IoT-BASED DISTRIBUTION TRANSFORMER OPERATIONAL STATUS MONITORING AND PROTECTION SYSTEM

An Undergraduate CAPSTONE Project
By

1.	MD. ROKIBUL ISLAM	ID: 16-32960-3	Dept: EEE
2.	NAYEEM HASAN	ID: 18-37077-1	Dept: EEE
3.	AL-FAIYAZ KIBRIA	ID: 18-39148-3	Dept: EEE
4.	MD. AZIZUL HOQUE ROBIN	ID: 18-39217-3	Dept: EEE

Under the Supervision of

MEHEDI AZAD SHAWON
Assistant Professor

Fall Semester 2022-2023
August, 2022

Faculty of Engineering
American International University - Bangladesh

IoT-BASED DISTRIBUTION TRANSFORMER OPERATIONAL STATUS MONITORING AND PROTECTION SYSTEM

A CAPSTONE Project submitted to the Faculty of Engineering, American International University - Bangladesh (AIUB) in partial fulfillment of the requirements for the degree of Bachelor of Science in their mentioned respective programs.

1. MD. ROKIBUL ISLAM ID: 16-32960-3 Dept: EEE
2. NAYEEM HASAN ID: 18-37077-1 Dept: EEE
3. AL-FAIYAZ KIBRIA ID: 18-39148-3 Dept: EEE
4. MD. AZIZUL HOQUE ROBIN ID: 18-39217-3 Dept: EEE

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American International University - Bangladesh

DECLARATION

This is to certify that this project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this project has been properly acknowledged.

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Students' names & Signatures

1. **MD. ROKIBUL ISLAM**

Rokibul
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

2. **NAYEEM HASAN**

Nayeem
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

3. **AL-FAIYAZ KIBRIA**

Faiyaz Kibria
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

4. **MD. AZIZUL HOQUE ROBIN**

Robin
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

APPROVAL

The CAPSTONE Project titled **IoT-BASED DISTRIBUTION TRANSFORMER OPERATIONAL STATUS MONITORING AND PROTECTION SYSTEM** has been submitted to the following respected members of the Board of Examiners of the Faculty of Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in the respective programs mentioned below on **January 2023** by the following students and has been accepted as satisfactory.

1.	MD. ROKIBUL ISLAM	ID: 16-32960-3	Dept: EEE
2.	NAYEEM HASAN	ID: 18-37077-1	Dept: EEE
3.	AL-FAIYAZ KIBRIA	ID: 18-39148-3	Dept: EEE
4.	MD. AZIZUL HOQUE ROBIN	ID: 18-39217-3	Dept: EEE

Supervisor
Mehedi Azad Shawon
Assistant Professor
Faculty of Engineering
American International University-Bangladesh

18.01.2023
External Supervisor
Bishwajit Banik Pathik
Assistant Professor
Faculty of Engineering
American International University-Bangladesh

Prof. Dr. Md. Abdur Rahman
Associate Dean
Faculty of Engineering
American International University-Bangladesh

Prof. Dr. ABM Siddique Hossain
Dean
Faculty of Engineering
American International University-Bangladesh

ACKNOWLEDGEMENT

Gratefulness and praises go to Allah, the Almighty, for the completion of this project. We would like to express our gratitude and appreciation to our Capstone project supervisor, **Mehedi Azad Shawon**, Assistant Professor, at the Faculty of Engineering, American International University-Bangladesh, for his relentless support and constructive criticism for guiding us through our project and book.

We would like to thank our Capstone project external supervisor, **Bishwajit Banik Pathik**, Senior Lecturer, Faculty of Engineering, American International University-Bangladesh, for his immense help and encouragement.

1. MD. ROKIBUL ISLAM
2. NAYEEM HASAN
3. AL-FAIYAZ KIBRIA
4. MD. AZIZUL HOQUE ROBIN

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ABSTRACT

The power transformer plays an important role in our electrical power distribution networks. To discover the flaw exactly and recognize it, a fault detection and locating system powered by the Internet of Things was installed. It will make it possible for computer team to address these problems more quickly, insulating transformers from harm and a crash. These systems use an Arduino microcontroller, an ESP8266 module, a voltage transformer, a current transformer and temperature sensor. This system automatically locates, analyzes, and classifies problems, and then calculates the fault distance from the control room using a load mechanism. However, our durability is significantly reduced if we are faced to overloading, heating, low or high voltage/current, sudden failures, and loss of supply. To evaluate a transformer's performance and guarantee operational safety, monitoring is necessary. Therefore, it is crucial to frequently check on the loaded distribution transformer's working status. There are two forms of monitoring: offline and online. Monitoring is the observation of transformer conditions. This study presents an IoT-based system for the development of real-time transformer parameter monitoring and control. This technology uses the local transformer to diagnose problems and transmit important parameters to a centralized web server. [1]

Chapter 1

INTRODUCTION

1.1. Overture

As the nation's economy and power system have advanced and developed, reliability and safety concerns have become more crucial. If we reflect on our everyday activities, we may conclude that electricity is an important part of our lives and that transformers serve as how electricity is delivered to us from power plants. In the system for distributing electricity, the transformer is crucial.[2] Therefore, transformer protection is crucial. Applications for transformers range from tiny ventures to large corporations. The failure of the internal winding insulation is ultimately responsible for 70–80% of all modern transformer failures, according to a review of the records of these breakdowns throughout the years.[3] These turn-to-turn problems frequently progress into more significant ground faults involving the iron core of power transformers, which are more expensive to fix if they are not soon identified. In contrast, they cause the power transformer tank to arc, which causes significant damage up until the Sudden Pressure Relay trips it. Due to the growing need for a reliable power supply. Usually, it involves using several strategies for monitoring, safeguarding, and controlling processes.[4] Transformer distribution is a crucial component of distribution networks. The detecting mechanism in use has a lot of flaws. A system's effectiveness depends on several variables, including the device's instability, jamming potential, the accuracy of the data produced when it is monitored, and if the system has any impact on other systems. At the location of the distribution transformer, sensors and Wi-Fi have been placed to read and measure the physical quantity, which is then converted into an analog signal. As the parameters were utilized, the system processed and stored the data. When a distribution transformer experiences an emergency, the collected parameters detect the signal and transmit a warning to the Android app with details on the parameter signals there, as determined by the microcontroller's data. The transformer has a long lifespan while operating normally; nevertheless, its lifespan is shortened by overloading. System dependability is decreased by distribution transformer overload.[5]

1.2. Engineering Problem Statement

The project addresses the issue of the Transformer Monitoring System and Protection in Bangladesh [6]. In our Country transformer failure, oiled failure system, and transformer voltage cut down have been major problems to the main electrical distribution system. In the past, distribution networks did not use the health monitoring system very often, and flaws could only be found after a total blackout. Due to numerous losses, the distribution system suffered severe consequences. To assist develop preventative actions in advance, a trustworthy health monitoring system was therefore essential. The real method of transmitting electricity digitally is through the next-generation electric power grid or smart grid. Digital technology makes it possible for utilities and consumers to communicate with each other ingeniously on a two-way. Our idea, which is based on the online monitoring of transformers' primary operating indicators, can give utilities vital information about the health of their transformers, enabling them to use the asset more effectively and maintain it for a longer period. Transformer magnetizing inrush currents after a quick surge in the terminal voltages may result in differential currents that are many times higher than the rated level and drop to that level within a few seconds. [7] Oil transformers are used to cool the insulation that separates the winding from the transformer housing and, in the end, act as a quenching medium to put out arcs that arise at the termination points of the transformer winding arrangement. Conditions like temperature changes might cause the oil level to drop. The transformer oil will unintentionally be considerably reduced if the transformer tank has a sudden puncture. Transformer functioning is severely hampered by a drop-in transformer oil below the necessary level, which also affects the oil's cooling and insulating properties. Moisture in the winding paper might raise the danger of excessive bubbling under high load, which could result in transformer damage. to prevent the mistake that results from mistaking a non-saturated solution's moisture value for solubility. The measurement of moisture solubility in transformer oil is suggested using an alternate, simply implementable approach.[8]

1.3. Related Research Works

Power transformers, which transform voltage levels, are one of the most significant pieces of electrical equipment used in power transmission networks. As a result, power transformer maintenance is required; however, because they are typically dispersed geographically, routine monitoring is problematic owing to a lack of staff. As mentioned above, transformer failure might occur, causing the transformer from the network to power down abruptly.[9] To avoid the shutdown caused by the adapter's transformer failure, a system for transformer monitoring and self-protection was designed in case maintenance was delayed. The temperature and humidity within the transformer were measured in this work, as well as the rate of loading on the transformer.[10] A self-protection system for the transformer is created and deployed utilizing the internet of things (IoT). Whereas, if the transformer is not repaired promptly, it will separate low-importance loads (workshops, homes, etc.) and keep high-importance loads (hospitals, etc.). If the transformer is unable to feed high-priority loads, it will separate all loads and remain in a no-load state where it will monitor its parameters. If all parameters of the transformer return to normal, the transformer will automatically restore the loads in order of priority.[11] The distribution transformer is used to supply power to users. It delivers the needed voltage to customers by lowering the voltage on the distribution side. As a result, monitoring the distribution transformer is an impossible operation for the energy department to complete on aregularly2]

1.3.1. Earlier Research

Many devices and parts of electricity assist humans in the transmission and regulation of the distribution based on consumption. The transformer is the piece of machinery that is most important for the transmission and distribution of electric electricity. An electrical equipment distribution transformer in power networks directly distributes electricity to low-voltage customers, and the state of its functioning is a key requirement for the overall network's operation. A smart electronic monitoring device and an IoT device are both parts of the project and are connected to the transformer.[13] Numerous transformer characteristics, including temperature and oil level, are continually monitored by an electronic device. BUYING SOFIARTO Munir used the Fast Fourier Transform (FFT) and Hilbert Huang Transform (HHT) to locate the discrete Fourier transform and transform the vibration data into tiny intrinsic mode functions, respectively, to monitor just the vibrations of the transformer. [14] The second method for assessing the condition of the transformer uses a common tool called a neural network. This method improves the precision and dependability of the transformer's condition by providing a relationship between the dissolved gases in the transformer oil. D S Suresh used IoT technology [15] to convey parameter values and emergency conditions through SMS while monitoring a transformer using a PLC and Supervisory Control and Data Acquisition system. [16] The examination above has led to the conclusion that the systems mentioned above have certain flaws, but we can improve them to a greater extent by adopting the suggested Microcontroller-based strategy. The system that is being suggested monitors all the important parameters, sends SMS notifications through IoT, and displays the data from various multiplication of the monitoring system. [17] The health monitoring system of the transformer which has been generating and providing the electricity for the power system generation. The IoT has been auto detection level by the transformed health monitoring system including oil level, oil temperature, critical or bad impact situation formation system out of the monitoring to provide the current that has been manipulating the strong ambition of the transformer monitoring system. The power transformer is an essential component in the power generating, transmission, and distribution sections. According to records, 40% of the transformer fails due to mechanical reasons.[18] Monitoring and controlling via the internet of things may be acceptable for manual operating systems in this system. For example, utilizing manpower to check the oil level and temperature level is not practicable in the case of the manual operating system. As a result, our system is based on online monitoring, which offers essential data and information on the condition of transformers and allows utility services to remain hopeful for an extended length of time.[19]

1.3.2. Recent Research

To convert electricity from one form to another, transformers are a crucial component. If operated at rated conditions and with minimal life, distribution transformers have a long lifespan because they are overloaded.[20] The way a doctor examines a patient's many symptoms to diagnose the illness and give treatment recommendations is like how a monitoring system uses various internal and exterior parameters related to a transformer. A distribution transformer's long service life is guaranteed when it is used in rated circumstances (as per the nameplate's specifications). However, if it can be subjected to overloading, heating, and low or high voltage current, it will suffer sudden failure and lose power to many users, which affects the dependability of the system or the device. The main factors that lead to distribution transformer failure include overloading, oil temperature load current, and inadequate transformer cooling. It is challenging to manually assess the status of every transformer in the current electric networks due to the widespread distribution of the transformers. From the power management at the issues of fault analysis to the received voltage and current system protection at the same time of high voltage measurement revoke. To the power information system, the health monitoring of the other sector can be established high-performance voltage generator to place high current provider system.[21] Power carrier communication is a common way for monitoring systems to transmit data, but it has certain drawbacks, including considerable frequency interference, signal attenuation that becomes worse with distance, and significant electrical noise caused by load variations. Therefore, real-time data transmission dependability cannot be guaranteed if power carrier communication is used to deliver the data.[22] Smart distribution transformers are required in the future trends of power systems since energy transmission will be digitalized in the future. As a result, people will connect the utility and consumers by measuring such parameters as voltage, current, the temperature of a winding, and the and oil Level of a transformer using various sensors, and in future trends, various updates may be discovered towards the revolutionary perfect system.[23]

1.4. Critical Engineering Specialist Knowledge

The most important part of this project is the power of the gadget, which has a lot of requirements and rules that it must abide by. For instance, to power our system, our gadget only needs a tiny bit of electricity from the power wires themselves. Safety was the main goal due to the risks associated with operating near high-voltage power lines and the potential for external contact. When the sensors used in a monitoring system are precise and accurate, the system is effective.[24] Due to this, the sensors had to be incredibly accurate in detecting the required information for our system to properly live up to professional quality. There are three sensors in total that measure the temperature within the transformer as well as the voltage and current flowing across the lines. The transformer line distribution system has been revoked the high-frequency system to generate low power consumption. Moisture in the winding paper might increase the danger of excessive bubbling at high loads, which could result in transformer damage. The transformer oil would unintentionally be considerably reduced if the transformer tank sustains a sudden rupture. Transformer functioning is severely hampered by a drop-in transformer oil below the necessary level,[25] which also affects the oil's cooling and insulating properties. To improve this section of the transformer quality management to manipulate the electricity to the product service outage reference to the power generation multiplication by the most of engineer's accusation information detect at the service design control monitoring or the health monitoring system.[26]

1.5. Stakeholders

The complex combination of paraffinic, naphthenic, and aromatic chemicals that makes up transformer oil. Undoubtedly, as oils age, the chemical structure and makeup of the molecules change. Therefore, NMR spectroscopy has been used to determine the chemical makeup of the thermally aged oils.[27] The government, companies operating in the electricity industry, consumers, and manufacturers are currently the key players. Government, power utilities, monitoring and aggregator manufacturers, policymakers, and owners must all actively participate if power transformer technology is to be effectively used.[28]

- All the manufacturers acknowledge the need to build and sell low- and high-performance transformers, and electrification of the drivetrain is a significant component of their expanding product ranges.

- Currently, utility-scale, and distributed energy storage are employed for their most basic capabilities, including stepping in when energy demand peaks and aiding in grid stability through services such as power generation mode at the state of current and voltage propagation.

- It is responsible for protection as per temperature, overhead voltage, and oil breakdown system has been trapping out the most comm tricks power consumption loss or efficiency up-down demonstration to the supply voltage in the transformer accusation technology.

- The owners are the ones that this project serves the most because the project's objective is to give different sorts of transformer health monitoring systems and control the protection. In IoT-based data multi-plication of the server integrated system to down the current and voltage provider system.

1.6. Objectives

The main objectives of this work are divided into two sections:

1.6.1. Primary Objectives

The main objectives in bullet points

- Construct an IoT Based Transformer Health Monitoring and Control system device to project the power of the Transformer.

- perhaps the entire condition of the distribution transformer could be continuously monitored by this equipment.

- processing the system that consists of a single-chip microcontroller, an IoT modem, and sensors.

1.6.2. Secondary Objectives

The secondary objectives are as follows:

- Finding the precise cause of the transformer system's failure might be possible with the help of this system.

- Either the transformer monitoring issue shorting out for various causes determines the technical support system from the health monitoring system.
- Here the overall system manages load balancing, which raises the material cost of the sub transformers.

1.7. Organization of Book Chapters

Briefly discussed how the contents of the book have been arranged chapter-wise. Provide details on how the contents are continued and the interconnection between the chapters.

Chapter 1: Introduction
Chapter 2: Project Management
Chapter 3: Methodology and Modeling
Chapter 4: Implementation of Project
Chapter-5: Results Analysis & Critical Design Review
Chapter-6: Conclusion

Chapter 2

PROJECT MANAGEMENT

2.1. Introduction

Power system protection is a vital factor to safeguard electrical components from defects to improve their lifetime, postpone unnecessary replacement costs of damaged ones, and ensure supply continuity to meet rising demand. The primary goal of this study is to create an IoT (Internet of Things)-based system that can be used to safeguard the transformer by monitoring and managing the working parameters, such as current value, oil level, and so on, and reporting on the same. This system is developed in such a way that it can detect parameters that are over the normal preset level and warns the user of the need to disconnect the transformer from the distribution line.[29] This procedure protects the transformer from any abnormal situations. As a result, this study covers the creation of online monitoring and management of problems in a transformer, as well as alarms. This internet of things system is installed at the transformer base, and the parameters are regularly checked and communicated to a centralized web server. Thus, the data are used to determine the transformer state in real-time and are saved in a server database for further study.[30] Many advancements in communication and hardware technology have been made; one potential example is IoT technology, which ranges from home automation to industrial IoT. The Internet of Things (IoT) is a new technology that has been a hot issue in recent years. There is a lot of literature on monitoring, regulating, and safeguarding transformers, and a lot of work has been done in this field.[31] A microcontroller-based system for monitoring and saving the substation transformer from current increase due to overload is presented [32]. A PLC-based automated control system was designed to monitor and identify internal and exterior defects in the transformer. To deliver the message to the electrical board, [33] presented a protection system that included a temperature sensor, microprocessor, LCD, GSM, and XBEE. For transformer protection, a typical fault-detecting approach was used. Because of the enhanced benefits, transformer failure monitoring based on vibration analysis is currently attracting the attention of academics.[34]

2.2. S.W.O.T. Analysis

SWOT analysis is a strategic planning technique that is used to evaluate a project's strengths, weaknesses, opportunities, and threats. It requires deciding on the project's goal. It also includes identifying internal and external effects. Those components are beneficial and those are detrimental to achieving that aim. It is vital to underline barriers and future possibilities while also recognizing defects and potential hazards so that steps may be done to address them. SWOT analysis highlights each of these components.

Strengths

- Four types of sensors can measure and control transformer load systems and health monitoring systems to reduce power system losses.
- The entering of the system of the device has been safe by the uses IOT server to monitor the whole system at the most uses power symmetric observation.
- To convert the system of AC to DC the short process to merge the main switch for control load and voltage.

Weaknesses

There are some areas where the project lags.

- Power transformer efficiency is great, especially for big transformers at full load. All transformers, however, have losses. These losses can be divided into two categories: copper or I2R losses and core or iron losses.
- To manufacturing line or the power system may be completely shut down for a considerable amount of time due to some transformer faults.
- The proper connection losses have been interrupted by the voltage or current sensor feedback output system.

Threats

- For high voltage and high load transformers, this device has revoked the measuring data to the up and down voltage ratio of the transformers.

- Power carrier communication has certain drawbacks such as significant frequency interference, increased signal attenuation with increasing distance, and significant load variations resulting in huge electrical noise.
- The system module of this device has not properly maintained the large-scale transformer for the input and output data visualization.

Opportunities

- About this system is the least expensive type of maintenance
- Consuming and saving manpower
- Conducting the monitoring process has spared the system from unnecessary shutdowns.
- To express the performance of maintenance only when it is needed, unnecessary inspections.

2.3. Schedule Management

Project scheduling, which is equally important as cost planning, determines the timeline, resources necessary, and realities of project delivery. A proper project schedule demonstrates task identification, identification, analysis, documentation, and prioritizing. A Gantt chart is a project management tool that may aid with project planning and scheduling.

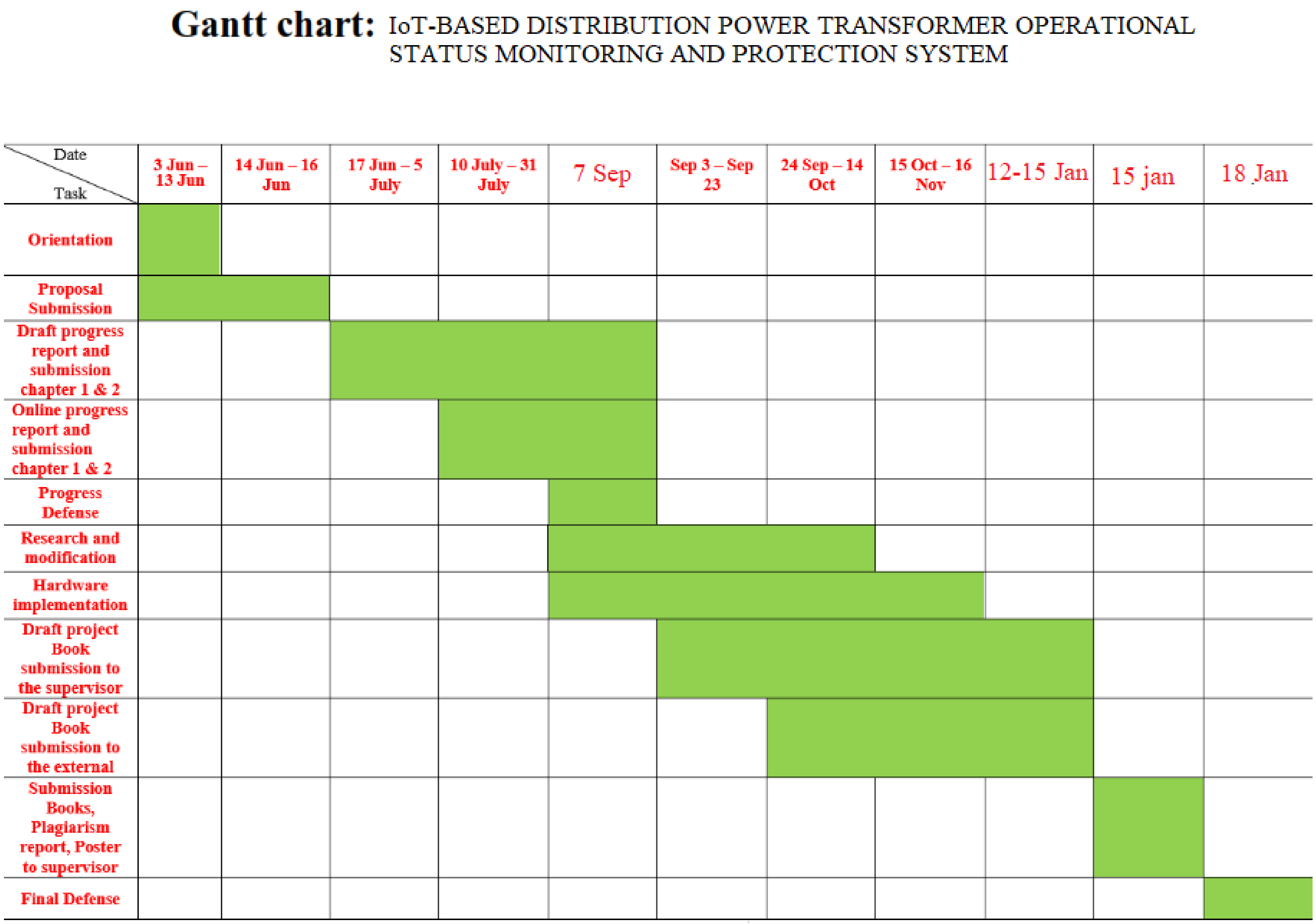

Figure 2.1: Gantt chart for schedule management

2.4. Cost Analysis

In our whole project work the all equipment and components represent this table 2.1 comparatively precise the setup section and headwear implementation.

Table 2.1: Whole project cost analysis

S/L	Name Of Components	Quantity	Price
01	Arduino nano	1pcs	880/-
02	LCD 20,4	1pcs	750/-
03	Transformer	3pcs	450×4=1400/-
04	wire	30ft	350/-
05	Solar panel	1pcs	450/-
06	I2C	1pcs	250/-
07	Vero board	2pcs	160/-
08	MCB Switch	1pcs	1150/-
09	Battery 5v	1pcs	980/-
10	Diode	12pcs	50/-
11	Node MCU	1pcs	740/-
12	12-volt bulb	3pcs	450/-
13	Switch	4pcs	40/-
14	PVC	5ft	500/-
15	Really module	1pcs	150/-
16	Glue stick	4pcs	120/-
17	Super glue	2pcs	50/-
18	Lead	15pcs	100/-
19	Current Transformer	3pcs	350×3=1050/-
20	Transistor	5pcs	50/-
21	Pir motion sensor	1pcs	250/-
22	DHT11	3pcs	600/-
23	Buzzer	1pcs	50/-
24	Resistor	15pcs	15/-
25	LM7812	3pcs	150/-
26	Capacitor	3pcs	60/-
27	LED	5pcs	10/-
22	Other	------------	1000/-
	Total	Total = 94	Total = 12105/-

2.5. P.E.S.T. Analysis

A PEST analysis is a strategic tool used by us to discover, evaluate, organize, and track macroeconomic factors that can impact our project now and in the future. The framework examines opportunities and threats due to political, economic, social, and technological forces.[35] A smart IoT-based fault detection and locating system was utilized to indicate and pinpoint the exact position of the defect. It will allow the technical personnel to respond more quickly to these errors, perhaps saving transformers from damage and crash. Political, Economic, Social, and Technological analysis is known as PEST analysis. This kind of study is used to evaluate outside variables that can affect a company's profitability. With bigger firms, which are more prone to feel the consequences of macro events, it is often more successful.

Political

A current transformer, a voltage transformer, an ARDUINO microcontroller, and an ESP8266 module are used in these systems. This system discovers defects automatically, analyzes and classifies them, and then determines the fault distance from the control room using an impedance-based algorithm technique. The control room receives the fault information. Finally, the time necessary to find a defect is drastically decreased since the system instantly and precisely offers correct fault location information. [36] Every aspect of our lives is dependent on energy. Electricity contains numerous components and equipment that assist humans in transferring and regulating distribution based on consumption. The transformer is the most important piece of electrical power transmission and distribution equipment. An electrical equipment distribution transformer directly distributes electricity to low-voltage users in power systems, and its functioning state is an essential indicator of overall network operation. [37] The vast majority of these devices have been in use for many years in various (electrical, mechanical, and environmental) circumstances. They are the primary components and account for a significant amount of capital investment. The operation of distribution transformers under rated conditions (as specified on their nameplate) ensures a long service life. However, if they are subjected to overloading, heating, and low or high voltage/current, leading to sudden failures and loss of supply, their life is drastically shortened.[38]

Economic

An IoT device and a smart electronic monitoring device are coupled to the transformer in the project. The electronic equipment continually monitors many transformer characteristics such as temperature and oil level. If any of the criteria fails, the system reacts quickly and generates a notification, which is automatically communicated through an IOT device to the government web page (ex. Blink).[39] Up until it reaches zero value or its salvage value, which is an estimate of the asset's value at the time it will be disposed of and may be zero, it loses a portion of its value each year. Depreciation cost is the annual lost portion of the asset cost. When an asset depreciates to zero or its salvage value, its lifetime is over. In the literature, the idea of depreciation is frequently debated.

Social

Most of the transformer solid insulation is made of paper-based cellulose. The primary cause of a transformer's physical demise may be attributed to the cellulose molecules' chemical alterations in the presence of heat, oxygen, water, and other substances, which lead to the electrical and mechanical deterioration of the insulating paper. Transformer loss is the capacity of the solid insulating material to sustain the intended stresses over time, including electrical, mechanical, and thermal ones. Until the asset wears out, the capacity of the insulating material to endure the aforementioned pressures remains constant or only marginally declines over time. At that point, the ability diminishes quickly. Transformer deterioration can be impacted by abnormal operating circumstances, such as prolonged periods of recurrent overloading and non-sinusoidal loads.

Technological

Transformer life management has become more popular recently for both technical and financial factors. Physical and economic lives are covered in some detail in the following subsections because, as was indicated in previous section, they are more important than technical lifetimes. The shortcomings of the models are discussed, along with reviews of the current end-of-life and successor versions. Additionally, the shortcomings of the few existing methods for determining the health index of operational transformers are discussed. The major objectives of the research in the thesis are to address these shortcomings in the current models of transformer physical and economic end of life as well as transformer health indexing. The other sections of this Chapter provide an overview of recent studies on the determination of the transformer health index and health state, as well as assessments of the physical and financial end of life of transformers.

2.6.Professional Responsibilities

2.6.1. Norms of Engineering Practice

The power transformer is an essential component of the power system network. The condition monitoring of oil-filled power transformers is now the most important requirement for their reliable operation and quality power delivery to utilities. The aging state of the dielectric liquid used for insulation and cooling can be utilized to determine the condition of such a transformer. Though dissolved gas analysis has received high praise in the field of transformer failure diagnostics, it does have certain limitations, such as the requirement of carrier gas and regular calibration.[40] Microcontroller-based systems provide real-time data monitoring, abnormal condition detection, high processing speed, inexpensive installation and maintenance costs, and increased adaptability. The current sensor detects the amount of load current at the distribution transformer's secondary.[41] The controller processes the current sensor data to determine the load current value. If the load current exceeds the pre-set value inside the controller, the relay is immediately activated. As a result, the load is isolated from the transformer, and the load current is reduced to zero. As a result, the transformer is shielded against damage caused by overloading. The load current readings are continually sent to the LCD and Android monitoring apps. The IoT module with WIFI delivers current values to the Android application.[36] If the detected load current value exceeds the predetermined value inside the controller, the system is intended to separate the load from the transformer. The system is also intended to use the IoT module to deliver the values of sensing load current and load conditions to the Android phone. [42] This circuit is intended to detect overloading and safeguard the transformer from harm caused by overloading. The load's reference value is set here. If the load exceeds the reference value, the microcontroller sends a trip signal to the transistor, causing the relay to trip in milliseconds. When the relay trips, the transformer is separated from the load. [43]

2.6.2. Individual Responsibilities and Function as Effective Team Member

Table 3.1: Individual Responsibilities

NAMES	RESPONSIBILITIES
MD. ROKIBUL ISLAM	• Reviewed papers for literature review • Wrote chapters 2,3 & 6 and parts of chapters 1 & 5 of the book • Designed the 3D model • Worked on hardware implementation • Prepared the presentation slides
NAYEEM HASAN	• Worked on literature review and report analysis research • Simulated the project • Did troubleshooting the result and Simulink design of it • Gathered all components and implemented hardware prototype model • Wrote chapters 1, 4 & 6 of the book
AL-FAIYAZ KIBRIA	• Solved simulation problem output to measure the output data • Reviewing papers for literature review • Wrote chapters 3, 2 & 6 of the book • Implemented hardware and prepared components for the project. • Researched project management
MD. AZIZUL HOQUE ROBIN	• Provided project idea • Simulated the project • Did troubleshooting the result and Simulink design of it • Prepared all calculations and set up project implantation • The implemented hardware part of the project • Wrote chapters 1, 4 & 6 & parts of chapter 5 of the book • Measured all data input and output of the project

While accountability is critical to the success of any project, it does not imply that a project manager must micromanage or browbeat workers into doing their jobs. Instead of being the sole one holding people accountable, such tactics usually foster dissension and resentment against the project manager, which is a superior strategy the project manager may employ. Our project team comprises four members, each of whom offered leadership for a certain phase because the project required us to go through several parts. Because our project is hardware-based, we had to take several efforts to work as a team and generate a great result. Our assignment was finished on time and to perfection owing to everyone's equal participation and knowledge of the situation. We had to go through proper planning from the beginning to make the project stand out, such as inventing project ideas, holding a kickoff meeting, emphasizing the interconnectedness of tasks, obtaining public commitments on action items, publicly following up on action items, confronting performance issues, escalating performance issues as needed, hardware foundation works, book writing, book researching, researching required book template's points, properly arranging. Individual accountability for each member of our team, as well as their leadership and equal performance, is now reflected here.[44]

2.7. Management Principles and Economic Models

Projects are all about planning to complete something with a specified end goal and a few milestones along the way within a specific time frame. The project lifetime includes initiating, planning, executing, and closing. Project management is essentially the process of ensuring that the project lifecycle proceeds smoothly by charting the path and addressing obstacles along the way.[45] In light of this project, the software and hardware implementation followed the methods outlined above. Both implementations encountered a few stumbling obstacles. Dealing with the current sensor of the interpreter voltage from the device ESP8236 for connecting the server error to fix down the major implanting on the full process of the management system. A prototype model was created in software to visualize the general structure of the hardware assembly process. The prototype model was constructed by planning and adhering to the strategic management process, and the ultimate aim was met. In the suggested method, an oil level sensor is installed in the transformer's tank. A float is used to measure the amount of oil. The float indicates the oil level, and the analog output voltage reflects this. This output voltage was sent to the microcontroller's sensor.[46]

2.8. Summary

As one of the most critical devices in the power system, the power transformer must be safeguarded from turn-to-turn problems. Although several approaches for transformer protection based on terminal currents and/or voltages have been given, flux-based solutions can provide more precise, sensitive, and secure outcomes.[47] Because any problem in the transformer windings would disrupt the symmetrical shape of the magnetic flux distribution, it may be regarded as an adequate requirement for achieving a good protection algorithm that can detect the fault occurrence and identify the faulty phase/region. Internal transformer faults frequently include many rotations. While the currents in the shorted turns are enormous in magnitude, the variations in currents at the transformer terminals are small in comparison to the transformer's rating.[48] This underlines the requirement for protective systems with great sensitivity and quickness. An examination of contemporary transformer breakdown records over a period of years revealed that internal winding insulation failure is ultimately responsible for 70% of overall transformer failures.[49] If not found early, these turn-to-turn faults frequently progress to more significant and expensive to fix ground faults affecting the power transformer iron core. Alternatively, they induce arcing within the power transformer tank, causing extensive damage until the Sudden Pressure Relay trips.[50]

Chapter 3

METHODOLOGY AND MODELING

3.1. Introduction

Transformers are the most important component of a power system. Any damage to a transformer disrupts the electricity system's equilibrium. Damage is mostly caused by overloading and poor cooling. The primary goal of employing IoT technology is to monitor the health of the distribution transformer in real-time. A transformer's properties, such as temperature, voltage, current, and oil level, are monitored, analyzed, and recorded on servers. We employ sensors connected to an Arduino ATMEGA2560 for this purpose. The recorded data may be transferred via a Wi-Fi module and viewed using IoT technology from anywhere in the globe. This aids in spotting human reliance and resolving an issue before it becomes a failure in the absence of human supervision.[51] Electricity contains numerous components and equipment that assist humans in transferring and regulating distribution based on consumption. The transformer is the most important piece of electrical power transmission and distribution equipment. The operation of distribution transformers under rated conditions (as specified on their nameplate) ensures a long service life. However, if they are subjected to overloading, heating, and low or high voltage current, leading to sudden failure and loss of power to a large number of consumers, their life is dramatically shortened, impacting system dependability. Overloading, oil temperature load current, and inefficient transformer cooling are the leading causes of distribution transformer failure.[52] Because current electric systems have a huge number of transformers scattered across a big region, it is impractical to manually measure the status of every single transformer. As a result, we require a distribution transformer system to monitor all critical parameters and deliver them to the monitoring system on time. It offers the required information regarding the transformer's health. This will assist and advise utilities in making the most use of the transformer and keeping it operational for a longer length of time. The primary goal of the project is to collect real-time data from a transformer remotely through the internet, which falls under the umbrella of the Internet of Things (IoT).[53]

3.2. Block Diagram and Working Principle

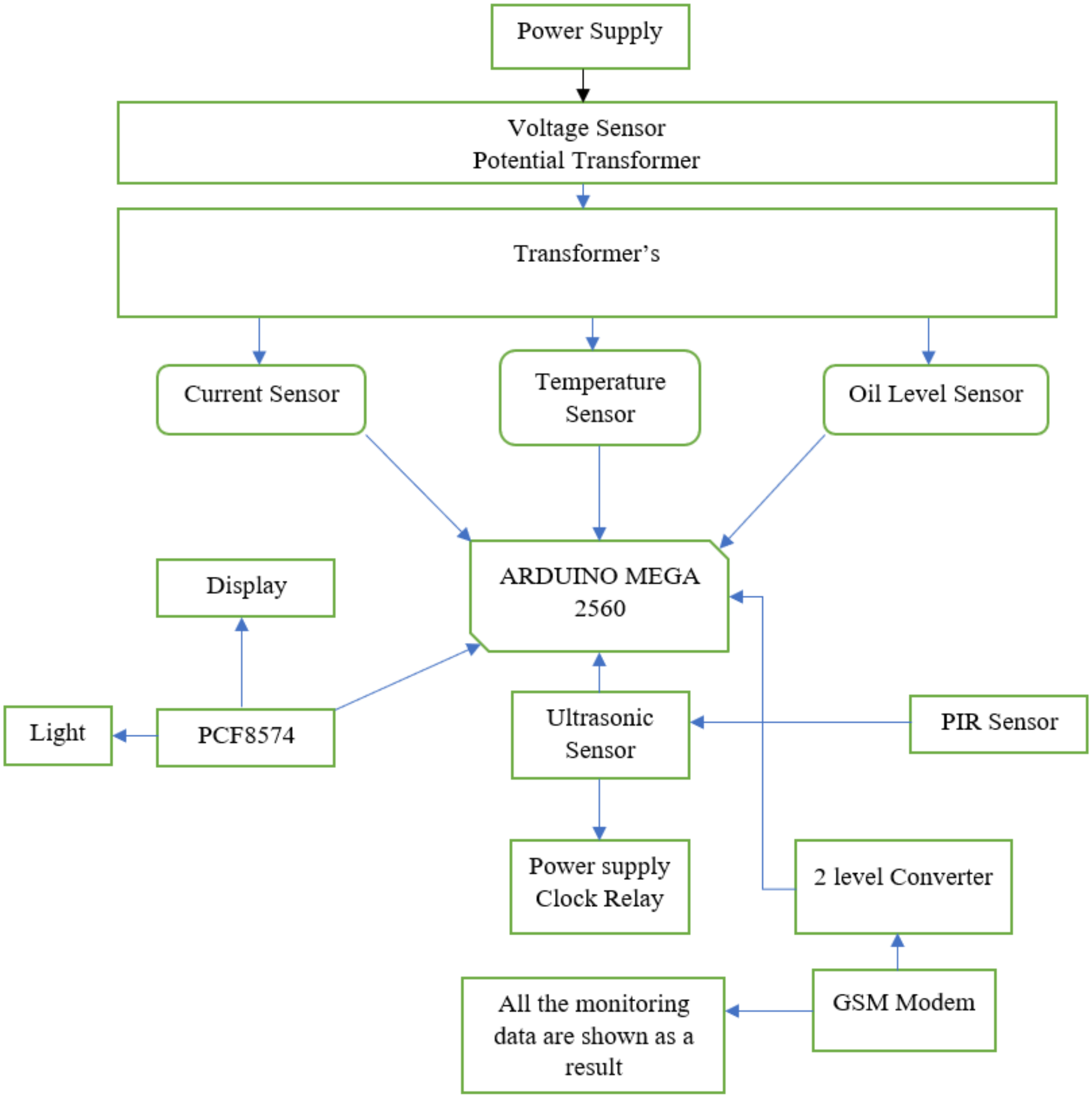

Figure 3.1: Block diagram of the whole Procedure

The block diagram in fig.1 indicates that the gadget used for invigilating (monitoring) must be located near the transformer itself. The blocks in the block diagram analyze several parameters that communicate the transformer's health. Furthermore, the suggested system includes a health monitoring system for the distribution of a transformer, which provides us with data on different transformer characteristics.

Working Principle

A distribution transformer is a step-down transformer that supplies power to consumers, such as those in homes or companies. Distribution transformers might encounter a variety of problems if their health is not monitored regularly.[54] Here in our prototype model, we made the connection in a sub-ordination circuit insister to the circuit demonstration. There are many components used to connect the bridge. We set up an MCB switch from grid-to-grid connection for safety issues. In MCB switch trip on the relay which is controlling the switch mode of the system. The relay output feedback has been connected by the voltage divider to connect the step-down transformer which is 220V 1A connected to three same modules. To get rid of the system, connection in a current transformer in three same modules which connected to the 3 LED light current loads. Besides, the solar panel is gotten to the converter into the AC/DC voltage connection term the output connection involved Arduino which gets to the system operator mode programming. The current load gets into the connected source of Arduino Mega where we get the 4 types of sensors are input to get output from the microcontroller. Several times we mention that it’s our IoT-based prototype so we used ESP8266 to set up an online platform server to handle this monitoring system. The motion sensor, voltage sensor, current sensor, and temperature sensor output get into the ESP8266 pinout form. In the meantime, the buzzer has connected the load of voltage and current sensor to monitor the oil level detection from the motion sensor. When the connection on board the MCB switch are on the whole continue with all component and get the display server of this delay time is 0.6 second. If the oil level detection is full the sensor pushes the data into Arduino and it will update the server on ESP8266 online we get messages or information about this the buzzer will alarm at that time. After that, we can see the display of all output about the sensor and others informed about the transformer’s health. In case of emergency backup, we made the optional system of solar panels to consume the transformer health monitoring system.

3.3. Modeling

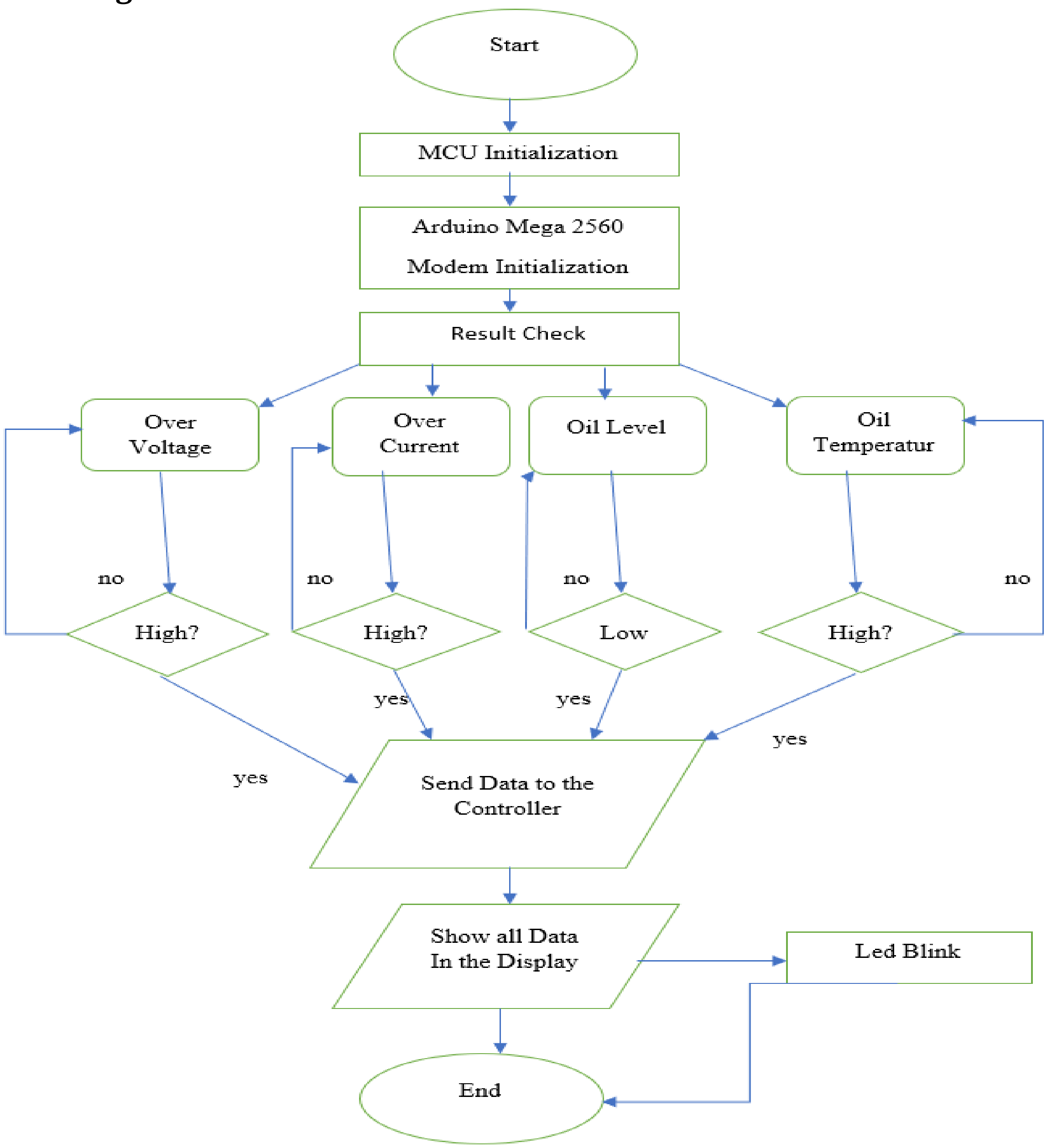

Figure 3.2: Flowchart of the proposed mode

In our hardware model prototype, the 3D or 2D model is not available. For this reason, to get the modeling part of understanding the whole process we get it into the flow chart system here. About this flow chart diagram, this prototype system has been easier to get understand as we present it.

3.4. Summary

It is utilized for power distribution as well as electrical isolation. The high-voltage transformer is a type of electrical transformer that has the greatest voltage and current ratings, as well as the highest power, voltage, and current ratings.[55] Electrical energy is transported through electrical transformers, which are used to deliver electricity from power plants to homes and businesses. We are employing sensors to check the transformer's health to protect it and provide timely service to the users. The ARDUINO Microcontroller board is used to monitor factors such as temperature, oil level, current, and so on. [56] Continuous monitoring is carried out, and if any parameter exceeds the defined limit, the transformer is disconnected, and information about this is provided on the web page, where authorized personnel may take the required action. [57] We will install server modules in all distribution transformers to receive and save transformer parameter information in a database application regularly. This database can be a valuable resource for engineers. The utility may monitor the operating behavior of its distribution transformers and identify defects by analyzing the recorded data.[58] We created a transformer monitoring circuit. We can find out whether the transformer is in bad shape from any place. There is no need for human intervention to monitor the transformer. When the transformer is in an abnormal state, the information on the webpage and SMS message is automatically updated.[59]

Chapter 4

PROJECT IMPLEMENTATION

4.1. Introduction

The detecting system is rather inconsistent. The performance of a system is determined by a variety of elements, including device instability, jamming capability, and the outcome of data accuracy when data is assessed, which is low or has no influence on another system. The transformer measuring system simply monitors one transformer parameter, such as current, voltage, power, and phase. There are methods for detecting several parameters, but the testing speed is slow, and the operation parameters are too long to manage with such speed.[60] Because monitoring centers will get detection data late, the three-phase equilibrium of distribution transformers cannot be determined. The monitoring system can check the status of an operation or defend against power theft, but it cannot month it or the data of transformers related to consumers to minimize costs. Many monitoring systems utilize power carrier communication to deliver data, however, there are certain drawbacks to employing power carrier communication: substantial frequency interference, signal attenuation as distance rises, and considerable electrical noise as the load varies. If carrier communication is employed to deliver real-time data, consistent satisfactory outcomes are not assured.[61] Based on the needs listed above, there is a growing demand for a real-time distribution transformer monitoring system. A system that detects all operational parameter operations and sends real-time data to the monitoring center. As a consequence, critical operational parameters are monitored to give functional data for the life of transformers, allowing the transformers to be used optimally and the asset to remain operational for an extended period. It will also assist in identifying problems before failure, saving money, and achieving more consistency.[62]

4.2. Required Tools and Components

IoT-based transformer monitoring system and protection in which people can control the system anywhere. Tools and components required to execute the project:

1. Arduino Mega
2. LCD Display (20×4)
3. Transformer
4. wire
5. Solar panel
6. I2C-LCD Adapter Module
7. Vero board
8. MCB Switch
9. Battery 5v
10. Diode
11. Node MCU
12. 12-volt bulb
13. Switch
14. PVC Board
15. Really module
16. Glue stick
17. Superglue
18. Lead
19. Current Transformer
20. Transistor
21. Pir motion sensor
22. Sensor DHT11
23. Buzzer
24. Resistor
25. Sensor LM7812
26. Capacitor
27. LED

4.3. Implemented Models

4.3.1. Simulation Model

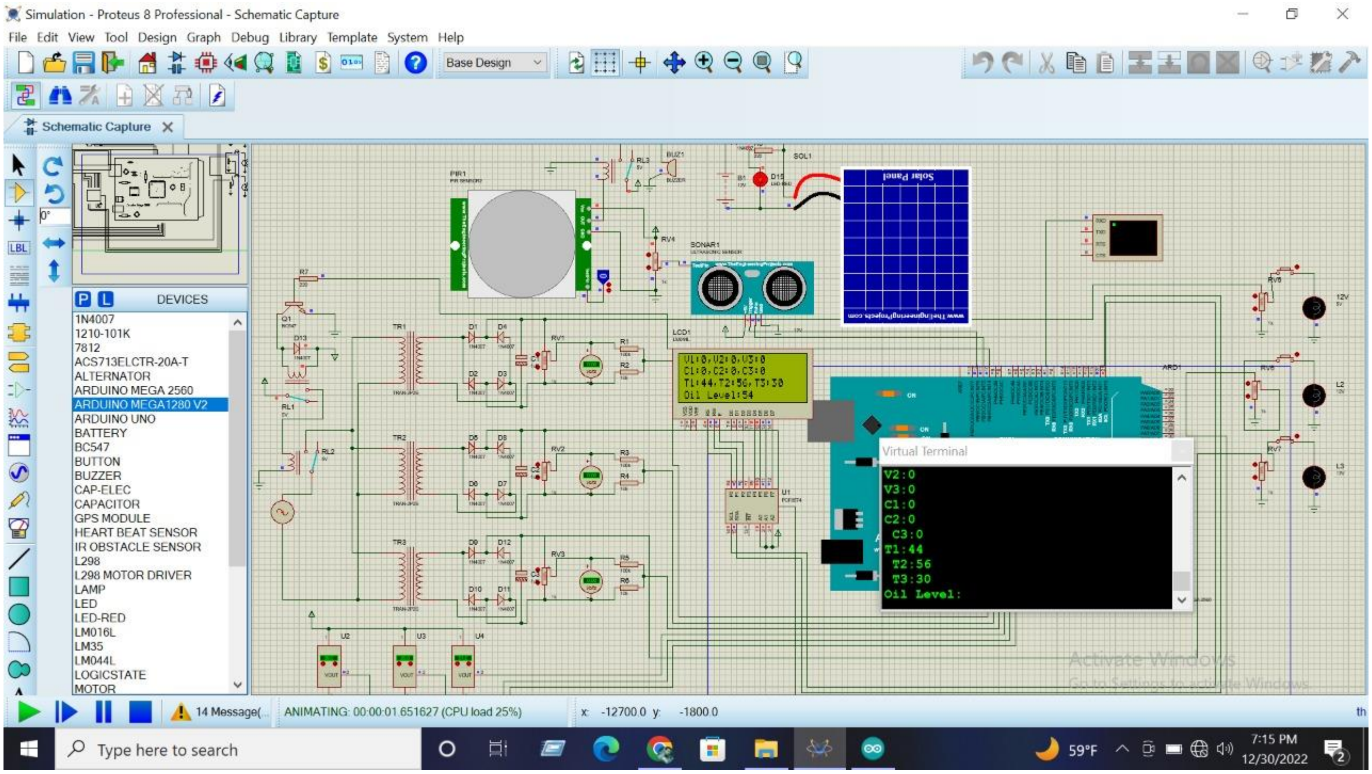

Figure 4.1: Off/On detection system

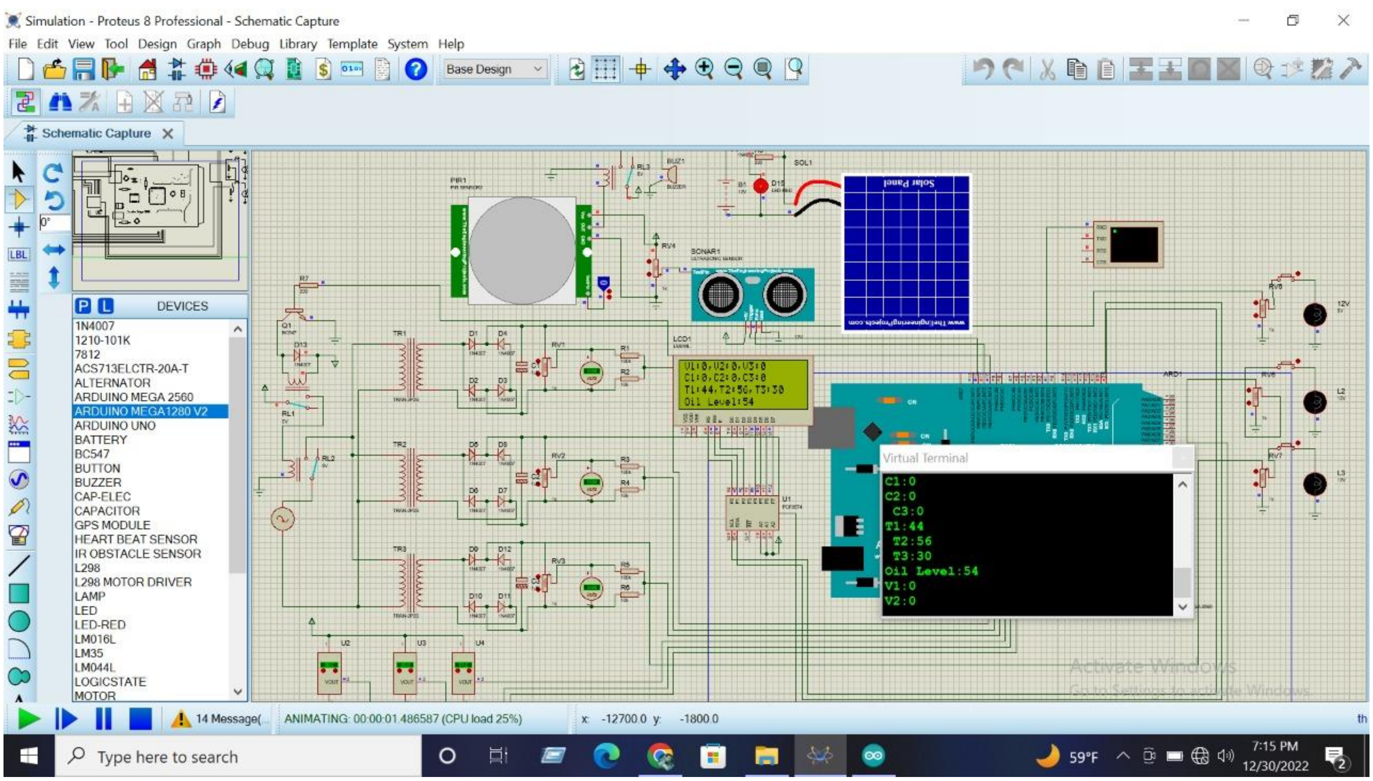

Figure 4.2: Simulation Running and display showing Output

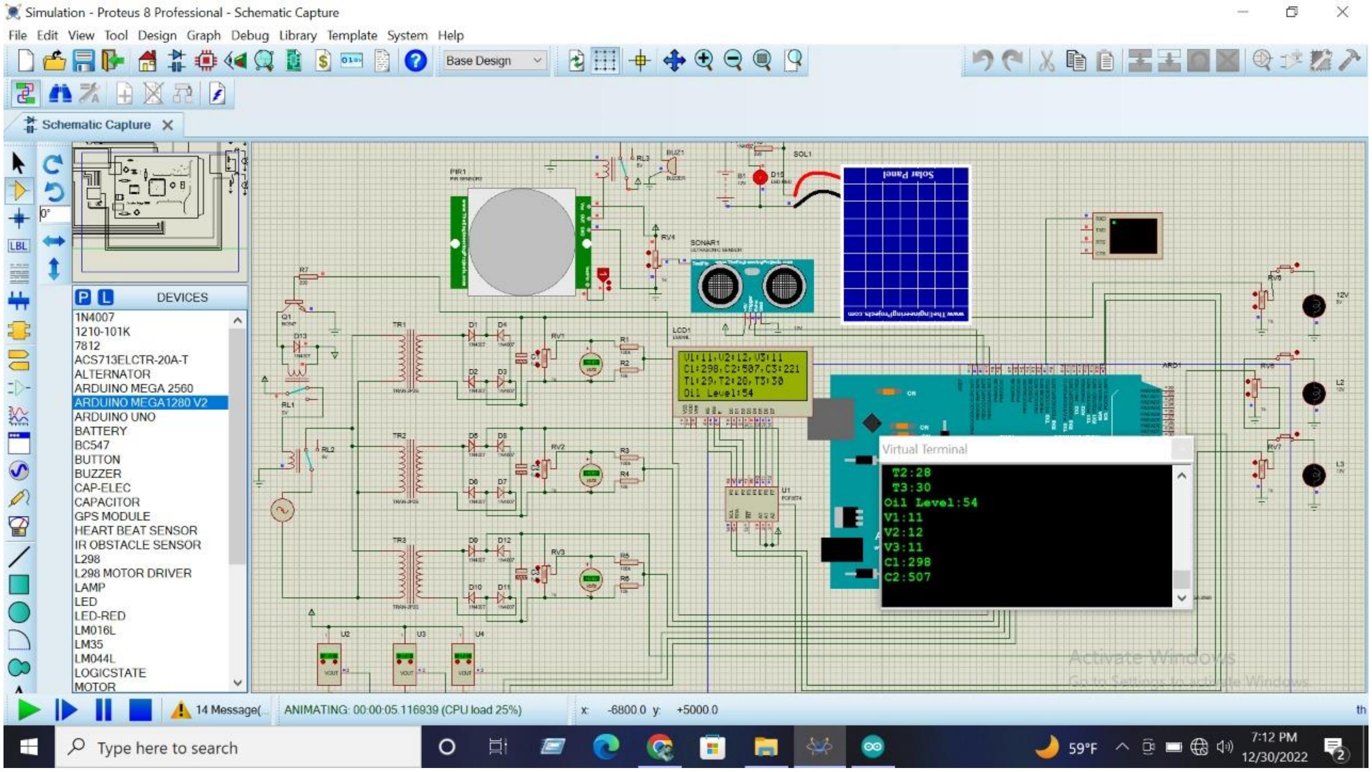

Figure 4.3: Simulation Running and display showing Output

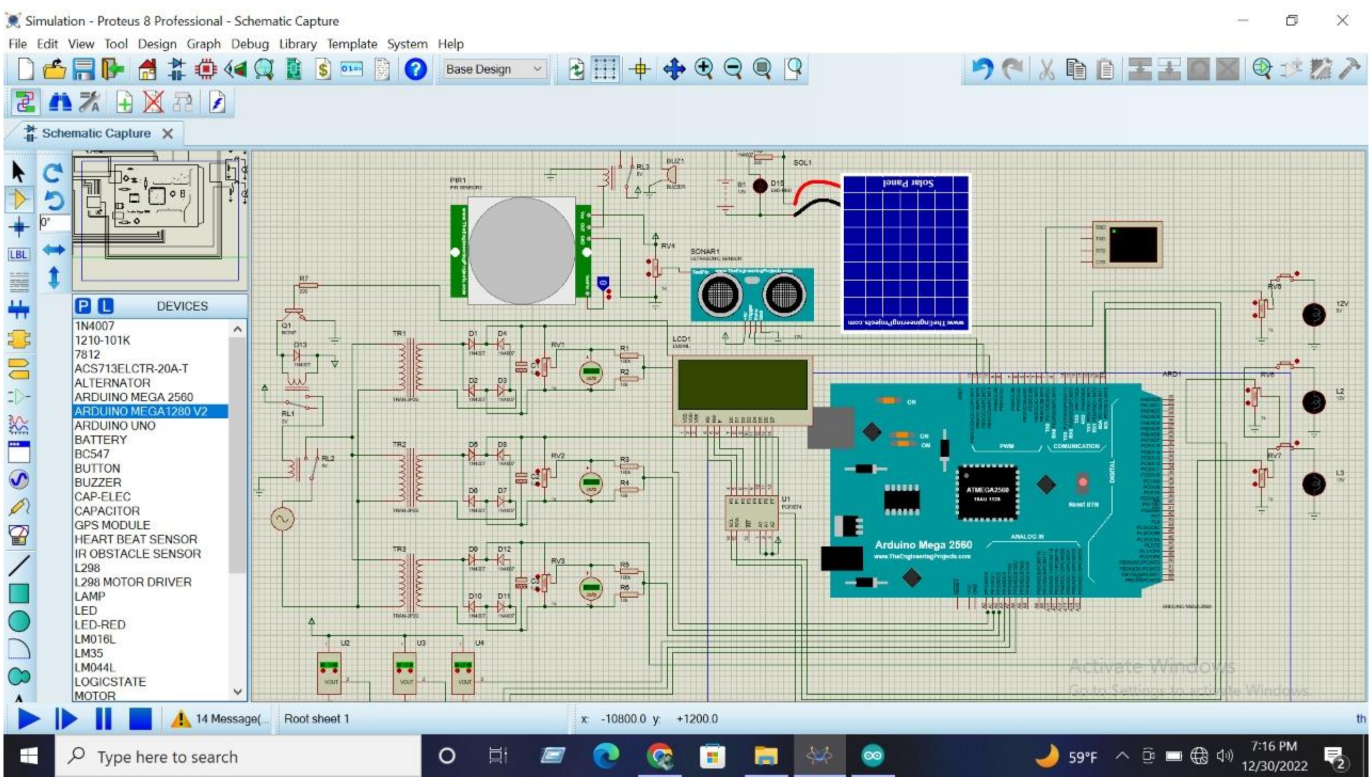

Figure 4.4: General simulation off mode

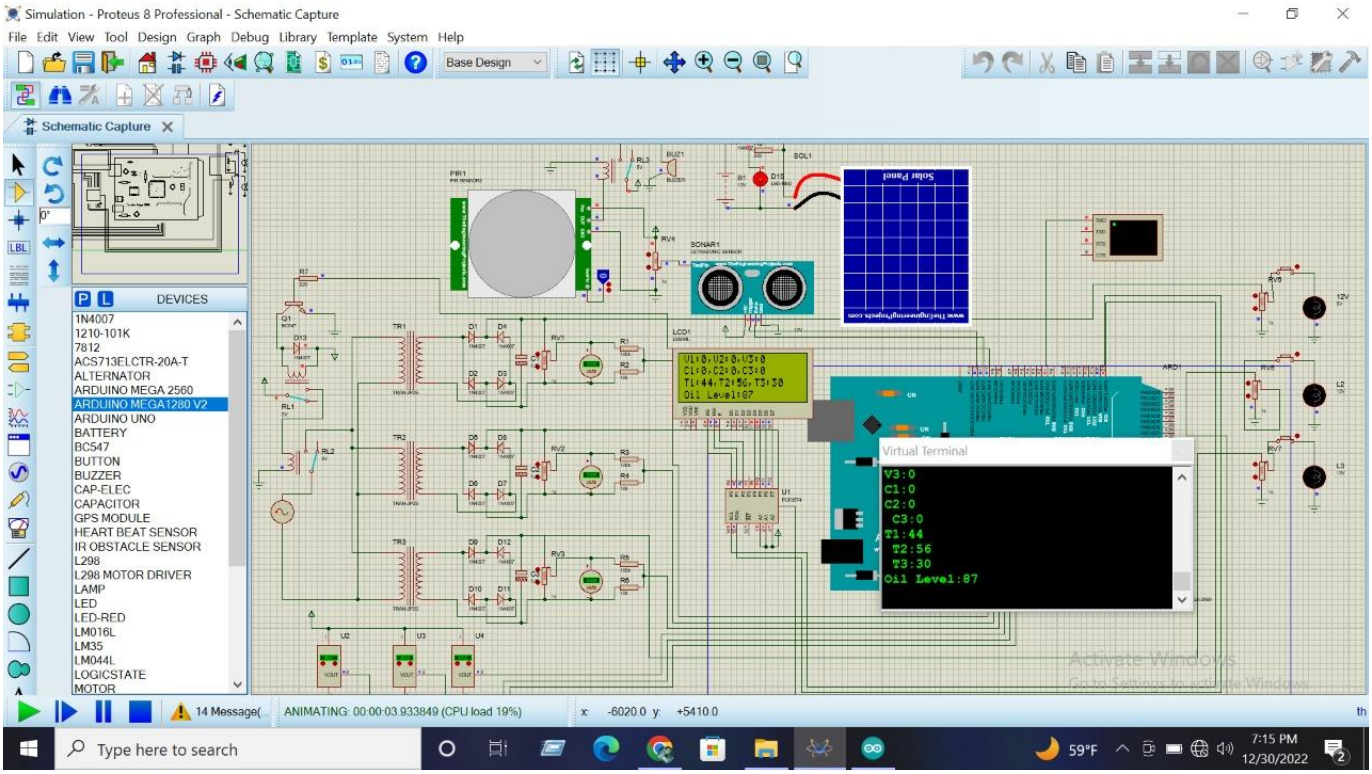

Figure 4.5: detection mode when program running with IoT

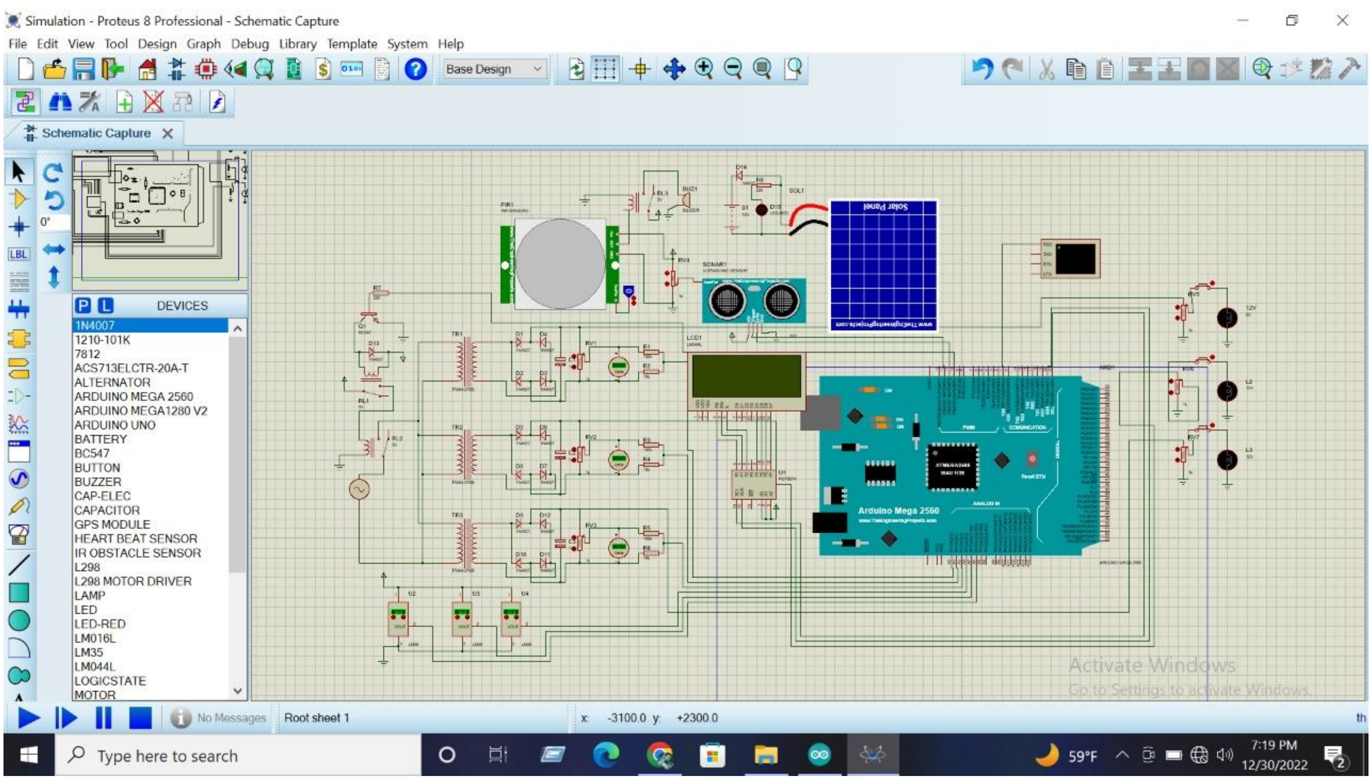

Figure 4.6: Charging circuit in different settings with IoT

4.3.2. Hardware Model

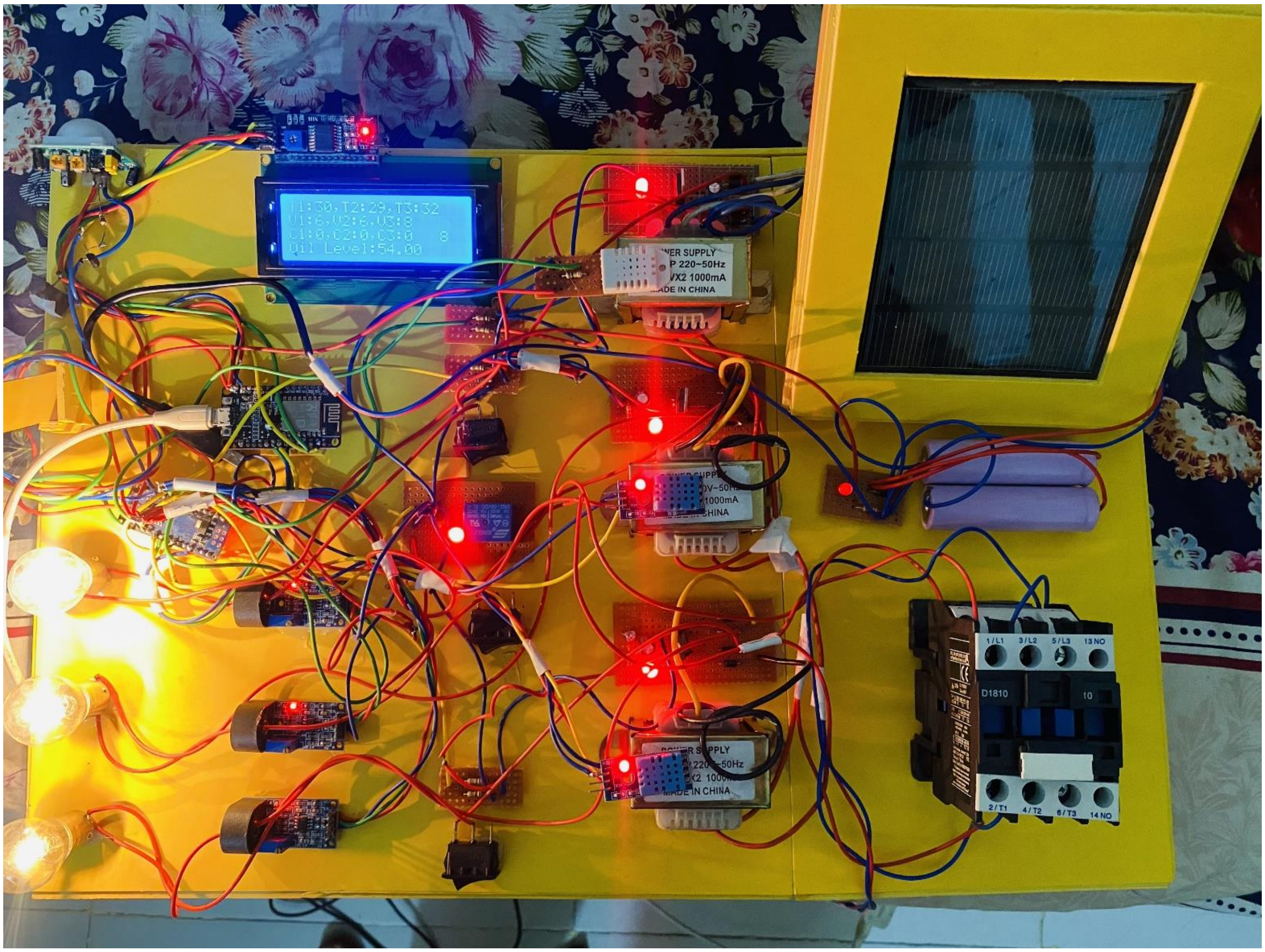

Figure 4.7: The prototype of the running system

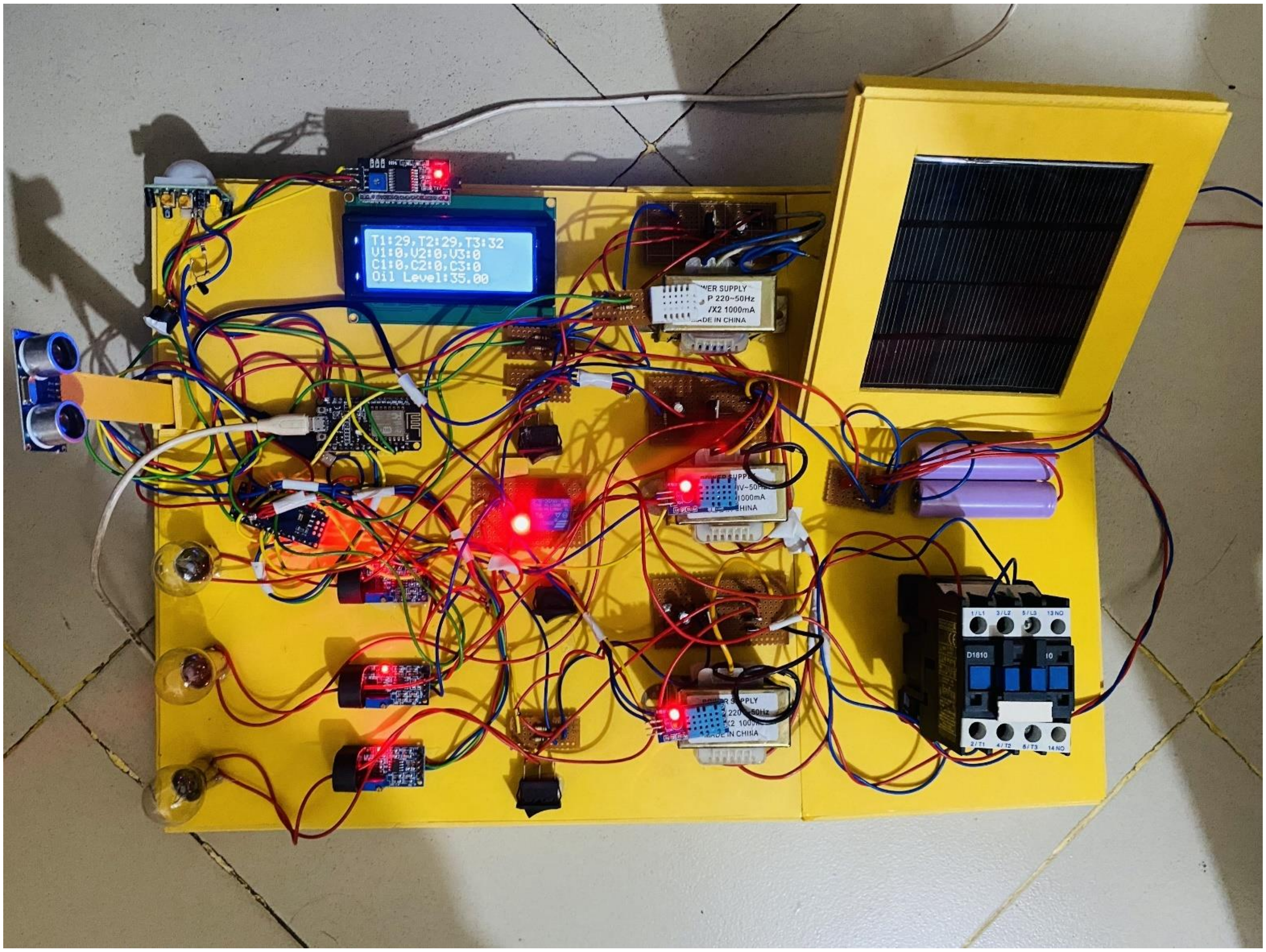

Figure 4.8: Load off / sensor Disconnected

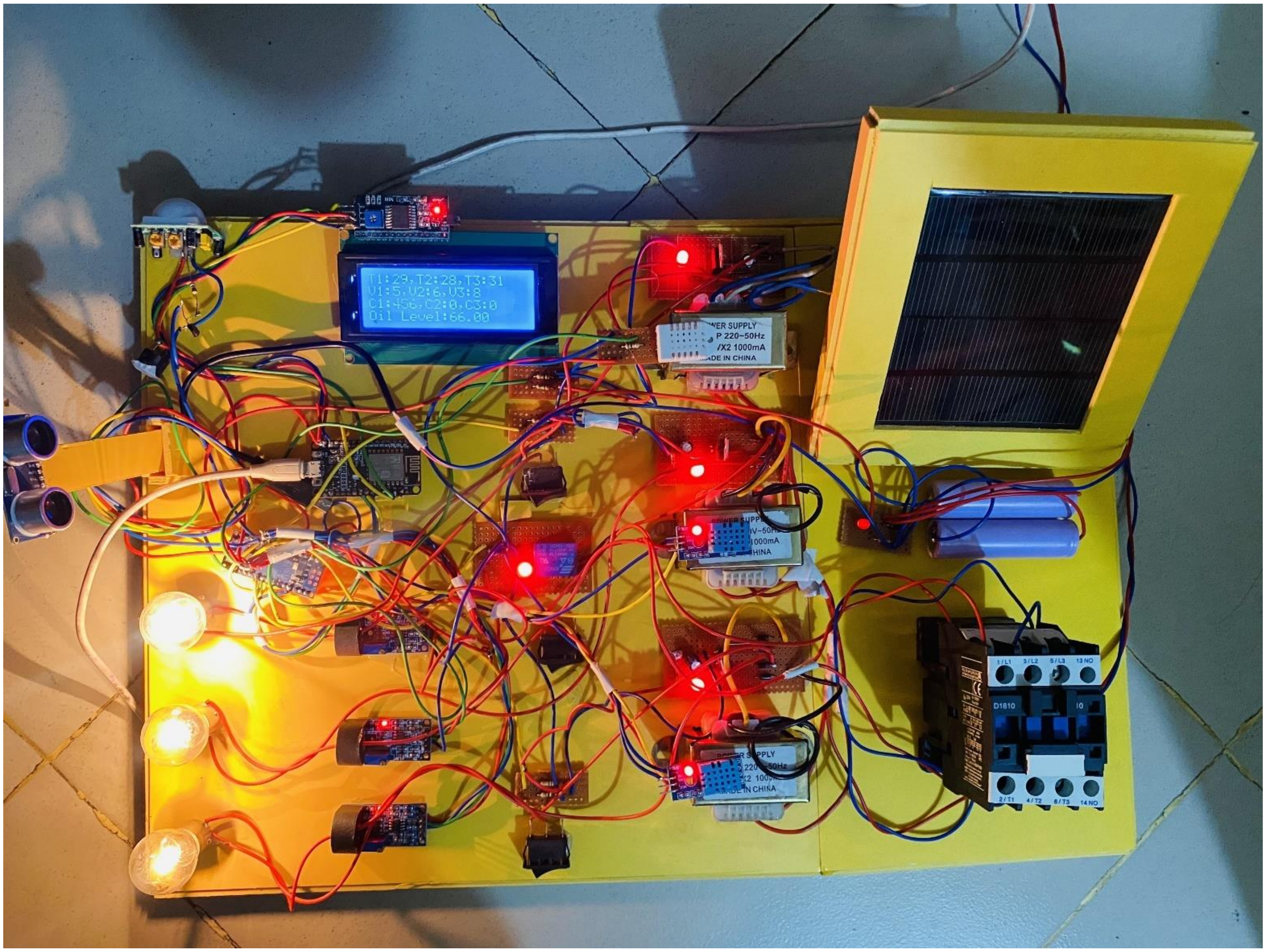

Figure 4.9: All load and components are connected & display the output

4.4. Engineering Solutions by professional practices

The power transformer is one of the most significant and expensive pieces of equipment in the whole power system network, and it plays a critical role in transmitting power from the producing source to distant locations.[63] As a result, extreme caution is required to ensure the transformer's proper operation. Because power transformers have high voltage, insulation is a major consideration. The transformer oil (TO), which also serves as a coolant and protects the transformer winding from direct oxidation, is an essential insulating material used in transformers.[64] Fortunately, the high-voltage power transformer health state may be determined by thoroughly studying the liquid dielectric medium. Because transformers are constantly subjected to electrical and thermal stressors, the organic hydrocarbon mixture of transformer oil degrades, producing gases such as hydrogen (H2), methane (CH4), ethane (CH6), ethylene (C2H4), and acetylene (C2H2).[65] The transmission of electricity will be digitalized in the future, necessitating the use of a smart distribution transformer. As a result, the people will communicate with the utility and the customers by measuring the parameters voltage, current, the temperature of a winding, and the oil level of a transformer using a variety of sensors. In the future, various trends may lead to the development of an innovative ideal system.[66] A system that might be utilized for real-time data monitoring of transformers through the internet of things can monitor oil detection level and temperature remote monitoring system. Engineers have to be solved transformer health-conscious about the losses of electricity in the terms of former days above many days. In this case, the smart monitoring system could be helpful by this modern technology to monitor this anywhere in any place.[67] Connecting load systems are more effective to reduce power system loss to be merged including the system of major modeling and software systems. The distribution transformer is the mainstay of every electricity distribution network. In this work, we are designing an online monitoring system that has several benefits for engineers such as information collection, improved management, condition evaluation, and decision-making.[68] on the other, the main objective of this project has been archived to anti-theft protection by the motion sensor which is protected by this sensor for thief curation in terms of the transformer safety purpose.

4.5. Summary

Most transformers burn due to overload; thus, by including monitoring and control circuits, the transformer's life can be extended. In this project, we created a system that continually monitors the load of the transformer and sends that information to a smartphone. These settings are presented on the phone.[69] We may watch the continuous information of the transformer in the display unit, such as why the transformer failed when power is restored, and so on. All the components have been used by the double recheck for proper ongoing connection in the transformer of the sensors. In power systems, a distribution transformer is a piece of electrical equipment that directly distributes electricity to low-voltage customers, and its operation is an important component of the overall distribution network operation. The operation of distribution transformers in rated condition (as specified on their nameplate) ensures their extended life.[70] However, if they are subjected to overloading, their life is dramatically shortened, leading to unexpected breakdowns and loss of supply to a large number of consumers, affecting system dependability. Some of the overloading components may not be used for the various purpose of the section of high voltage transformer. Implementing processes should maintain engineering ethics to develop the hardware model. The project model source of the system management to the special monitoring factor can discuss in the previous section of this book. [71]

Chapter 5

RESULTS ANALYSIS & CRITICAL DESIGN REVIEW

5.1. Introduction

A typical transformer measuring system detects only one transformer parameter, such as power, current, voltage, or phase. While some methods can detect several parameters, the acquisition and operation parameters take too long, and the testing speed is insufficient. Overloading and poor transformer cooling are the leading causes of distribution transformer failure.[72] The monitoring equipment or methods now employed to monitor distribution transformers have several flaws and shortcomings. The detecting mechanism itself is untrustworthy. The major performance is the device's instability, weak anti-jamming capabilities, low data measurement precision, or even state monitoring systems that should have no influence. Timely detection data will not be provided to monitoring centers in time, making it impossible to estimate the three-phase balance of distribution transformers.[73] A monitoring system can only monitor the functioning status of distribution transformers or defend against power theft; it cannot monitor all user data of distribution transformers to cut expenses.[74] Many monitoring systems convey data via power carrier communication; however, this method has major drawbacks: substantial frequency interference, signal attenuation as distance increases, and load changes cause significant electrical noise. As a result, if power carrier communication is used to convey data, the dependability of real-time data transmission cannot be guaranteed.[75]

5.2. Results Analysis

After completing the final implementation of the project, the detection result and corresponding solar and sensors were considered in the Proteus simulation model.

5.2.1. Validity of transformer health status measurements

In our compression of the data, we use standard multi-meter model is **DT-9205A** for the realistic data measurement.

Table 5.1: Data analysis for Current

Current	Hardware Measurement Data	Multimeter Measurement Data
$\mathbf{I}_{Transformer1}$	698 mA	730 mA
$\mathbf{I}_{Transformer2}$	698 mA	733 mA
$\mathbf{I}_{Transformer3}$	698 mA	740 mA

$$R_{B1} = \frac{Measurement\ Value - True\ value}{True\ value} \times 100\%$$

$$= \frac{730-698}{698} \times 100\%$$

= 4.58%

$$R_{B2} = \frac{Measurement\ Value - True\ value}{True\ value} \times 100\%$$

$$= \frac{733-698}{698} \times 100\%$$

=5.01%

$R_{B3} = \frac{Measurement\ Value - True\ value}{True\ value} \times 100\%$

$= \frac{740-698}{698} \times 100\%$

=6.1%

In calculate the current and hardware system module, the approximate error for the accuracy of 5% accuracy. In that case, we have said that the project running component and module properly to gain the correct value for the future scope implantation and its minimum error for this project and the project is more accurate in this system observation gain. In the current system calculation of the overall execution, R_{B1} is 4.58 % and R_{B2} is 5.01% and R_{B3} is 6.1% which is more efficient for this project and is being implemented for a big purpose in the future

Table 5.2: Data analysis for Voltage

Voltage	**Hardware Measurement Data**	**Multimeter Measurement Data**
$\mathbf{V}_{Transformer1}$	5V	5.2V
$\mathbf{V}_{Transformer2}$	6V	6.25V
$\mathbf{V}_{Transformer3}$	7V	7.3V

$R_{B1} = \frac{Measurement\ Value - True\ value}{True\ value} \times 100\%$

$= \frac{5.2-5}{5} \times 100\%$

=2.6%

$R_{B1} = \frac{Measurement\ Value - True\ value}{True\ value} \times 100\%$

$= \frac{6.25-5}{5} \times 100\%$

=3.2%

$R_{B1} = \frac{Measurement\ Value - True\ value}{True\ value} \times 100\%$

$= \frac{7.3-7}{7} \times 100\%$

=1.7%

In calculate the voltage and hardware system module, the approximate error for the accuracy of 5% accuracy. In that case, we have said that the project running component and module properly to gain the correct value for the future scope implantation and its minimum error for this project and the project is more accurate in this system observation gain. In the current system calculation of the overall execution, R_{B1} is 4% and R_{B2} is 5% and R_{B3} is 6% which is more efficient for this project and is being implemented for a big purpose in the future.

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5.2.2. Simulated Results

The system is designed using Proteus simulation software, and the simulation design is shown below.

Data Collecting from IoT/Blynk server by using Node MCU (ESP8266) module.

Figure 5.1: Transformer-1 Monitoring Data from IoT module with current, voltage and temperature.

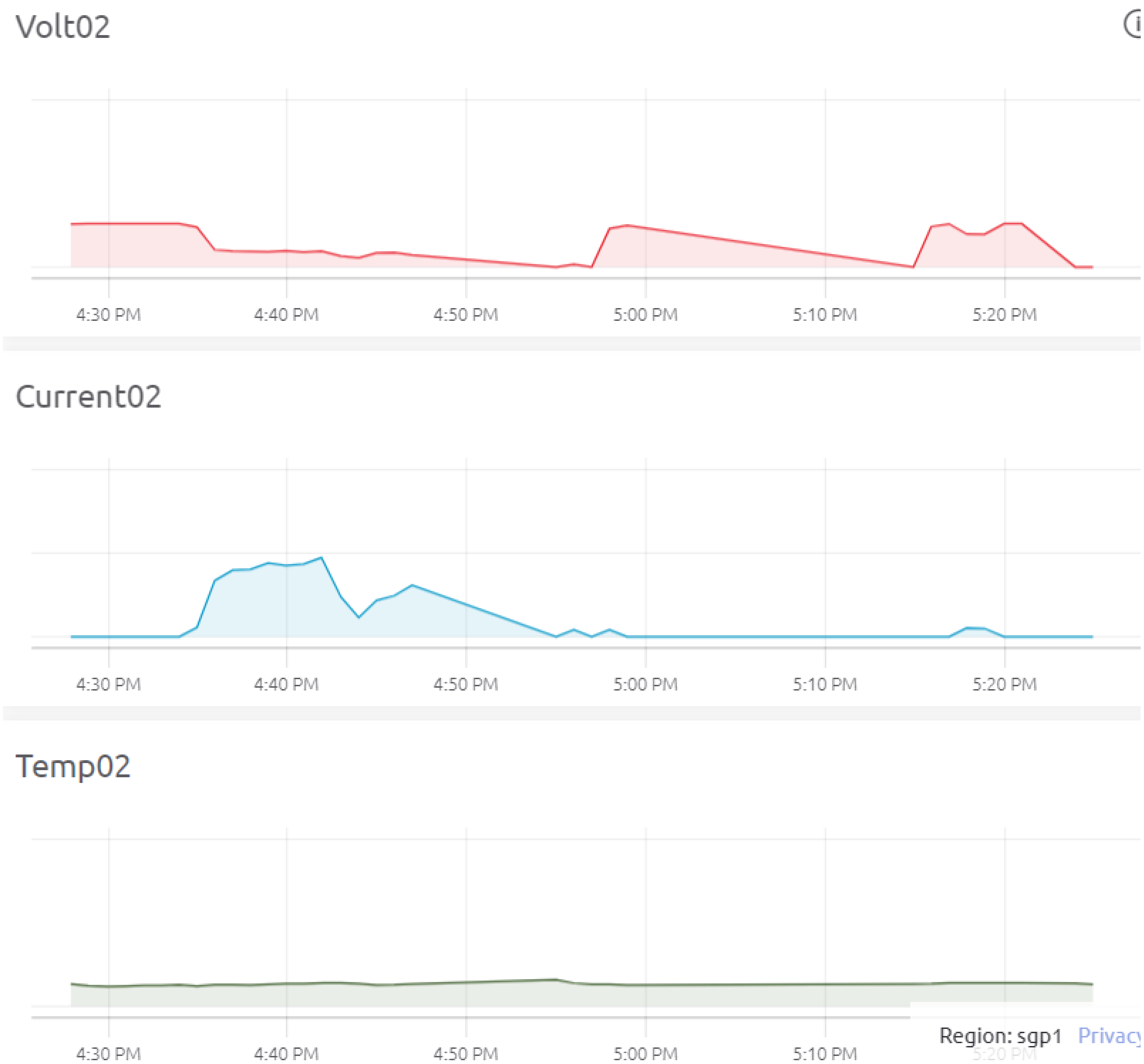


Figure 5.2: Transformer-2 Monitoring Data from IoT module with current, voltage and temperature.

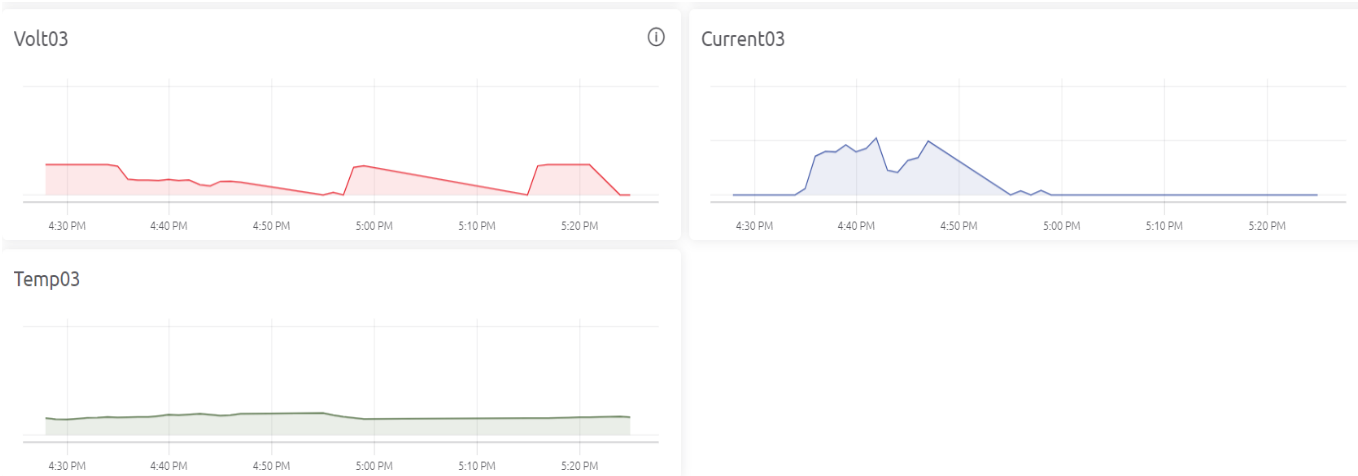


Figure 5.3: Transformer-3 Monitoring Data from IoT module with current, voltage and temperature.

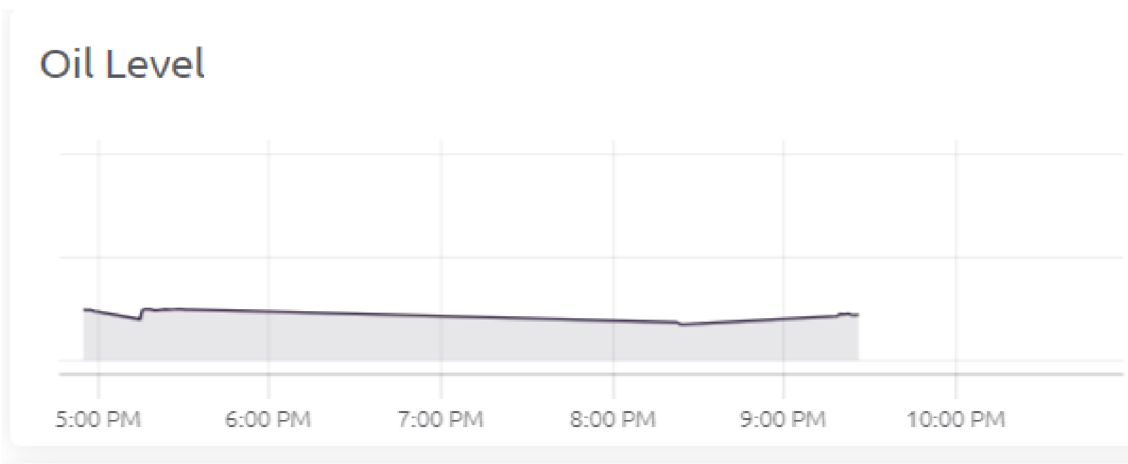


Figure 5.4: Transformer Monitoring Data from IoT module with Oil level

In this data monitoring system, the blyink server of IoT module that has been shown in figure which mention transformer current, voltage and temperature. In this Figure we are collected 4 types of data as current, voltage, temperature and oil level measurement. In the terms of conditions, the no-load data condition of the figure in current and voltage level of observation time was 4:30 PM to 4:35 and on-load data condition of the figure in current and voltage level observation time was 4:36 PM to 4:44 PM. No similar change about oil level and temperature data to trip mode condition and it has been slowly increasing of that system by timing format.

5.2.3. Hardware Results

Collecting the data monitoring observation of in our hardware module has bellow as

5.2.3.1. No-load condition:

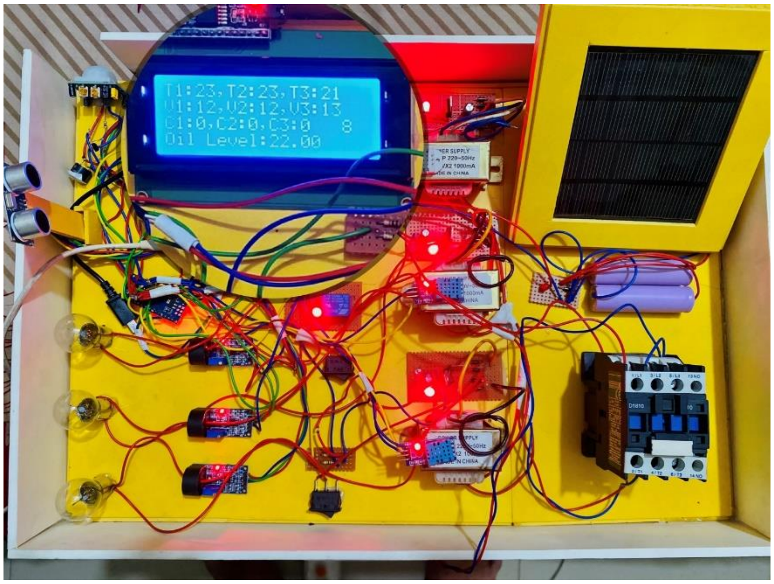


Figure 5.5: No-load condition of our hardware module

In the figure below of the no-load condition as per the time mention was 4:30 PM to 4:35 PM on current and voltage and temperature data of C1=C2=C3=0 and voltage V1=12v, V2= 12v and V3= 13v. Temperature is T1=23, T2= 23 and T3= 21 and as well as the blyink server data measurement is the similar of the perspective module. And the oil level detection is 22 as per the same ratio of blyink server data observation on our hardware module.

5.2.3.2. On-load condition:

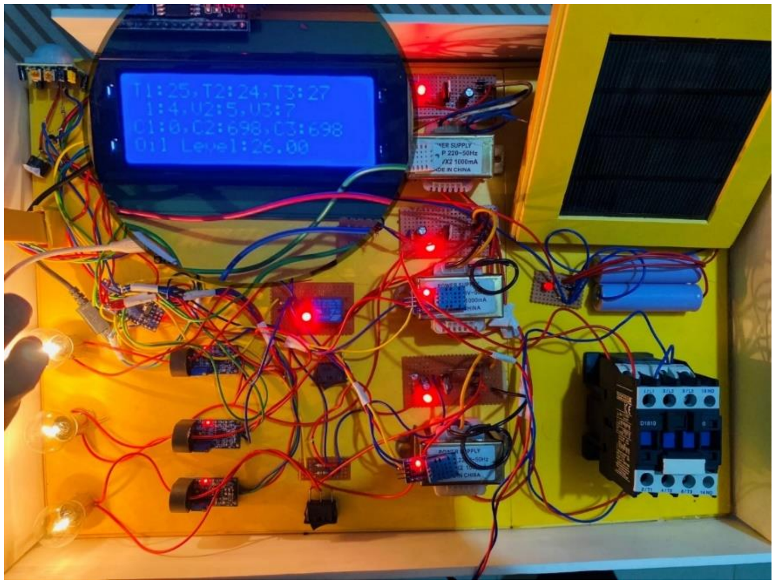


Figure 5.6: On-load condition for our hardware module.

In the figure below of the no-load condition as per the time mention was 4:36 PM to 4:44 PM on current and voltage and temperature data of C1=C2=C3=698 and voltage V1=4V, V2= 5V and V3= 7V. Temperature is T1=25, T2= 24 and T3= 27 and as well as the blyink server data measurement is similar to the perspective module. And the oil level detection is 26 as per the ratio is increasing of blyink server data observation on our hardware module.

5.2.3.3. Trip Open for Thermal Protection

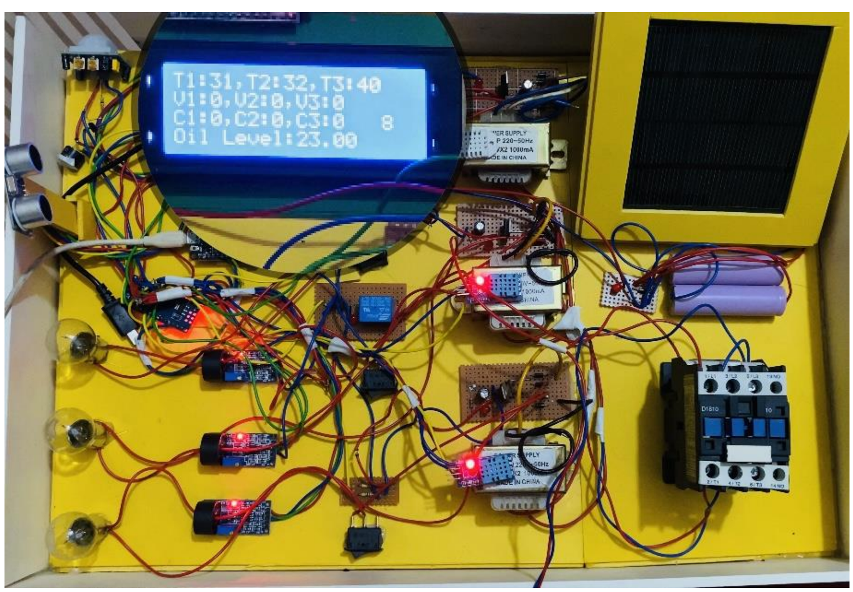


Figure 5.7: Trip Open for our thermal Protection of hardware module

In the figure below of the no-load condition as per the time mention was 4:44 PM to 4:46 PM on current and voltage and temperature data of C1=C2=C3=0 and voltage V1=0v, V2= 0v and V3= 0v. Temperature is T1=31, T2= 32 and T3= 40 and as well as the blyink server data measurement is the similar of the perspective module. In this system temperature increasing 40 so that our full system has been shut down in 1 minute and oil level has been 23 on this trip condition mode.

5.2.3.4. System Restoration after trip by thermal protection:

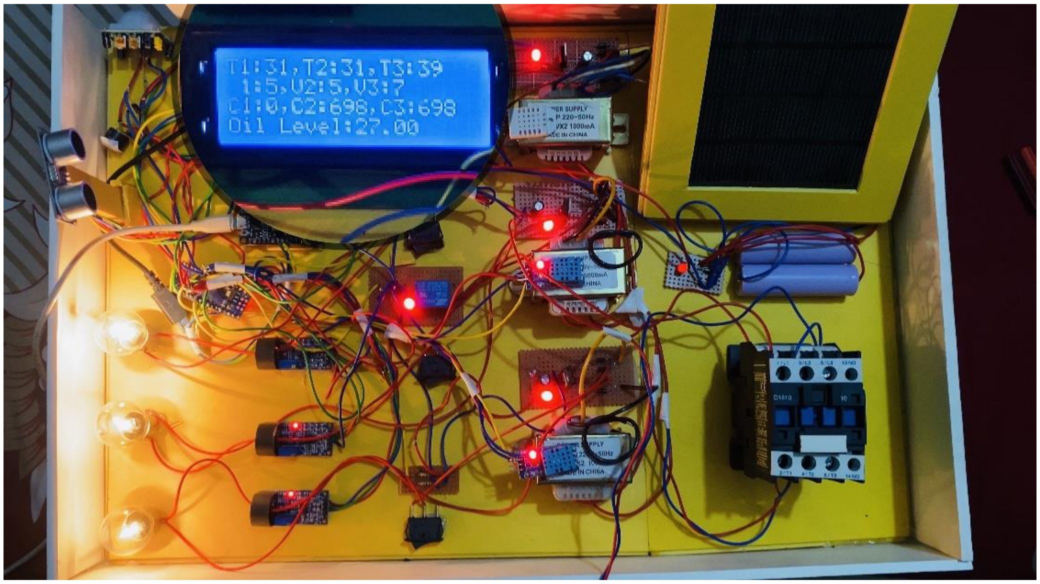


Figure 5.8: System restoration after trip by thermal protection.

In the figure below of the no-load condition as per the time mention was 4:46 PM to 4:48 PM on current and voltage and temperature data of C1=C2=C3=698 and voltage V1=5V, V2= 5V and V3= 7V. Temperature is T1=31, T2= 31 and T3= 39 and as well as the blyink server data measurement is the similar of the perspective module. After the one-minute natural cooling the system will be restored by the help of on-load thermal protection and the system will be turn on and the oil level has been 27 as per the blyink server data observation is increasing up by the hardware module system.

5.3. Comparison of Results

The hardware and simulation parts of the project do not have major differences. Still, there are a few tweaks that are shown as a comparison.

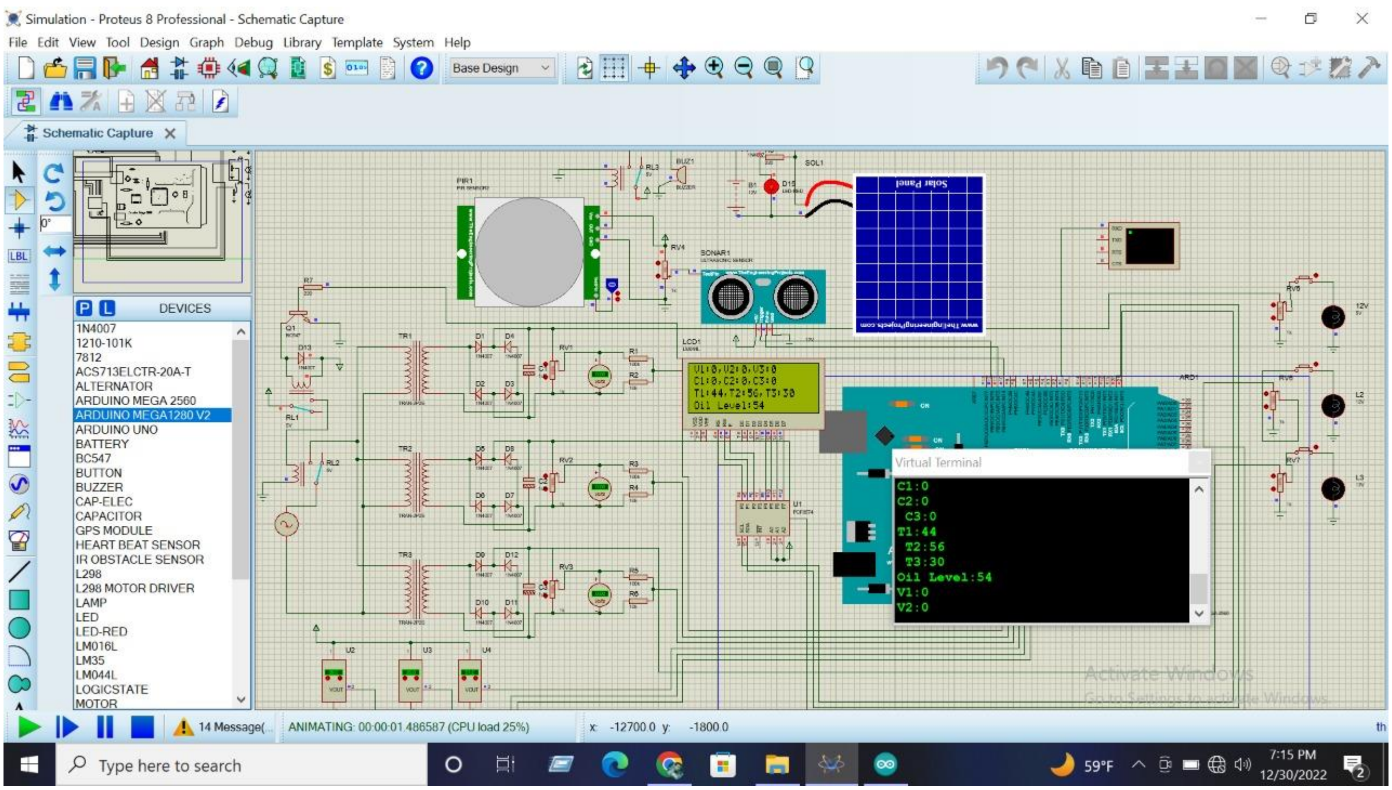
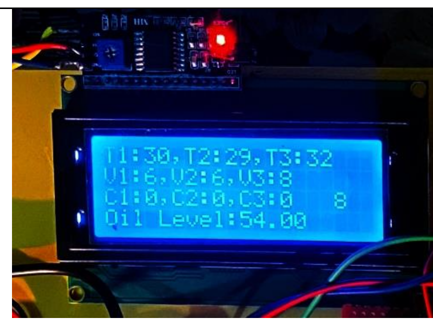


Figure 5.9: transformer monitoring and protection system

This system simulation model has been compromised in previous software and its results have been compared to the hardware model in the above section in this chapter.

Table 5.3: Comparison between software simulation and hardware implementation

<table>
<tr><th>Software Simulation</th><th>Hardware implementation</th></tr>
<tr><td>In software system the simulation uses some components variance to the values of the listed components on the transformer and other sensors.</td><td>In the prototype, the system we fixed some components used to get the exact output feedback.</td></tr>
<tr><td>The transformers 220V and 2A which is more ineffective than the hardware version in the running model.</td><td>There we can use step-down voltage 220V 1A where we can fix the current and voltage deviation rules.</td></tr>
<tr><td>In temperature,
T1= 44
T2= 56
T3= 30
Oil level = 54</td><td>In temperature,
T1= 30
T2= 29
T3= 32
Oil Level= 54</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>In diffrenence between load and transformer the equipment of this system has programmed in module by the IoT device.</td><td>There is no major system change in this capability because transformer output has been compared by the software simulation which is a more sufficient monitoring process.</td></tr>
</table>

5.4. Summary

According to the aforementioned specifications, we require a distribution transformer real-time monitoring system to detect all operational parameters and communicate them to the monitoring center in real-time.[76] It leads to online monitoring of important operating characteristics of distribution transformers, which can give useful information on transformer health, allowing utilities to make better use of their transformers and maintain the asset in service for a longer period. This will aid in the early detection of issues, resulting in considerable cost savings and increased reliability.[77] Fuse, circuit breakers, and electromechanical relays have been used for decades to protect electrical systems. However, they are untrustworthy. Commercially, transformers are currently monitored manually, with a person visiting a transformer regular basis for maintenance and recording important parameters. This sort of monitoring cannot detect intermittent overload heating of transformer fluid and windings.[78] All of these variables can dramatically shorten the life of a transformer.[79] The creation of a complicated algorithm and software that takes remedial activities when a deadly anomaly occurs. A more comprehensive approach to corrective action is to equip the microcontroller to receive instructions from the central grid via a secure server, and the microcontroller should comprehend the instructions and execute the appropriate actions to remedy the irregularity.[80]

Chapter 6

CONCLUSION

6.1. Summary of Findings

A microcontroller-based system for monitoring and saving the substation transformer from current increase due to overload is presented. An IoT-based automated control system to monitor and diagnose internal and exterior transformer failures were presented.[81] A temperature sensor, microcontroller, LCD, ESP, and XBEE in a protective system are proposed to transmit the message to the electrical board. For transformer protection, a typical fault-detecting approach was used. Because of the enhanced benefits, transformer failure monitoring based on vibration analysis is currently attracting the attention of academics.[82] This approach produces good results, but it may be enhanced further by employing computer algorithms to evaluate data and forecast faults.[83] The working section of the proposed system is verified to the alarming system at the saturation and ratio brief on the result section. The transformer health monitoring system lack to detect various types of problems in similar problems.[84] The voltage across the delay time of V_{CC} approaches the timing sensitivity at the temperature and Ultrasonic sensor. This work describes the creation of an IoT-based system for real-time monitoring and control of transformer parameters. This system is installed near the transformer, and the parameters under consideration are diagnosed and transferred to a centralized web server. Thus, the data is used to determine the state of the transformer in real-time and is saved in a server database for future examination.[85]

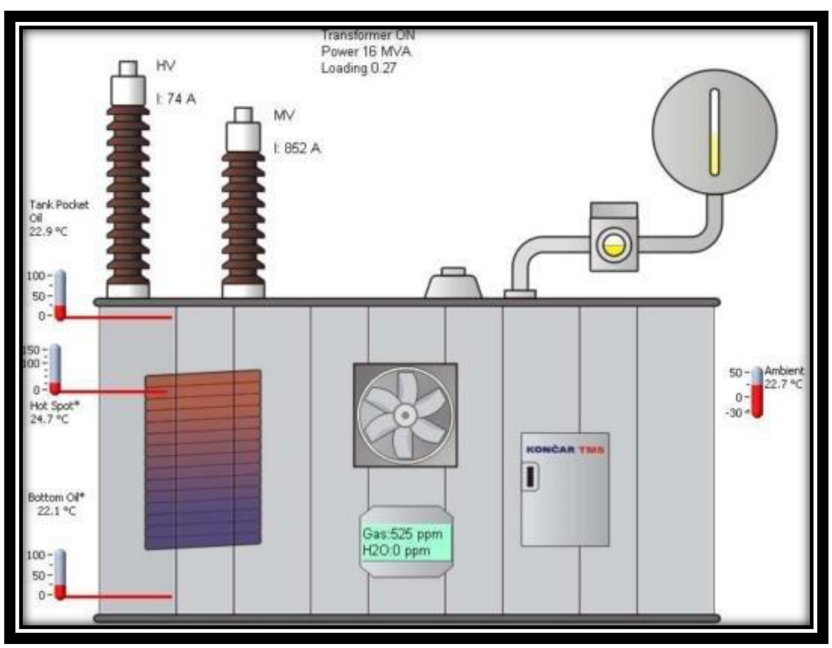


Figure 6.1: Power Transformer [1]

6.2. Novelty of the work

The transformer is an important strength in the transmission and distribution network. Important factors that affect the power supply's dependability and quality include how it operates and is controlled. The current power system has a lot of transformers, making it challenging to manually check each transformer's status. As a result, a transformer condition monitoring system has been created. With automated data capture, this condition monitoring system can track the state of several transformer parameters in real time. According to some specified instructions, this monitoring system is configured to look for abnormal circumstances based on predetermined values. IoT-based remote monitoring will make it easier to spot issues before they become serious. The information gathered by various types of sensors, which assist in detecting the status of transformers, may be used to identify various defects. This system may be a sophisticated kind of automation that does not rely on human reliance or manual testing. It is affordable since it uses a wireless communication method. Condition monitoring provides better transformer protection as a result. Additionally, the proposed system's primary structure needs to be created while adhering to appropriate engineering standards. The design system of this monitoring system can be more punctual at the stage of data visualization to keep the voltage and current ratio to measure the transformer oil level, temperature, and humidity in the case of detection data to maintain the same way of health monitor in the transformer internal system of look out the problems and try to solve or fix those issues. In order to alleviate issues, these kinds of features have been worked out through connection leveling. The solar system uses the server DNO diagnostic procedure of the power system Manu-plication to attempt to repair the emergency power backup to loss of grid failure and continuously monitors the view of the transformer health system. In this project, we focus on the safety of transformers for a variety of reasons, including anti-theft protection. This project makes use of a motion sensor to detect theft and is a cutting-edge application of the system for transformer protection.

6.3. Cultural and Societal Factors and Impacts

Electricity contains numerous components and equipment that assist humans in transferring and regulating distribution based on consumption. The transformer is the most important piece of electrical power transmission and distribution equipment. The operation of distribution transformers under rated circumstances (as specified on their nameplate) ensures a long service life. However, if they are subjected to overloading, heating, low or high voltage current, and leading to sudden failure and loss of power to a large number of customers, their life is dramatically shortened,[86] impacting system dependability. Overloading, oil temperature load current, and inefficient transformer cooling are the leading causes of distribution transformer failure.[87] Because current electric systems have a huge number of transformers scattered across a big region, it is impractical to manually measure the status of every single transformer. As a result, we require a distribution transformer system to monitor all critical parameters and deliver them to the monitoring system on time. It offers the required information regarding the transformer's health. This will assist and advise utilities in making the most use of the transformer and keeping it operational for a longer length of time. The primary goal of the project is to collect real-time data from a transformer remotely through the internet, which falls under the umbrella of the Internet of Things (IoT). [88] During a fast surge in terminal voltage, the transformer magnetizing inrush currents may create differential currents that are many times higher than the rated level and then decline to that level within a few seconds. Currently, the usual technique is to apply discrimination based on the second to the first harmonic ratio in the differential current. Second harmonic stabilization is a brilliant approach; nevertheless, it does not always prevent errors, which might have severe repercussions. [89] The issue is most severe when activating a transformer that has an internal short circuit. For a modest inter-turns defect, the inrush magnetizing currents dominate the differential current, while the short circuit current contributes only a tiny percentage of the total current. The level of the second harmonic for an inrush may cause the relay to stop working for many seconds. If the fault lasts more than one second, the gases produced by the internal arc burning in the oil may cause the transformer tank to explode.[90]

6.4. Limitations of the Work

The transformer is an important component in the electrical realm. Keeping an eye on the transformer's status is a key duty. Any little flaws with the transformer might lead to significant complications. It is critical to monitor the health of transformers regularly. Preventive devices are used to identify the defect and will be useful at the time of the fault.[91] The transformer's critical parameter is supplied to the android system regularly. With the aid of these factors, the involved individuals take the appropriate actions and better maintain the transformer. The suggested embedded system measures the transformer's current level, oil level, and temperature level. The main purpose of this technology is to forecast and avoid transformer faults. [92]

Although our project has many applications and advantages there are some limitations of the project as well and the good thing is that these limitations are minor and don’t affect the efficiency of the system. Limitations are given below:

- In this system of the monitoring process, this system of functions in high voltage transfer load according to the current load that has not reached the full signal process in this system of monitoring.
- For the uncertainty of bad weather, the sensors have not measured all of the data actuation in voltage and current ratio, and the detection system has been lost in the meantime.
- This system does not cover the substation high load transformer data to visualize the system properly accomplishing the transformer health consequences of the monitoring process.

Our solution, which is based on online monitoring of key operational parameters of distribution transformers, may give vital information about the health of transformers, allowing utilities to make the most use of their transformers and maintain the asset in service for a longer period. This system handles load balancing, which incurs additional material costs for the sub-transformer.

6.5. Future Scopes

Using an open technology such as IoT for real-time monitoring of electricity lines helps to keep prices down and power usage low. This experiment demonstrates that sensors may be used in both traditional and smart grids to monitor various grid properties. It is possible to conclude that our model displays findings on the internet via the IoT module as well as on the onboard LCD Display. The system has the following future scopes which make the system more reliable and effective [93]:

- System will be capable of communicating in both directions.
- System will be able to measure more transformer parameters.
- Data at the monitoring station will get updated whenever requested by the monitoring person.
- The creation of a complicated algorithm and software that takes remedial activities when a deadly anomaly occurs. A more comprehensive approach to corrective action is to equip the microcontroller to receive instructions from the central grid via a secure server, and the microcontroller should comprehend the instructions and execute the appropriate actions to remedy the irregularity.
- The monitoring system can automatically evaluate and identify anomalous data features by utilizing the anti-theft module, master software, and IoT means of communication, distribution transformer. If the monitoring measurement is incorrect, an alarm will be generated in the master.

Currently, transformer maintenance is performed manually on-site. By adopting our solution, concerned staff will be able to take precautionary steps such as sending a relay signal from the central grid, which would shut down the system.[94]

6.6. Social, Economic, Cultural, and Environmental Aspects

6.6.1. Sustainability

The approach is more effective and efficient than the traditional methods currently in use. The advantages of this approach over previous techniques include faster response, greater isolation, and more precise fault detection. With the aid of this method, the maintenance personnel of the Electricity Power Authority's department may maintain constant monitoring of the transformer through a personal computer and correct the problem without the need for linesmen. The transformer is the costliest equipment utilized in the delivery of electrical energy. Continuous transformer condition monitoring is cost-effective.[95] IoT monitoring is far superior to physical monitoring. Ankush Ramesh Rao Kadam et al., 2019 suggested a project to record and monitor critical transformer metrics such as oil level, current load level, temperature, and voltage level. This system was created with the aid of an Arduino controller and many sensors. The obtained data will be analyzed and saved using the system memory. In the event of an emergency, the measured data will be shown in the monitor using inherent features. The transformer is a key equipment for transferring electrical electricity to multiple locations. Traditional transformer monitoring systems rely on cable connectivity, making continuous monitoring impossible. To protect the transformer against faults, many ways are utilized.[96] The suggested system uses several sensors and microcontrollers to autonomously monitor the transformer characteristics. This system is primarily made up of three essential sensors and an Arduino controller. By properly monitoring transformer health, power system dependability and safety challenges may be resolved. This study presents a novel method for measuring the health of a transformer using an Android handset. Different sensors are utilized to determine the transformer's health. The current android device-based approach's performance demonstrates that this method can measure the health state of any operational transformer.[97]

6.6.2. Economic and Cultural Factors

As a piece of equipment ages, it fails more frequently and requires more maintenance time until it approaches the end of its useful life. Maintenance actions can extend the life of equipment but can be quite expensive for equipment towards the end of its useful life. For power transformers, there are three types of lifetimes: physical lifetime, technological lifetime, and economic lifetime.[98]

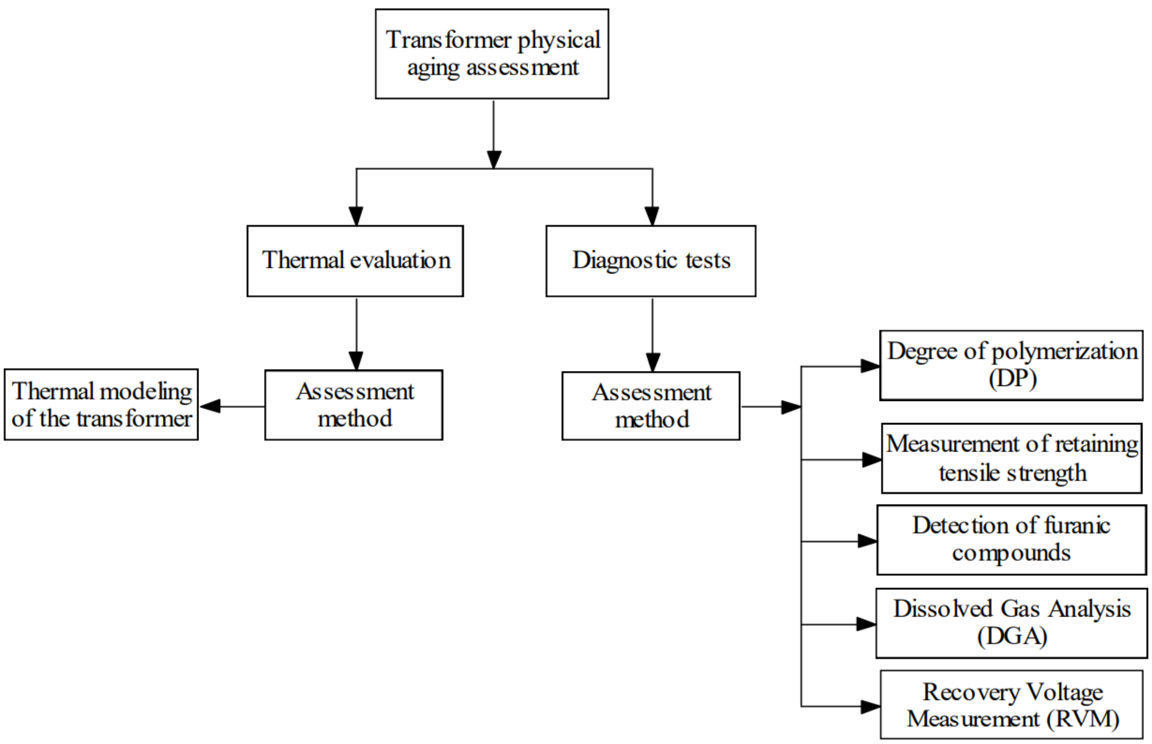


Figure: A complete classification of the transformer's physical aging mechanisms.

Transformers that have been in use for many years have been discovered to contain significant quantities of furans in the oil. It is not possible to evaluate the life expectancy of oil-filled transformers in terms of furans quantities. Thus, while diagnostic tests give helpful information about the status of transformers and can expose faults, they do not provide any sort of conclusive quantitative information about life expectancy that is essential for power system planning in the future.[98] The accurate loss in the life of a transformer may be computed using the aforementioned processes. Calculating transformer aging based on the hot spot temperature is clearly understood. However, the major issue in adopting this insulation end-of-life model is identifying the right treatment of the transformer load and ambient temperature, including the related uncertainties, to get trustworthy HST values and hence reliable transformer loss-of-life values. The transformer start processing stands by the direct protection to the facility of the people at the remove of high-level risk in our cultural civilization. It is often more cost-effective to retire and replace equipment before its capital value hits zero and before its physical lifetime expires, rather than continuing to face high operating and maintenance costs. This notion, along with the concepts of depreciation, is explained in the following subsections.[99]

6.7. Conclusion

Utilizing a microcontroller-based relay, this device offers IoT-based transformer protection and monitoring system. A transformer current-detecting circuit was created, and the results were confirmed using a proteus simulation. This system device approach is cost-effective and small in scale. The transformer fault analysis can be a very perspective section to construct a high-efficiency current or voltage migration. This circuit is intended to keep an eye on overloading and guard against overload-related transformer damage. The load reference value is established at this place. If the load is greater than the reference value, the microcontroller sends a trip signal to the transistor, tripping the relay in a matter of microseconds. A transformer will be unplugged from the load as the relay trips. The IoT module will deliver information to the specified cellphone numbers simultaneously. In this system, the preferred energy management and efficiency technology is identified as the IoT wireless open typical technology. Utilizing an open standard like IOT with a system for real-time power line monitoring lowers costs and reduces power usage. This system can demonstrate that sensors may be used to monitor various grid parameters on both traditional and smart grids. Our model is displaying findings both on the onboard Liquid Crystal Display (LCD) and the internet through the GSM module. Human instinct will be reduced by using IoT to monitor various distribution transformer parameters, and data will be saved for consumption and potential power theft. Our electricity system would become more precise and dependable with the application of IoT. We can create a database of all the distribution transformer's parameters, which are positioned at various locations, in future work. By installing the suggested system modules at each transformer, we can collect all the data. The transformer magnetizing inrush currents may result in differential currents that are many times larger than the rated level during a rapid surge in the terminal voltages and that level will return within a few seconds.

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