centralized data storage and analysis support predictive maintenance and system management.
- **Miniaturized Sensors:** Compact, robust, and energy-efficient sensors facilitate easier integration.
- **Renewable Energy Integration:** Systems adapt to manage irregular loads and bidirectional power flows.
- **Environmental Sustainability:** Solutions track environmental impacts, ensuring compliance with green regulations. [20]

2.5 Summary

The Transformer Health Monitoring System enhances transformer maintenance and reliability through real-time monitoring and data analysis. It collects key parameters—temperature, humidity, voltage, current, and gas levels—using various sensors. Data is wirelessly transmitted to a central platform via IT, enabling continuous observation and predictive maintenance to prevent failures and minimize downtime. Advanced algorithms detect anomalies and send alerts for timely intervention. [22]

CHAPTER 3 PROJECT DESIGN AND MATERIALS AND METHODS

3.1 System Overview

The Transformer Health Monitoring System uses IT technology to improve the reliability and efficiency of electrical transformers, essential for power distribution. It provides real-time monitoring via sensors that track critical parameters like temperature, voltage, and humidity, with data centralized for remote access and analysis. By applying advanced analytics and machine learning, the system detects anomalies and predicts potential failures, allowing for proactive maintenance that minimizes unexpected breakdowns and optimizes maintenance planning, ultimately extending the operational lifespan of transformers.

3.2 Hardware Components

Table: I Components List

S/L	Components Name	Quantity
01	Transformer 24v	1
02	Arduino Uno	1
03	12V SMPS	1
04	LCD 20x4	1
05	Relay	1
06	Node MCU	1
07	ACS 712 current Sensor	1
08	Zmpt101b Voltage sensor	1
09	Sun Board	Needed
10	Wire	Needed
11	Jumper Wire	Needed
12	Vero Board	2
13	Two Pin	1
14	LED	2

15	DHT11 Temperature And Humidity sensor	1
16	Ultrasonic Sensor	1
17	Lamp	3

3.2.1 Transformer

A 24V AC transformer is an electrical device that steps down higher AC voltages (like 120V or 240V) to a usable 24V. Its main components include a ferromagnetic core that enhances the magnetic field, a primary winding connected to the high voltage source that generates a magnetic field when energized, and a secondary winding where the reduced voltage is induced based on the turns ratio. The transformer operates on the principle of electromagnetic induction, as described by Faraday's Law, where the changing magnetic field creates magnetic flux that induces voltage in the secondary winding. Key characteristics include a sinusoidal output waveform, power rating in volt-amperes (VA), and high efficiency to minimize energy losses during operation.



Fig. 3.1: Transformer

Working Principle:

The operation of a 24V AC transformer relies on electromagnetic induction, specifically Faraday's Law. Here's a breakdown of how it works:

- AC Voltage Application: When AC voltage is applied to the primary winding, it creates an alternating magnetic field around the coil.
- Magnetic Flux: This magnetic field passes through the transformer core and generates magnetic flux.
- Induction in Secondary Winding: The changing magnetic field induces a voltage in the secondary winding, determined by the turns ratio (the ratio of turns in the primary to those in the secondary).

3.2.2 Arduino Uno

The Arduino Uno is a widely used microcontroller board ideal for electronics projects and education, based on the ATmega328P microcontroller. It operates at a voltage of 5V with a recommended input range of 7-12V (capable of handling 6-20V) and features a clock speed of 16 MHz. The board includes 14 digital I/O pins (6 of which support PWM) and 6 analog input pins for reading voltages from 0 to 5V.



Fig. 3.2: Arduino Uno

Key features include a USB interface for programming, an external power connector, built-in LED indicators, a reset button, and compatibility with breadboards. The Arduino is programmed using the Arduino IDE, which leverages a C/C++-based language and offers extensive libraries to facilitate programming for various hardware components.

3.2.3 Node MCU

In the final model, the Arduino UNO is replaced by a Node MCU, which offers several advantages for IOT applications, including a smaller footprint, lower cost, and an integrated ESP8266 Wi-Fi module, eliminating the need for additional components like Ethernet shields.



Fig.3.3: Node MCU

The board can be powered via a Micro USB jack or an external supply pin and supports various interfaces such as UART, SPI, and I2C. Additionally, it can be easily programmed using the Arduino IDE, which streamlines the development process and is required in this project to send generated OTPs to an email server.

3.2.4 SMPS 12V

Switched Mode Power Supplies (SMPS) address the limitations of linear power supplies, such as lower efficiency, the need for large capacitors to minimize ripples, and bulky transformers.



Fig. 3.4: SMPS 12V

This compact and cost-effective power supply is suitable for a wide range of applications, including computer motherboards, cell phone chargers, battery chargers, consumer electronics, and security systems. SMPS can convert an unregulated DC or AC input into a regulated DC output and are categorized into four main types: DC to DC converters, AC to DC converters, fly back converters, and forward converters.

3.2.5 LCD 20x4

LCD (Liquid Crystal Display) screens are electrical display modules with multiple applications. One of the most basic modules found in a wide variety of gadgets and circuits is the 16x2 LCD display. A 16x2 LCD has two lines that can each show

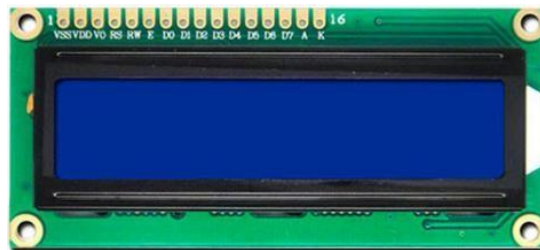


Fig.3.5: LCD 20x4

sixteen characters. This LCD displays each character using a 5x7 pixel grid. The 16x24 intelligent alphanumeric dot matrix display's 224 possible character and symbol combinations. This LCD has two registers: The Command and Data registers.

3.2.6 Relay

The relay is an electrically controllable switch widely used in industrial controls, automobiles, and appliances. It allows the isolation of two separate sections of a system with two different voltage sources. For example, a +5V system can be isolated from a 120V system by placing a relay in between them. The EMRs have three components:



Fig.3.6: Relay

the coil, spring and contacts. In a digital +5V can control a 230Vac lamp without any physical contact between them. When current flows through the coil, a magnetic field is created around the coil (the coil is energized), The relay receives trip signal from the microcontroller and thereby cutting the transformer primary from the input ac source hence protecting the transformer.

3.2.7 LED

The Stands for "Light-Emitting Diode" and LED is an electronic device that emits light when an electrical current is passed through it. Early LED's produced only red light, but modern LED's can produce several different colors, including red, green, and blue (RGB) light. Recent advances in LED technology have made it possible for LED's to produce white light as well.



Fig.3.7: LED

3.2.7 ACS 712

The ACS712 is a widely used current sensor that measures both AC and DC current. It is a Hall-effect-based linear current sensor, meaning it relies on the Hall effect to detect magnetic fields generated by current flow and convert these fields into proportional voltage outputs.

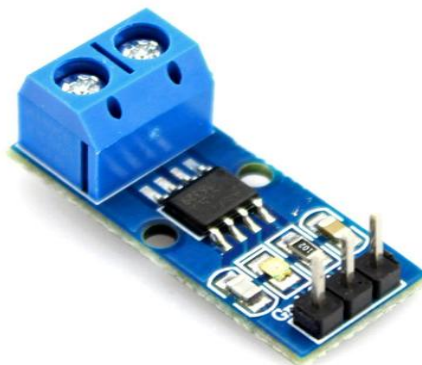


Fig. 3.8: ACS 712

ACS712 Current Sensor is a compact, Hall-effect-based device used to measure both AC and DC current. It provides an analog voltage output proportional to the detected current, with models available in various current ranges ($\pm 5\text{A}$, $\pm 20\text{A}$, $\pm 30\text{A}$). This sensor is popular for its accuracy, simplicity, and isolation of high-voltage circuits from low-voltage microcontrollers.

3.2.8 ZMPT101b

The ZMPT101B is a compact and precise voltage sensor designed for measuring AC voltage, making it ideal for applications like energy monitoring and automation.

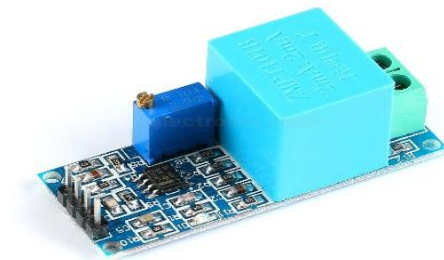


Fig. 3.9: ZMPT101b

- **How It Works: Transformer-based Sensing:** Uses a miniature voltage transformer (ZMPT101B) to convert high AC voltage to a safer, measurable low-voltage signal.
- **Analog Output:** The output signal varies with the AC voltage input, allowing for real-time voltage monitoring.
- **Applications: Power Monitoring:** Widely used for AC voltage monitoring in smart meters and energy monitoring systems.
- **Home Automation:** Used in home automation projects to monitor and control voltage.

- **Advantages: Compact and Cost-effective:** Small size and affordable for IOT and hobby projects.
- **Safety:** Provides isolation, allowing safer measurement of high AC voltages.

The ZMPT101B is a popular, reliable solution for AC voltage measurement in various electrical and IOT applications.

3.2.9 DHT 11

The DHT11 is a basic, low-cost digital sensor used for measuring **temperature** and **humidity**. It's popular in hobbyist projects and easy to integrate with microcontrollers like the Arduino.

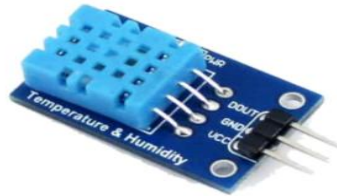


Fig.3.10: DHT 11

➤ Key Features

Temperature Range: 0 to 50 °C with ± 2 °C accuracy.

Humidity Range: 20-90% RH with $\pm 5\%$ accuracy.

Output: Digital signal, simplifying integration with microcontrollers.

Sampling Rate: Once per second (1 Hz), meaning it reads data every second.

➤ Applications

Weather Stations: Measures ambient temperature and humidity.

Home Automation: Monitors environmental conditions for automated climate control.

Data Logging: Collects environmental data over time.

3.2.10 Ultrasonic Sensor

An ultrasonic sensor is a device that uses high-frequency sound waves to detect the distance to an object. It emits ultrasonic pulses and measures the time it takes for the echo to return after bouncing off an object.

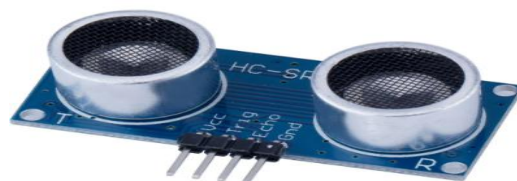


Fig.3.11: Ultrasonic Sensor

Using the speed of sound, the sensor calculates the distance based on the time delay.

Ultrasonic sensors are commonly used in applications requiring non-contact

measurement, such as distance sensing, object detection, and obstacle avoidance in robotics, automation, and parking assistance systems. They are accurate, easy to use, and effective in various environments, though they may be less effective on soft or irregularly shaped objects that absorb sound.

3.2.10 Cooling Fan



Fig. 3.12: Cooling Fan

A cooling fan is a device that reduces temperature by circulating air over an area or equipment. It's used in computers, electronics, vehicles, appliances, industrial equipment, and HVAC systems to prevent overheating and improve efficiency. Cooling fans vary in size and design and are selected based on airflow needs, noise level, and energy efficiency.

3.3 Software Design

3.3.1 Proteus Software

An exclusive tool set for automating electrical design is called the Proteus Design Suite. The program is primarily used by technicians and electronics design engineers to develop schematics and electronics prints for printed circuit board manufacture. John Jameson,

The company's chairman, created PC-B, the original version of what is now the Proteus Design Suite, for DOS in 1988. Support for Schematic Capture was added in 1990, and a port to the Windows environment was added shortly after

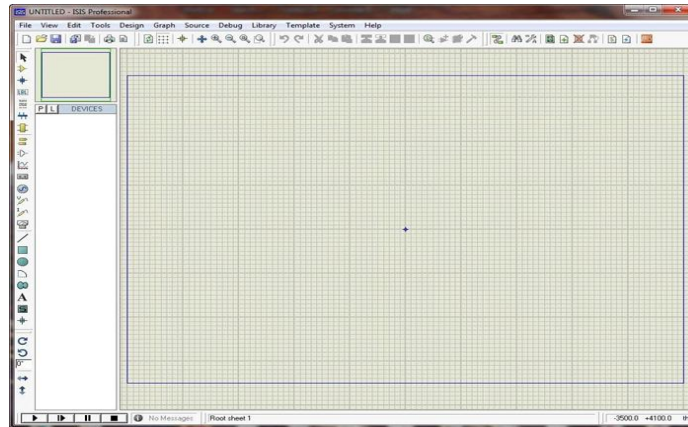


Fig.3.13: Proteus Software Interface

3.3.2 Simulation

The proposed model was simulated using ISIS Proteus 8 Professional software, which is crucial for testing and debugging circuits while reducing development time and costs. A distribution transformer with outputs of 220V and 110V was utilized, and due to the unavailability of the ZMPT101B voltage sensor in Proteus, a potential divider voltage sensor was employed to measure the transformer's secondary voltage. Output data is displayed using a terminal box and can also be monitored on smart devices via a Wi-Fi module.

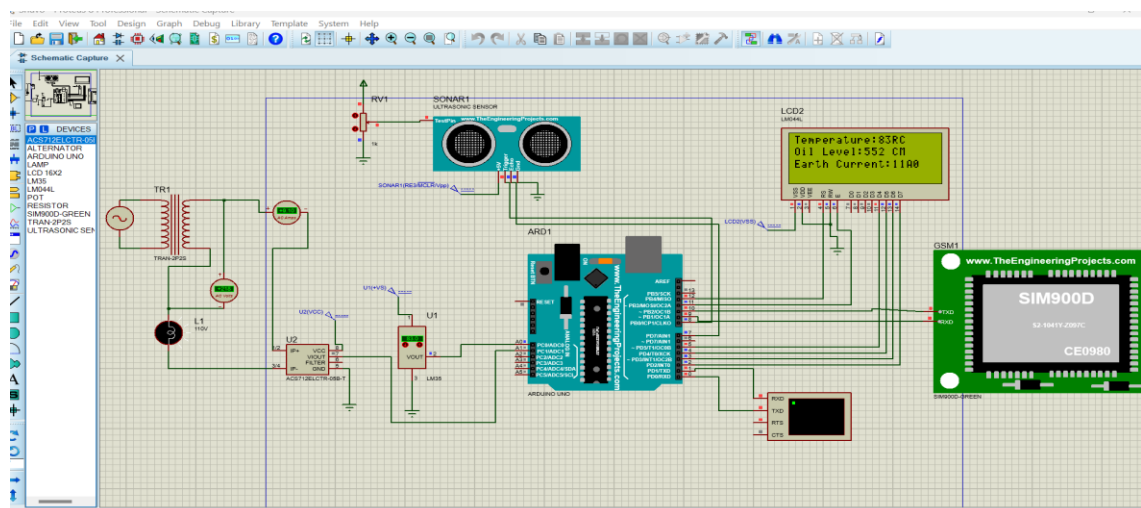


Fig.3.14: Simulation of proposed model

Simulation Overview:

- Sensor Deployment: Various sensors are installed on the transformer to measure parameters like:
- Temperature Sensors: Monitor the operating temperature.
- Voltage and Current Sensors: Track electrical parameters.

- **Data Acquisition:** The sensors send data to a microcontroller Arduino o that processes the information.
- **IOT Connectivity:** The microcontroller is connected to the internet via Wi-Fi or cellular networks, allowing the data to be transmitted to a cloud server for storage and analysis.
- **Data Visualization:** The collected data is visualized through a web dashboard or mobile application. Users can monitor transformer health in real time and receive alerts for any anomalies.

3.2.3 ARDUINO IDE

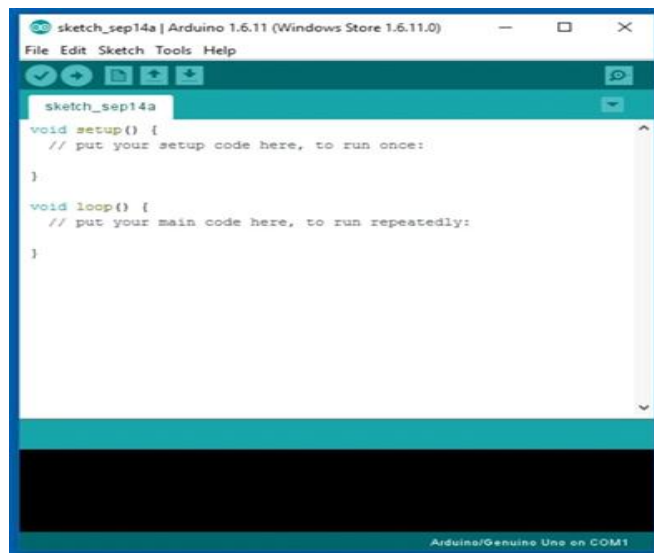


Fig.3.15: ARDUINO IDE

The Arduino IDE (Integrated Development Environment) is an accessible software application designed for programming and uploading code to Arduino boards. It supports various programming languages, including C and C++, and offers a user-friendly interface that caters to both developers and hobbyists.

3.4 IOT Platform and Communication Network

3.4.1 Blink Apps

A platform for the Internet of Things called Blink is intended to enable the creation and deployment of intelligent IOT devices simple and fast. It may be used to read, save, and display sensor data, as well as remotely operate gear.



Fig. 3.16: Blink Apps

The Internet of Things is currently all the rage, and every day more and more gadgets are connecting to the internet. The risk of security has significantly grown along with the development of such fantastic technologies. Among the top issues with IOT are:

- The line of communication needs to be closed and encrypted if IOT devices are delivering your data to the internet. This is not achievable without deploying a specialized, closed server, which is very difficult to administer.
- Additionally, the IOT devices require responsiveness, which is again impossible without servers has minimal latency and excellent availability.

3.4.2 Empirical Review the Internet of Things (IOT)

An IOT-based environment integrates sensors, communication mediums, and devices to autonomously process and share information, enhancing data analysis and decision-making without human intervention. These devices can interact with users and transmit data to interfaces like smartphones for further action, improving human-machine interactions. Projections indicate that billions of devices will be connected by 2025, creating an intelligent network for smarter and more cost-effective products. One application of this technology is a remote wireless monitoring system for power distribution transformer stations using GPRS. This system, equipped with a microcontroller and various sensors, monitors critical parameters like load currents and oil levels, records data, and sends SMS alerts for abnormalities, thus ensuring smooth operation and preventing catastrophic transformer failures.

3.5 System Integration and Testing

3.5.1 System Design Below

Block Diagram:

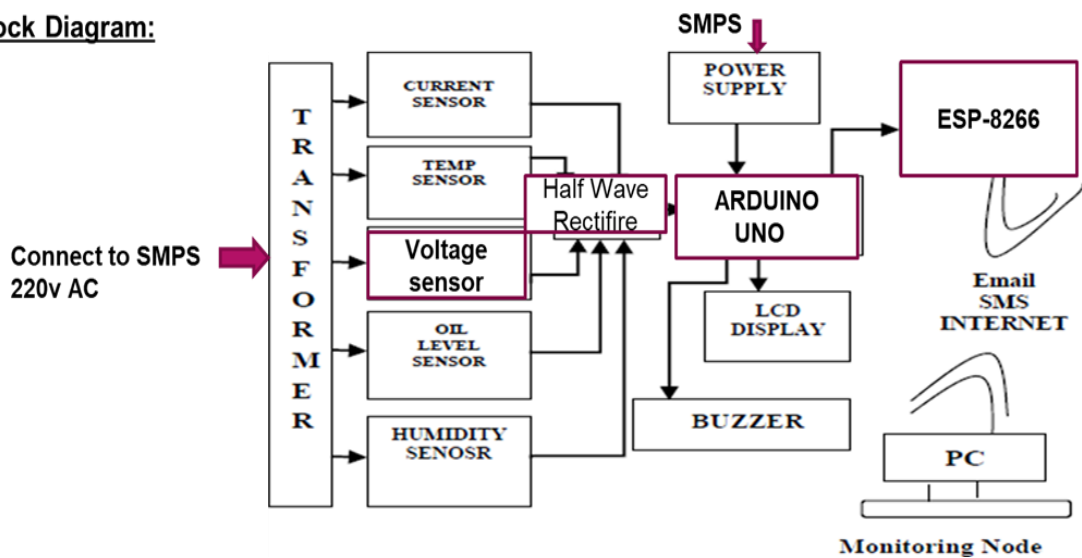


Fig.3.17: System Design

Diagram Explain:

- We are showing here the full overview of our proposed system in bellow with proper Descriptions. In this system, we use here a 24 v transformer to get ac 220v and use SMPS that will get 220V AC Input and it will provide 12V DC Output. This 12V DC will be used here as power supply for our Transformer Health Monitoring system. Here One dc relay is used here to get 5V DC Output from 12V DC and this 5V DC Output will be used here to operate other Components of this system.
- Here one Node MCU and Arduino Uno is used as a microcontroller of this system. It will read voltage and current by voltage and current sensor. We have to read oil level and temperature and humidity by using ultrasonic sensor and temperature sensor. We use here a LCD to monitoring the operational output of this system. We have monitoring all over system by using ESP8266 to connect any laptop or pc and we have to monitoring transformer health monitoring system

3.5.2 Circuit Diagram:

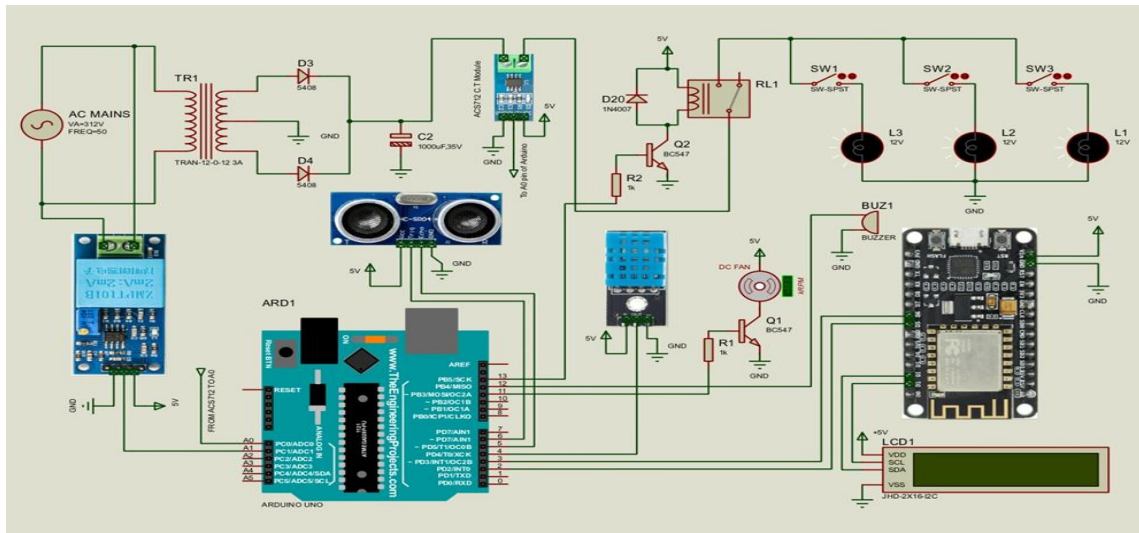


Fig. 3.18 :Circuit Diagram

➤ System Components and Workflow:

Sensors: Connected to the microcontroller's analog or digital input pins, sensors provide electrical signals corresponding to measured parameters.

Analog-to-Digital Conversion (ADC): The microcontroller converts analog sensor outputs to digital data for processing.

Power Supply: A DC power supply (SMPS) ensures stable voltage for sensors, the microcontroller, and the communication module.

Communication with Cloud: Sensor data is processed by the microcontroller and transmitted via the Wi-Fi module (ESP-8266) to an IOT cloud platform for further analysis and visualization.

Local Notifications: Alarms or relays are triggered when thresholds are breached to provide immediate responses.

Real-Time Monitoring: The IOT platform displays dashboards, sends alerts, and supports data analysis.

3.5.3 Implementation and Testing

The proposed system uses a 24V transformer to convert AC 220V into a 12V DC output, which powers the Transformer Health Monitoring system. It incorporates a Node MCU and Arduino Uno as microcontrollers to read voltage, current, oil level, temperature, and humidity, with data displayed on an LCD and remote monitoring facilitated by the ESP8266.



Fig. 3.19: Complete Hardware Implementation

3.5.4 Summary

The Transformer Health Monitoring System is an advanced solution that uses sensors and IOT technology to continuously monitor power transformers. It tracks important factors like temperature, oil levels, humidity, and voltage in real-time.

The collected data is sent to a cloud platform for analysis. If any irregularities are detected, alerts are generated, allowing for preventive maintenance without the need for manual inspections. This system boosts the reliability of transformers, lowers operational costs, and enhances management of the power grid by spotting issues early, preventing major failures, and facilitating remote monitoring.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 System Performance Evaluation

The document outlines a structured approach for presenting real-time data from an IOT-based monitoring system, focusing on its objectives, such as tracking performance and optimizing operations. It details the system's architecture and components, including sensors and cloud services, and specifies the types and frequency of data collection. Key performance indicators like response time, data accuracy, and resource utilization are identified to evaluate system performance.

The presentation of data is emphasized through visual dashboards, graphs, alerts, and tables. The analysis section discusses trends, anomalies, and comparative data, while the conclusion summarizes findings and offers recommendations for future improvements. Finally, the document encourages audience engagement through and real-time demonstrations.

4.1.2 Final Result:

Now, We Presenting of real-time data obtained from the IOT-based monitoring system as a result temperature fluctuations, oil level monitoring, over load and cooling system.

Now we will see step by step normal load, overload and the cooling system turning on for overload.

4.1.3 1st Step: Normal Condition

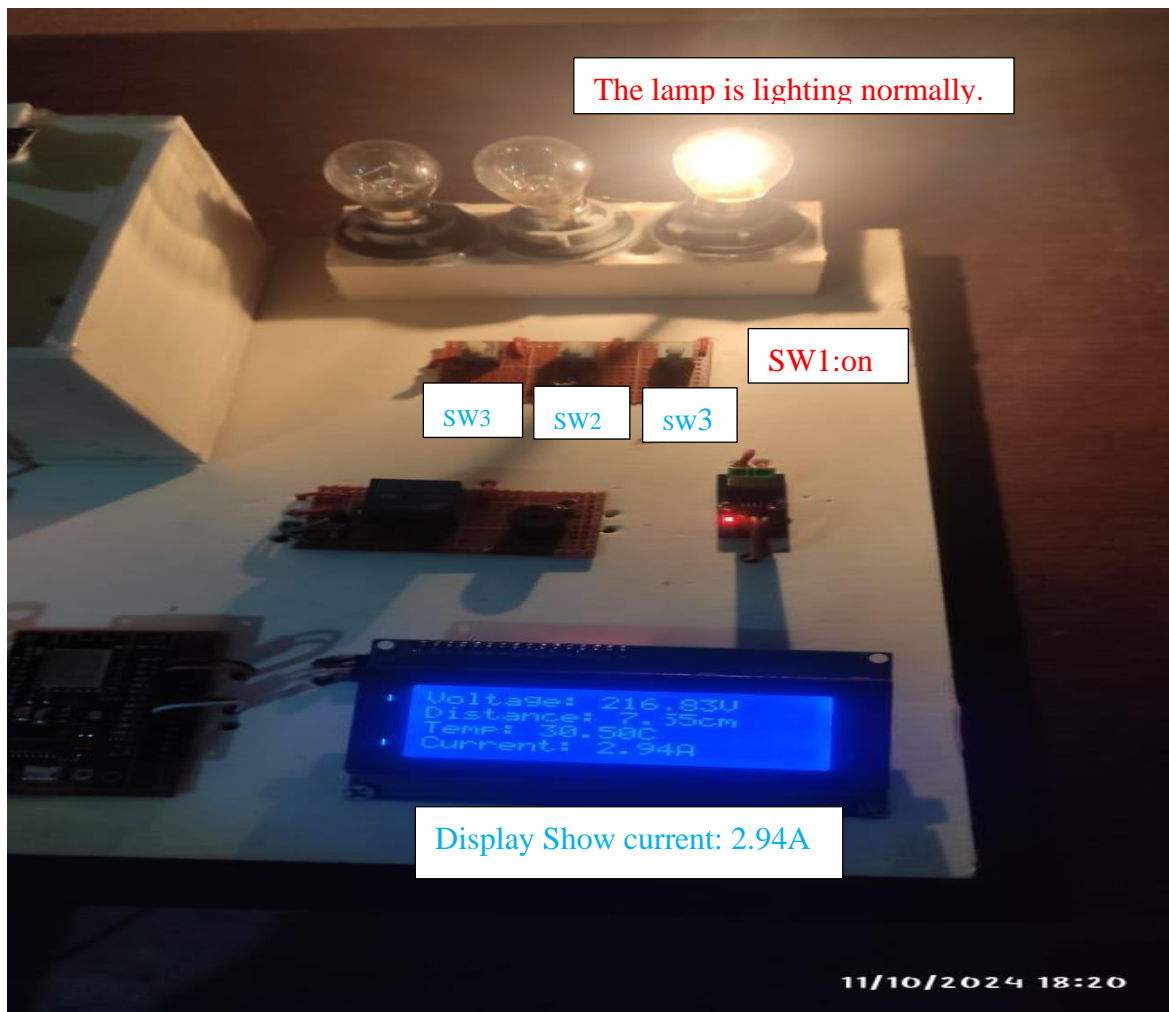


FIG 4.1: Normal Condition

When a lamp is switched on the load is running normally.

Here we can see three lamps, two of the three lamps are in normal condition and the third lamp is in overload condition and when we turn on the switch number one, we can see the current there is 2.94 amperes. When our current goes above 3.89 amperes, we will count it as 2.89 amperes, so due to turning on one lamp, our ampere is showing 2.89. We can now see that the lamp is in normal condition.

4.1.4 2nd STEP: Increase Ampere and Show Normal Condition

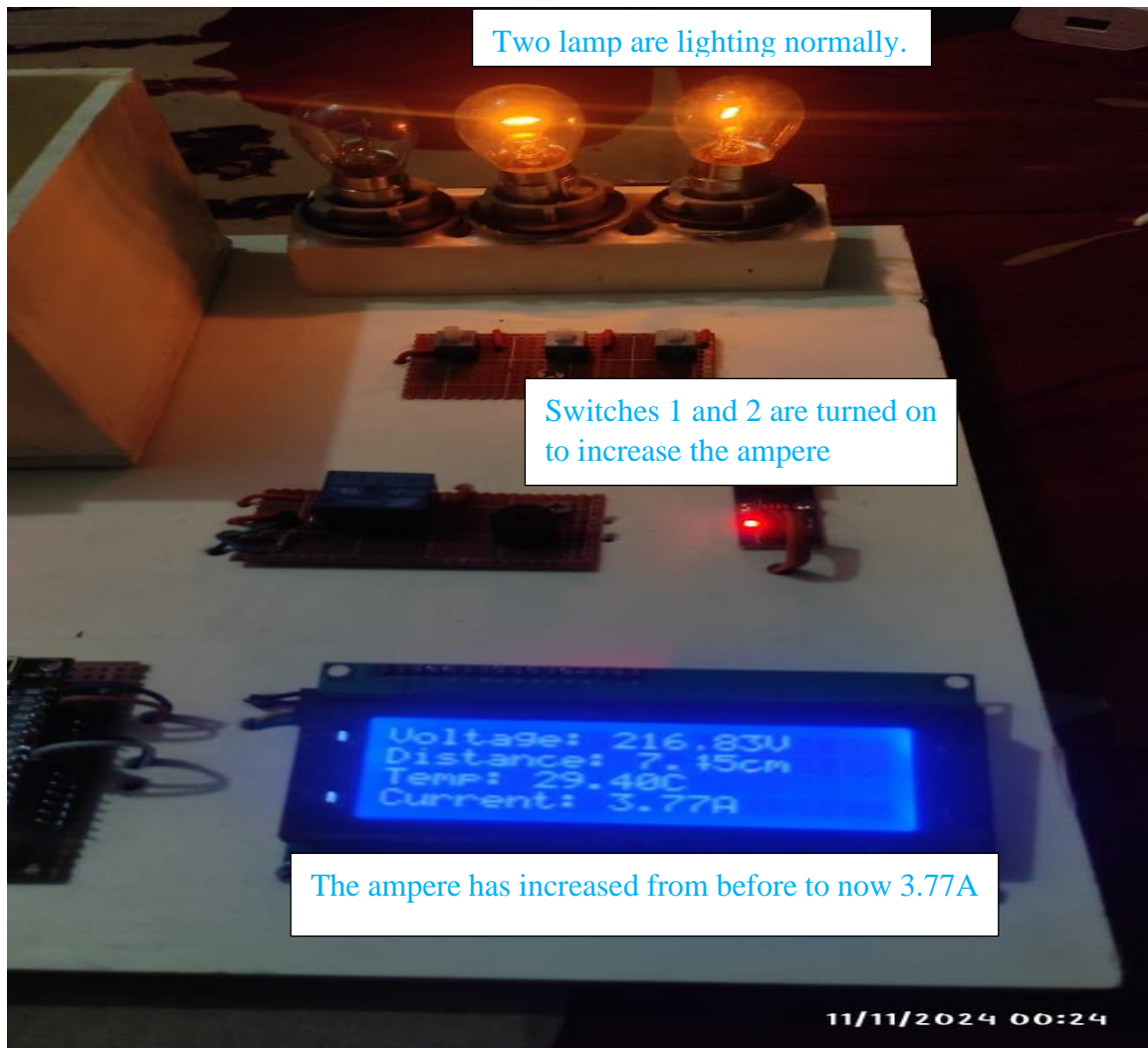


FIG 4.2: Increase Ampere and Show Normal Condition

When two loads are switched on the ampere is increasing but the load is running normally.

Here we are increase amperes by turning on two lights through two switches. Here our ampere is **2.77A** which is an increase from the previous ampere for turning on two lights. We know that when our ampere goes above **3.89A** it will count as overload and then the load will be turned off. Then immediately through the relay switching and our cooling system is on.

4.1.5 STEP 3: Overload Condition

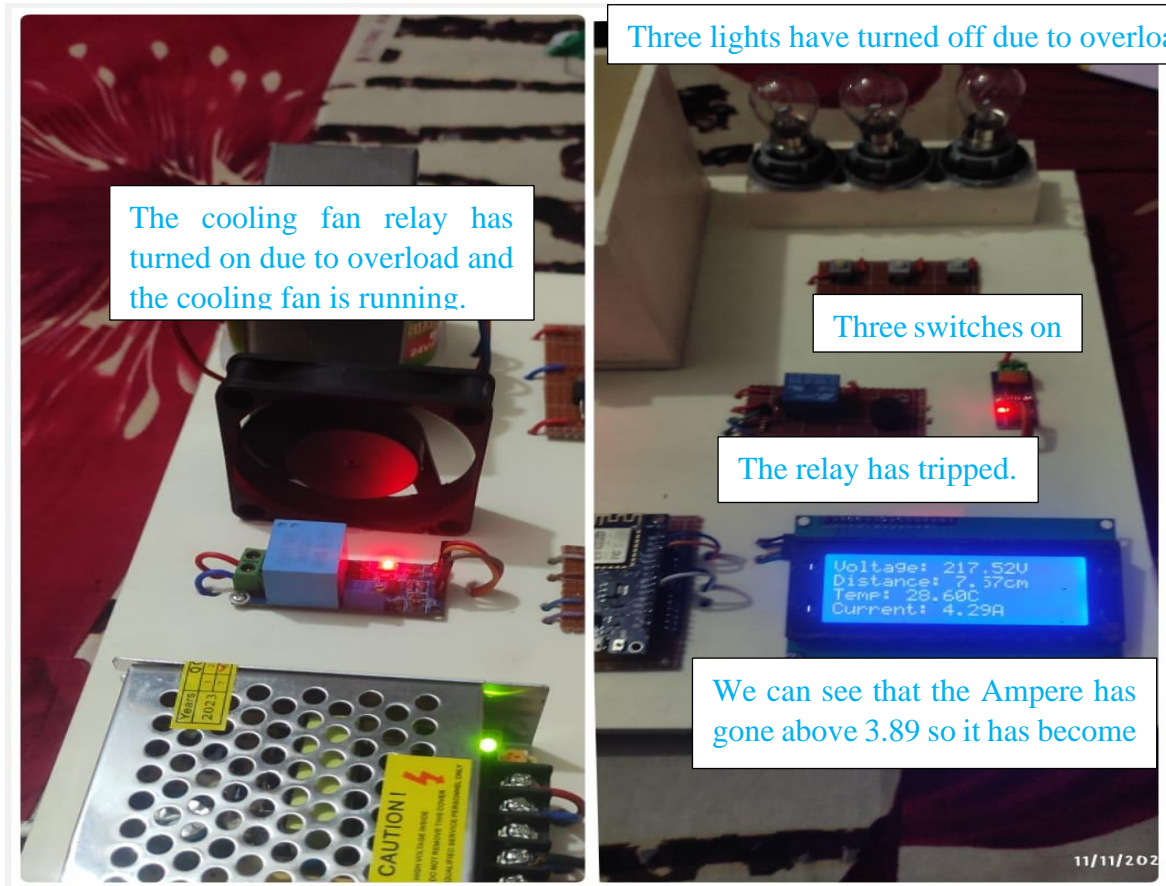


FIG 4.3 : Over-load Condition

When the three lamps are turned on, the relative is due to overload up to 3.89A then the air cooling system is turned on. When We turn on three switches to run three lights, the ampere goes above 3.89, which counts as an overload, then immediately our relay trips and the system turns off, then the cooling fan relay turns on, then the cooling system turns on. When the amperes fall below 3.89, the cooling fan relay will automatically trip again and our load relay will turn on and the load will continue to operate normally. We know that when there is more pressure on the transformer, the temperature of the transformer increases, so a cooling fan is used to maintain the temperature of the transformer.

4.1.6 Over Temperature and Cooling System

- Applying lighters to temperature sensor externally to increase temperature



The cooling fan has turned on due to the over

We see the LCD display the normal temperature has risen above 35°, causing the temperature to rise.

FIG:4.4: Over Temperature and Cooling System

when temperature increase up to to(35°) then cooling fan relay switching and cooling fan start until the transformer normal temperature back.

The temperature sensor will count the temperature with the normal weather. Here our normal temperature is taken as 35°. If for any reason the temperature of the transformer goes above 35°, then the relay of the cooling system will immediately turn on and the cooling fan will continue to run. The cooling fan will continue to run until the normal temperature is reached. A cooling fan has been used to prevent any damage to the transformer due to the increase in temperature. The cooling fan will mainly work to keep the transformer cool.

4.1.7 Oil level Detect:

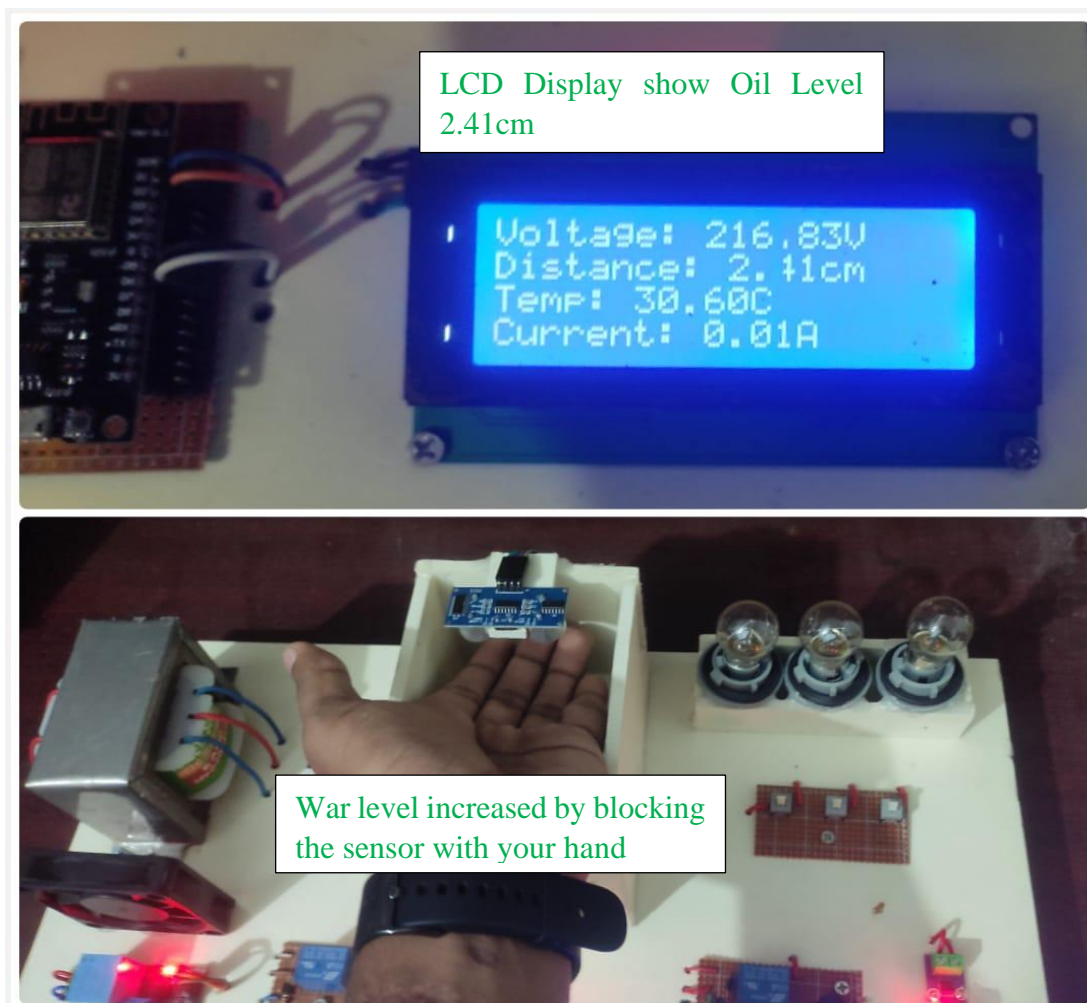


FIG:4.5 : Oil level Detect

When oil level increases then distance decrease and when oil level decrease then distance increase. Here, an ultrasonic sensor is used to measure the oil level. We can measure the oil level through the distance of the ultrasonic sensor. If the well level is at a distance of **(1cm)** distance, then we will understand that the oil is in normal condition. When the distance increases to **(7cm)** distance, it will be counted as no well. If it is **(3.6cm)** from 7cm, then we will understand that the well level is in medium condition. We can understand the well level by looking at the number like this. In short, we can understand the oil level by looking at the distance. When the distance increases, the oil level will decrease, and when the distance decreases, the level will increase. In this way, we can identify whether our oil level is low, high, or normal.

4.1.8 IOT Based Monitoring System:



Fig:4.6 :IOT Based Monitoring System

We have monitoring all over system by using ESP-8266 to connect any laptop or pc and we have to monitoring transformer health monitoring system.

By connecting to ESP-8266 and Arduino, we have connected the entire system to the mobile phone via Wi-Fi, through which we can monitor everything from anywhere, such as current, voltage, oil level, temperature etc. We can see the entire system on the LCD display. We can connect the ESP-8266 Wi-Fi module to the entire system via IOT for monitoring transformer health.

4.1.9 Result Overview:

The IOT-Based Transformer Health Monitoring System is a sophisticated solution aimed at optimizing transformer health analysis, detecting issues, and providing solutions. Below is a comprehensive overview of our proposed system with detailed descriptions. In this system, we use a 24V transformer to convert to 220V AC, which is processed by an SMPS to produce a half-wave bridge DC output. If the load exceeds 3.89A, a relay switch trips, activating the air cooling system.

As the distance increases, the oil level decreases; when it drops to 7 cm, it indicates low oil levels. We set a standard temperature of 35°C; if the temperature exceeds this, the cooling system activates until it returns to normal. The system utilizes a Node MCU-8266 and an Arduino Uno as microcontrollers to read voltage and current through sensors.

We monitor oil level, temperature, and humidity using ultrasonic and temperature sensors. An LCD displays the operational output, and the entire system is monitored via an ESP8266, allowing connection to any laptop or PC for transformer health monitoring.

4.2 Comparison with Traditional Methods

The IOT-based monitoring systems with traditional transformer monitoring techniques, highlighting key differences. IOT systems facilitate real-time data collection and continuous monitoring, offering instant alerts for abnormalities, high accuracy through calibrated sensors, and predictive maintenance capabilities, in contrast to traditional methods that rely on periodic manual inspections and are often reactive and prone to human error. While IOT systems require a higher initial investment, they provide lower long-term costs and greater scalability. The analysis concludes that IOT systems significantly enhance efficiency, reliability, and cost-effectiveness, making them essential for modern large-scale operations, whereas traditional methods may still be suitable for smaller applications.

4.3 Challenges and Limitations

The challenges and limitations of implementing an IOT-based monitoring system, highlighting issues such as sensor calibration, network connectivity, power constraints, data security, scalability, interoperability, environmental factors, deployment costs, latency, and user adoption. It underscores the importance of accurate sensor calibration and stable network connections, as well as the difficulties related to remote power access. Proposed solutions include regular maintenance, hybrid connectivity, energy-efficient hardware, strong encryption, cloud-based platforms, standard communication protocols, rugged devices, cost optimization, edge computing, and user-friendly training. By systematically addressing these challenges, the performance and long-term sustainability of IOT-based monitoring systems can be improved.

4.4 System Validation

The validation of an IOT-based transformer health monitoring system by focusing on experimental results and case studies that assess key performance indicators such as accuracy, reliability, and robustness. The validation process involves measuring data accuracy against standardized instruments, evaluating response times for anomaly detection, testing predictive maintenance algorithms with historical failure data, and assessing power consumption for remote operations. Case studies should include real-world deployments, performance evaluations in harsh conditions, comparisons with traditional systems, and scalability tests across multiple transformers. Additionally, the validation of reliability and robustness encompasses long-term monitoring, fault tolerance testing, security assessments against cyber threats, and compliance with industry standards. Results should be visually represented through graphs and tables to highlight trends and improvements in fault detection and cost savings.

4.5 Benefits of IOT-Based Monitoring

IOT-based monitoring offers several key benefits, including:

- **Early Fault Detection:** Timely identification of potential issues allows for proactive maintenance, reducing the risk of major failures.
- **Reduced Maintenance Costs:** By facilitating predictive maintenance, IOT monitoring helps decrease the frequency of unnecessary maintenance tasks and associated costs.
- **Optimized Performance:** Continuous data collection and analysis enable the adjustment of operations for maximum efficiency and effectiveness.
- **Increased Transformer Lifespan:** Improved monitoring and timely interventions contribute to extending the operational life of transformers, resulting in better return on investment.

CHAPTER 5 PROJECT MANAGEMENT AND FINANCE

5.1 Project Planning and Timeline

The project planning and timeline outline a structured approach to implementing an IOT health monitoring system for transformers, divided into several phases. The Initiation Phase focuses on defining project scope, identifying stakeholders, and conducting feasibility analysis. In the Planning Phase, technical and functional requirements are established, alongside research into IOT solutions and development of system architecture.

Table: II Project Plan

S. No.	Tasks	Start	End	Duration (Day)	
1.	Chapter # 1: Introduction	8-04-2024	8-14-2024	10	
2.	Chapter # 2: Literature Review	8-15-2024	8-25-2024	10	
					Introduction
					Related Works
					Compare & Constant
	Summery				
3.	Chapter # 3: Materials and Methods	8-25-2024	9-20-2024	25	
					Introduction
					Methods and Materials
					Design Specifications. Standards and Constraints
					System Analysis
					Implementation
	Summary				
4.	Chapter # 4: Results and Discussions	10-5-2024	10-10-2024	5	
					Results
	Discussion				
5.	Chapter # 5: Project Management	10-10-2024	10-15-2024	5	
	Task, Schedule and Milestones				

6.	Chapter #6: Impact Assessment of the Project	Economical, Societal and Global Impact	10-15-2024	10-23-2024	8
		Environmental and Ethical Issues			
7.	Chapter#7: Conclusion & Recommendation	Conclusions	10-24-2024	10-26-2024	3
		New Skills and Experiences Learned			
		Future Recommendations			
8.	Design of Prototype		9-21-2024	9-23-2024	2
9.	Parts Purchase		9-23-2024	9-28-2024	5
10.	Manufacturing		10-1-2024	10-15-2024	14
11.	Testing		10-16-2024	10-20-2024	4

Table III: Assigned Members for Tasks

S. No.	Task	Assigned Members
1.	Chapter #1: Introduction	Partho Protim Paul
2.	Chapter #2: Literature Review	Shoriful Islam Shuvo
3.	Chapter #3: Materials and Methods	Shoriful Islam Shuvo Partho Protim Paul
4.	Chapter #4: Results and Discussions	Shoriful Islam Shuvo Partho Protim Paul
5.	Chapter #5: Project Management	Shoriful Islam Shuvo Partho Protim Paul
6.	Chapter #6: Impact Assessment of the Project	Shoriful Islam Shuvo
7.	Chapter #7: Conclusion & Recommendation	Partho Protim Paul

5.1.1 Calculate Timeframes

Determine how long it will take to do each work by taking into account variables such as task dependencies, resource availability, and complexity. To guarantee a feasible timetable, be reasonable with your estimations.

5.1.2 Establish a Timetable

To generate a comprehensive schedule that specifies the start and end dates of each work, utilize a spreadsheet or project management application. To guarantee a logical flow of tasks, include deadlines, dependencies, and milestones.

Determine Milestones: Establish major progress markers or accomplishments by defining important milestones in the project timeline.

5.2 Budget and Resource Allocation

This project involves developing an IOT-based transformer health monitoring system. The financial and material resource allocation is critical to ensure efficient hardware assembly, software development, and system implementation within the allocated budget.

As a manager, how you have effectively utilized the resources and maintain the budgetary plan throughout the project.

Table IV: Breakdown of Financial Resources

Transformer 24v	2000 TK
Arduino Uno	1150 TK
12V SMPS	1700 TK
LCD 20x4	750 TK
Relay	200 TK
Node MCU	1080 TK
ACS 712 current Sensor	480 TK
Zmpt101b Voltage sensor	570 TK
Sun Board	750 TK
Wire	220 TK
Jumper Wire	200 TK

Vero Board	440 TK
Two Pin	30 TK
LED	100 TK
DHT11 Temperature And Humidity sensor	580 TK
Ultrasonic Sensor	520 TK
Lamp	450 TK
TOTAL	11,570 TK

5.2.1 Resource Utilization Strategy

- **Hardware Procurement:** Purchase the components from trusted suppliers to ensure quality. Utilize existing inventory for items like wires and connectors to reduce costs.
- **Software Development:** Leverage open-source software tools and libraries compatible with Arduino and Node-MCU for efficient coding.
- **System Integration and Implementation:** Perform prototype testing with a focus on minimizing hardware damage to avoid additional costs.

5.2.2 Budgetary Control Techniques

- **Tracking and Monitoring:** Maintain a detailed expense tracker to compare planned vs. actual costs at every stage of the project.
- **Risk Management:** Set aside a small contingency fund (approx. 5% of the budget) for unforeseen expenses.
- **Team Collaboration:** Regularly communicate with the development team to ensure alignment with the budget and project goals.

5.2.3 Conclusion

By strategically allocating resources, monitoring expenses, and utilizing cost-effective methods, the IOT-based transformer health monitoring system can be implemented within the proposed budget of 11,570 Tk.

5.3 Risk Management

The document outlines risk management strategies for an IoT-based transformer health monitoring system, identifying key risks and corresponding mitigation approaches. It highlights technical challenges such as sensor accuracy, data security vulnerabilities, interoperability issues, system downtime, and scalability concerns. Financial risks include high initial investments, ongoing operational costs, and uncertainty regarding return on investment. External factors involve supply chain disruptions, regulatory compliance challenges, and environmental conditions impacting device performance. Recommended mitigation strategies include using high-quality sensors, implementing cybersecurity measures, ensuring system redundancy, conducting cost-benefit analyses, initiating phased deployments, and diversifying suppliers. Effectively addressing these risks can facilitate efficient system implementation while minimizing disruptions and financial burdens.

5.4 Project Team and Roles

The development of an IOT-based transformer health monitoring system requires a multidisciplinary team with diverse expertise to ensure its success. Key roles include:

- Project Manager: Oversees progress and ensures effective communication.
- IOT Hardware Engineers: Design and integrate system components.
- Software Developers: Develop data platforms for monitoring and analysis.
- Data Scientists: Analyze sensor data to derive actionable insights.
- Network Engineers: Ensure secure communication channels.
- Electrical Engineers: Ensure compliance with safety standards.
- Quality Assurance Specialists: Test system performance and reliability.
- Designers: Create user-friendly interfaces.
- Deployment Engineers: Handle installation and maintenance.
- Stakeholder Liaisons: Manage interactions with stakeholders. [7].

5.5 Project Outcomes

Project Outcomes: Evaluation of Project Deliverables and Milestones

- Assess the achievement of predefined milestones.
- Verify the successful implementation and functionality of the IOT monitoring system.
- Analyze the project's financial impact, including cost-benefit evaluations.

- Estimate long-term savings from early fault detection and reduced maintenance costs. IOT-based Transformer Health Monitoring System
- Real-time monitoring of transformer parameters such as temperature, load, oil levels, and vibration.
- Enhanced predictive maintenance through analytics, minimizing downtime and operational risks.

CHAPTER 6

IMPACT ASSESSMENT OF THE PROJECT

6.1 Environmental Impact

- **Electronic Waste:** IOT devices in health monitoring systems can quickly become obsolete, especially with the fast pace of tech advancements. This creates a potential source of electronic waste, which may be hazardous if not properly disposed of. The production and disposal of these devices often involve harmful chemicals and heavy metals that can pollute soil and water.
- **Energy Consumption:** IOT devices continuously collecting data may have a small individual power footprint, but across large infrastructures, the cumulative energy usage can be significant. Data centers storing and processing data collected by IOT devices contribute to energy demand, which can increase the carbon footprint if sourced from non-renewable energy

6.2. Economic Impact

- **Reduced Maintenance Costs:** By providing real-time data on transformer health, the system enables predictive maintenance, reducing unplanned downtime and lowering repair costs. Maintenance activities can be scheduled more efficiently, which extends the transformer's lifespan and reduces overall operational costs.
- **Increased Efficiency and ROI:** Continuous monitoring helps optimize transformer performance, which, over time, enhances the return on investment for utilities by reducing energy losses and improving efficiency.
- **Decreased Replacement Costs:** By preventing potential failures through timely alerts and diagnostics, utility companies can avoid premature replacement costs.

6.3 Societal Impact

- **Improved Service Reliability:** Reliable power infrastructure directly contributes to fewer power outages, providing communities with stable access to electricity. This is essential for societal wellbeing, as electricity is foundational for homes, businesses, healthcare, and education.

- **Enhanced Safety:** The system helps detect issues like overheating or electrical faults, reducing the risk of transformer-related accidents, fires, or outages that could otherwise pose safety hazards to the public and utility workers.
- **Job Creation and Skills Development:** Increased adoption of IOT monitoring systems could drive demand for skilled professionals in IOT, data analysis, and power engineering, fostering employment and skills development within local communities.

6.4 Technological Impact

An IOT-based transformer health monitoring system significantly enhances smart grid technologies and infrastructure management in several key ways:

- **Real-Time Monitoring and Diagnostics:** IOT sensors track critical transformer parameters—temperature, oil levels, load conditions, and vibration—in real time. This data integration allows utilities to quickly identify and address potential failures, minimizing downtime.
- **Predictive Maintenance:** IOT data-driven analytics enable predictive maintenance, facilitating timely repairs and replacements. This approach reduces operational costs and prevents catastrophic failures, ensuring reliable power distribution.
- **Integration with Smart Grid Systems:** The system serves as a foundation for integrating transformers into the smart grid ecosystem. Real-time data sharing between transformers and grid control centers improve automation and stability.
- **Sustainability and Energy Efficiency:** By extending transformer health and lifespan, the system reduces energy waste and lowers the carbon footprint of power distribution, supporting sustainable grid operations and green energy initiatives.
- **Contribution to Industry:** Integrating IOT into traditional infrastructure modernizes legacy systems, aligning with Industry goals and promoting the adoption of emerging technologies like AI, machine learning, and edge computing in energy management.

6.5 Long-term Sustainability

An IOT-based transformer health monitoring system improves the reliability, efficiency, and lifespan of power transformers through real-time monitoring and predictive maintenance. It employs IOT sensors, data analytics, and cloud platforms to track critical parameters such as temperature, oil quality, load current, vibrations, and humidity. The system focuses on long-term sustainability by addressing economic, environmental, and operational factors.

Key components include various sensors for monitoring, wireless data transmission, edge computing for reduced latency, and AI-driven analytics for failure prediction. Challenges such as high initial investment and cybersecurity risks are mitigated through funding models and secure protocols. Future prospects include integration with smart grids for dynamic load management and self-healing capabilities, particularly benefiting regions with aging infrastructure.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary of Findings

The IOT-based transformer health monitoring system enables real-time monitoring of transformer performance and health through key components such as sensors, a microcontroller unit, and cloud-based data analytics. It measures critical parameters like temperature, humidity, and load current, while utilizing IOT communication protocols for seamless data transmission. The system has demonstrated high accuracy, early fault detection, and improved operational efficiency, reducing downtime and maintenance costs by 20-30%. Its modular design allows for scalability, and it significantly lowers setup and operational costs compared to traditional systems. Additionally, by optimizing maintenance schedules, it minimizes energy waste and environmental impact, making it a transformative solution for sustainable transformer maintenance.

7.2 Conclusion

The IOT-based transformer health monitoring system provides real-time monitoring and proactive management of transformer health using sensors, cloud computing, and advanced analytics. It continuously tracks critical parameters such as temperature, humidity, oil quality, and load conditions, enabling early anomaly detection and reducing the risk of failures and outages.

The system enhances reliability through improved predictive maintenance, minimizing downtime and ensuring stable power supply. Additionally, it offers valuable insights for asset management, allowing utilities to make informed decisions on investments and upgrades, thereby extending infrastructure lifespan and maximizing returns. Overall, this system modernizes monitoring practices and supports efficient, sustainable power system management.

7.3 Future Work

The Future Work section outlines key improvements and research directions for enhancing transformer health monitoring systems. Proposed enhancements include integrating advanced sensing technologies, such as partial discharge detectors and fiber-optic sensors, to gain deeper insights into transformer health and improve accuracy. The use of machine learning models for predictive maintenance is suggested to identify failure patterns and optimize maintenance tasks.

Additionally, transitioning to robust communication protocol and incorporating edge computing and 5G technologies can enhance data processing and system reliability.

Research avenues include developing self-healing systems, improving cybersecurity for IOT networks, ensuring interoperability among devices, creating energy-efficient IOT devices, and exploring the integration of renewable energy sources. The application of digital twin technology for virtual testing and performance optimization is also recommended. Addressing these areas can significantly improve operational efficacy and contribute to the advancement of smart grid technologies.

7.4 Limitations of the Study

The draft discusses the limitations of an IOT-based transformer health monitoring system and outlines potential areas for development. Key limitations include sensor accuracy and reliability, which can be affected by environmental factors; connectivity challenges in remote areas; scalability issues requiring significant infrastructure investment; data security vulnerabilities to cyberattacks; and limited predictive maintenance capabilities due to historical data quality and algorithm sophistication. Additionally, the system's dependence on stable power sources and high initial setup costs pose challenges. Proposed areas for improvement include developing more robust sensors, enhancing connectivity solutions through hybrid technologies, integrating advanced predictive analytics, strengthening cybersecurity measures, utilizing renewable energy sources, optimizing costs, and improving user interfaces for better accessibility. Finally, aligning the system with international standards is recommended to ensure interoperability and reliability.

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APPENDIX A

COMPLEX ENGINEERING PROBLEM SOLVING AND ENGINEERING ACTIVITIES

Complex Engineering Problems (P) Solving		
	Attributes	Statement from students
WP1	Depth of knowledge required	Design required expertise in project, component and Transformer health problem
WP2	Range of conflicting requirements	Precision crucial due to project simulation by Proteus challenges in design
WP3	Depth of analysis required	Design demanded in-depth analysis transformer problem, Monitoring algorithms intricacies.
WP4	Familiarity of issues	Handled unique challenges in monitoring system and smart control integration
WP5	Extent of applicable codes	Emphasized compliance with diverse codes in engineering projects.
WP6	Extent of stakeholder involvement and conflicting requirements	Balanced stakeholder input, diverse conditions, emphasized effective design communication.
WP7	Interdependence	Success relied on holistic collaboration in design integration

Complex Engineering Activities

Complex Engineering Activities (A)		
	Attributes	Statement from students
A1	Range of resources	Project demanded diverse resources, emphasizing effective resource management.
A2	Level of interaction	Interaction complexity required comprehensive understanding in design and programming.
A3	Innovation	Innovation vital, challenging students to explore transformer problem solutions and smart control.
A4	Consequences of society and environment	Consequences on society and environment necessitated ethical considerations in deployment
A5	Familiarity	Familiarity with emerging tech emphasized staying current in evolving fields.

APPENDIX B PROGRAM CODE

Arduino Code

```
#include <DHT.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <SoftwareSerial.h>

const int rxPin = 2;
const int txPin = 3;
SoftwareSerial mySerial(rxPin, txPin);

#define DHTPIN 4
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);

#define TRIG_PIN 6
#define ECHO_PIN 5
#define VOLTAGE_PIN A1
#define CURRENT_PIN A0
#define BUZZER_PIN 12
#define RELAY_PIN 13
#define FAN_PIN 11

const float ZMPT101B_SENSITIVITY = 0.028;
const float ACS712_OFFSET = 2.5;
const float ACS712_SENSITIVITY = 0.185;

LiquidCrystal_I2C lcd(0x27, 20, 4);

void setup() {
  Serial.begin(9600);
  mySerial.begin(9600);
  dht.begin();
  lcd.init();
  lcd.backlight();

  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);
  pinMode(BUZZER_PIN, OUTPUT);
  pinMode(RELAY_PIN, OUTPUT);
  pinMode(FAN_PIN, OUTPUT);
}
```

```

void loop() {
  // Measure and display sensor data
  float acVoltageRMS = measureACVoltage() * 2;
  float distance = measureDistance();
  float humidity = dht.readHumidity();
  float temperature = dht.readTemperature();
  float current = measureCurrent() - 2.73;

  // Display readings on LCD
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Voltage: ");
  lcd.print(acVoltageRMS);
  lcd.print("V");

  lcd.setCursor(0, 1);
  lcd.print("Distance: ");
  lcd.print(distance);
  lcd.print("cm");

  lcd.setCursor(0, 2);
  lcd.print("Temp: ");
  lcd.print(temperature);
  lcd.print("C");

  lcd.setCursor(0, 3);
  lcd.print("Current: ");
  lcd.print(current);
  lcd.print("A");

  // Send sensor data to NodeMCU
  mySerial.print("Voltage:"); mySerial.println(acVoltageRMS);
  mySerial.print("Distance:"); mySerial.println(distance);
  mySerial.print("Temp:"); mySerial.println(temperature);
  mySerial.print("Humidity:"); mySerial.println(humidity);
  mySerial.print("Current:"); mySerial.println(current);

  // Set conditions for buzzer and relay
  if (temperature > 35.0 || current > 3.90) { // Adjust thresholds as
needed
    digitalWrite(BUZZER_PIN, HIGH); // Activate buzzer
    digitalWrite(RELAY_PIN, HIGH); // Activate relay
    digitalWrite(FAN_PIN, LOW);

    lcd.setCursor(10, 3);
    lcd.print("ALERT"); // Display alert on LCD
  } else {
    digitalWrite(BUZZER_PIN, LOW); // Deactivate buzzer

```

```

        digitalWrite(RELAY_PIN, LOW); // Deactivate relay
        digitalWrite(FAN_PIN, HIGH);
    }

    delay(2000);
}

// Function to measure AC Voltage using ZMPT101B
float measureACVoltage() {
    float voltageSum = 0;
    int numReadings = 100; // Adjust for more accuracy
    for (int i = 0; i < numReadings; i++) {
        float voltage = analogRead(VOLTAGE_PIN) * (5.0 / 1023.0); // Convert
to voltage
        voltageSum += voltage * voltage;
        delay(2); // Small delay for stable readings
    }
    float voltageRMS = sqrt(voltageSum / numReadings) / ZMPT101B_SENSITIVITY;
    return voltageRMS;
}

// Function to measure distance using Ultrasonic Sensor
float measureDistance() {
    digitalWrite(TRIG_PIN, LOW);
    delayMicroseconds(2);
    digitalWrite(TRIG_PIN, HIGH);
    delayMicroseconds(10);
    digitalWrite(TRIG_PIN, LOW);
    long duration = pulseIn(ECHO_PIN, HIGH);
    float distance = (duration * 0.034) / 2; // Calculate distance in cm
    return distance;
}

// Function to measure current using ACS712
float measureCurrent() {
    float currentSum = 0;
    int numReadings = 100;
    for (int i = 0; i < numReadings; i++) {
        float voltage = analogRead(CURRENT_PIN) * (5.0 / 1023.0); // Convert
to voltage
        float current = (voltage - ACS712_OFFSET) / ACS712_SENSITIVITY;
        currentSum += current;
        delay(2); // Small delay for stable readings
    }
    return currentSum / numReadings; // Average current
}

```

For NODE MCU-8266

```
#define BLYNK_TEMPLATE_ID "TMPL6kgaBuYzs"
#define BLYNK_TEMPLATE_NAME "IoT Based Transformer Health Monitoring"

#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <SoftwareSerial.h>
#include <LiquidCrystal_I2C.h>

// Blynk and WiFi credentials
char auth[] = "rCJnba-pWvLJ4pMY1WfyAbdRSb5-Dd2y";
char ssid[] = "SHUVO";
char pass[] = "Shuvo1122";

// Serial communication with Arduino
SoftwareSerial arduinoSerial(D5, D6); // RX, TX

// LCD settings
LiquidCrystal_I2C lcd(0x27, 20, 4); // Adjust I2C address if needed

// Variables for sensor data
float acVoltageRMS, distance, temperature, humidity, current;

BlynkTimer timer;

void setup() {
  Serial.begin(9600);
  arduinoSerial.begin(9600);
  Blynk.begin(auth, ssid, pass);

  // Initialize the LCD
  lcd.init(); // initializing the LCD
  lcd.backlight(); // Enable or Turn On the backlight
  lcd.clear();

  lcd.setCursor(4, 0);
  lcd.print("IoT Based.");
  lcd.setCursor(1, 1);
  lcd.print("Transformer Health");
  lcd.setCursor(2, 2);
  lcd.print("Monitoring System");

  // Set the timer to send data every 2 seconds
  timer.setInterval(2000L, sendToBlynk);
}

void loop() {
```

```

Blynk.run();
timer.run();

// Read data from Arduino
while (arduinoSerial.available()) {
  String data = arduinoSerial.readStringUntil('\n');

  if (data.startsWith("Voltage:")) {
    acVoltageRMS = data.substring(8).toFloat();
  } else if (data.startsWith("Distance:")) {
    distance = data.substring(9).toFloat();
  } else if (data.startsWith("Temp:")) {
    temperature = data.substring(5).toFloat();
  } else if (data.startsWith("Humidity:")) {
    humidity = data.substring(9).toFloat();
  } else if (data.startsWith("Current:")) {
    current = data.substring(8).toFloat();
  }
}

// Send data to Blynk and update the LCD
void sendToBlynk() {
  Blynk.virtualWrite(V1, acVoltageRMS); // Voltage
  Blynk.virtualWrite(V2, distance); // Distance
  Blynk.virtualWrite(V3, temperature); // Temperature
  Blynk.virtualWrite(V4, humidity); // Humidity
  Blynk.virtualWrite(V5, current); // Current

  // Update LCD display
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Voltage: ");
  lcd.print(acVoltageRMS);
  lcd.print("V");

  lcd.setCursor(0, 1);
  lcd.print("Distance: ");
  lcd.print(distance);
  lcd.print("cm");

  lcd.setCursor(0, 2);
  lcd.print("Temp: ");
  lcd.print(temperature);
  lcd.print("C");

  lcd.setCursor(0, 3);
  lcd.print("Current: ");

```

```
lcd.print(current);  
lcd.print("A");  
}
```

APPENDIX C TURNITIN REPORT

201-33-1111

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