Faculty of Electrical Technology and Engineering

DEVELOPMENT OF A SYSTEM ON MONITORING TRANSFORMER USING MICROCONTROLLER

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Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

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DEVELOPMENT OF A SYSTEM ON MONITORING TRANSFORMER USING MICROCONTROLLER

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DEDICATION

Thank you to my parents, Mohammad Mohlas Bin Sallen and Norazalifah Binti Mujer and family for the constant understanding, encouragement, and support that got me through my academic path. My perseverance has been fueled by your faith in my ability and your willingness to make sacrifices. This thesis serves as an homage to the courage and love you have bestowed upon me.

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ABSTRACT

Transformers are crucial components of power distribution networks, and it is crucial to continuously monitor their performance parameters to guarantee efficient and dependable power transmission. By utilising microcontroller (ESP32) and Internet of Things connectivity capabilities, the suggested system seeks to improve transformer monitoring capabilities. The transformer unit, microcontroller unit, and IoT gateway are the system's three primary parts. The transformer unit gathers data from the three phases of the transformer, including voltage, current, temperature, and oil level. After that, the microcontroller unit which is ESP32 receives these parameters and processes them. The cloud-based monitoring platform and the microcontroller are connected through the IoT gateway. It creates a secure connection to the internet and delivers the data that has been gathered to a distant server for archival and analysis. The monitoring platform via smartphone offers operators a simple user interface. The proposed system has a few benefits over conventional monitoring methods. In the beginning, it permits real-time monitoring of crucial transformer parameters, enabling prompt detection of anomalies and potential failure prevention. Second, the IoT technology integration allows for remote access to the monitoring platform. In conclusion, the combination of an IoT-based system with a microcontroller-based system provides a reliable and scalable solution for monitoring three-phase transformers.

ABSTRAK

Transformer ialah komponen penting dalam rangkaian pengagihan kuasa, dan adalah penting untuk memantau parameter prestasi mereka secara berterusan untuk menjamin penghantaran kuasa yang cekap dan boleh dipercayai. Dengan menggunakan mikropengawal (ESP32) dan keupayaan sambungan Internet of Things, sistem yang dicadangkan berusaha untuk meningkatkan keupayaan pemantauan transformer. Unit pengubah, unit mikropengawal dan gerbang IoT ialah tiga bahagian utama sistem. Unit pengubah mengumpulkan data daripada tiga fasa pengubah, termasuk voltan, arus, suhu dan paras minyak. Selepas itu, unit mikropengawal iaitu ESP32 menerima parameter ini dan memprosesnya. Platform pemantauan berasaskan awan dan mikropengawal disambungkan melalui gerbang IoT. Ia mewujudkan sambungan selamat ke internet dan menghantar data yang telah dikumpulkan ke pelayan yang jauh untuk arkib dan analisis. Platform pemantauan melalui telefon pintar menawarkan pengendali antara muka pengguna yang mudah. Sistem yang dicadangkan mempunyai beberapa faedah berbanding kaedah pemantauan konvensional. Pada mulanya, ia membenarkan pemantauan masa nyata parameter pengubah penting, membolehkan pengesanan segera anomali dan potensi pencegahan kegagalan. Kedua, integrasi teknologi IoT membolehkan akses jauh ke platform pemantauan. Kesimpulannya, gabungan sistem berasaskan IoT dengan sistem berasaskan mikropengawal menyediakan penyelesaian yang boleh dipercayai dan berskala untuk memantau transformer tiga fasa.

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CHAPTER 1

INTRODUCTION

1.1 Background

This chapter briefly explain the concept and idea of the proposed project. In this chapter, the explanation on the background of the project, problem statement that led the idea of this project, objectives that should be achieve, project scope and the expected outcome of this project.

1.2 Project Background

Transformers serve an important role in the functioning of the electricity grids. Power system reliability is tight knit to the electrical and mechanical integrity of transformer [1]. For the transmission and distribution of electric power in electrical power networks, three-phase transformers are crucial parts. Three-phase transformers come in several varieties according to its application, setup, and design. In this chapter focusing more on step down transformer and oil-filled transformer. Oil is used as an insulating medium and as a coolant in oil-filled transformers. They frequently work in high-power applications and have oil cooling systems installed.

This chapter focuses on indoor transformers because they can utilise liquid or air-cooling techniques, as well as rely on the interior air temperature for cooling, which is relevant to my research. Reasonable control of transformer temperature and indoor temperature rise is the basis for ensuring the good operation of indoor transformers [2].

In order to prevent sudden network breakdowns and damage of network components which can cause significant economic and environmental losses, it would be of benefit to implement a permanent on-line diagnosis and prognosis system, which will alert the grid operator on the condition of transformer structure [1].For transformers to operate at their best, to avoid malfunctions, and for electrical power networks to run smoothly, monitoring is essential.

The development of Internet of Things (IoT) technology, it is now more practical than ever to use microcontrollers to monitor transformers and take advantage of IoT connectivity. Transformers can be remotely monitored and operated by combining microcontrollers with IoT capabilities, allowing for real-time data collection, analysis, and preventative maintenance. Preliminary intelligent knowledge-based system will perform not only accessing, but also processing transformer lifespan and operating conditions [3].

In a prior project, the online monitoring system was made up of mobile users, GSM networks, embedded systems, sensors placed at the transformer site, and GSM modems. Before converting the physical quantity arriving from the distribution transformer to an analogue signal, sensors are mounted on the transformer side to read and measure it. ADC is used to process the obtained analogue signals before feeding them to the microcontroller. To the GSM module, the pre-programmed microcontroller transmits a signal. The GSM module sends an SMS to the user. Due to how convenient it is to operate a transformer from a single location and how much time and effort it saves, this capability has become essential [4].

1.3 Problem Statement

In monitoring transformer nowadays just in a one room that we can monitor and notify whenever the transformer is having problem or not. In our project we use ESP32 and Blynk app as platform to monitor or notify somebody that the transformer having problem just using smartphone. Oil level sensor which is quite outdated will be change with ultrasonic sensor which is more advanced and give more accurate readings or results.

Unbalance when an unbalance may be indicated by a higher temperature on one phase. Keep in mind that the maximum voltage on balancing is normally 2% as you compare the current on each phase. This means that no phase's voltage should differ by more than 2% from the sum of the voltages of the other three phases. because a change in load configuration is the most frequent source of unbalance [5].

If temperatures are much higher than expected and the appliance is not in direct sunlight, overloading and cooling are likely to be the culprits. Compare the kVA, voltage, and current to the transformer's nameplate. There probably is an overload if the power consumption exceeds the information on the nameplate [5].

1.4 Objective of Project

The objective of this project is to develop a monitoring system on transformers using a microcontroller. The monitoring system can assist in making sure the transformer operates as efficiently as possible, identifying faults, and averting any damage. The following is a list of objectives to be achieved:

a) Create a system by simply using microcontroller to monitor three phase transformers.

b) Monitoring three phase transformers via IoT which is Blynk app for smartphone.

c) Create a system that can control the use of voltage in a phase.

1.5 Scope of Project

Monitor three phase transformers using microcontroller include voltage in each. phase, current for the three-phase transformer, oil level and temperature:

a) Each transformer will be provided with DHT11, it will measure temperature for each phase.

b) Ultrasonic sensor to sense oil level on transformer.

c) ACS712 current sensor to measure current for the three-phase transformer.

Create a system to notify somebody when transformer having problems just using a smartphone via Blynk app:

a) Using Blynk app as platform on smartphones to notify when transformer having problems.

b) Implementing IoT in this system it can make it easier for someone to monitor the condition of the transformer.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A three-phase transformer monitoring system is a specialized system used to monitor the health and performance of three-phase transformers. These systems are typically designed to detect and alert operators of any abnormalities in the transformer's operation, such as overheating, overloading, or insulation breakdown. Consequently, the method and consideration for monitoring three-phase transformers are briefly covered in this chapter.

2.2 Transformer

A three-phase transformer is a type of electrical transformer that is designed to handle three-phase power systems. It consists of three sets of primary and secondary windings, each wound around a common magnetic core. This type of transformer is widely used in power distribution systems to transfer electrical energy between different voltage levels.

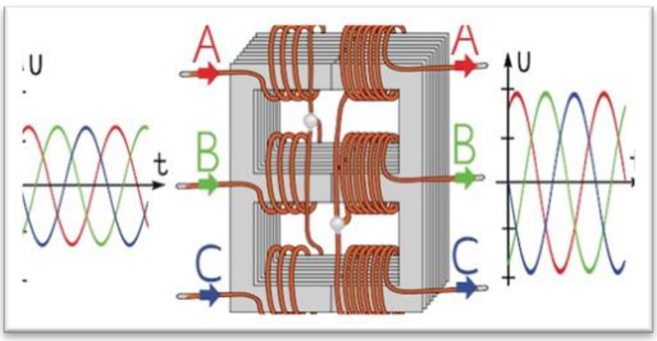

Figure 2.1 Three-phase transformer

Three-phase transformers, whether with Delta or Star connected windings, are the backbone of the electrical power distribution system. The single-phase, two-winding voltage transformer, which may be used to change the relationship between the secondary voltage and the primary supply voltage, has been studied in terms of its construction and operation up to this point. However, in addition to connecting to just one phase, voltage transformers can also be constructed to link to two, three, six, or even complex combinations of up to 24 phases for some DC rectification transformers [6].

2.3 Three Phase Transformer Connections

There are numerous ways to link the primary and secondary windings of a transformer to meet almost any application. For three phase transformer windings, there are three possible connections: "star" (wye), "delta" (mesh), and "interconnected star" (zigzag). The three winding combinations may be star-delta, star-star, or delta-delta, with the primary linked in a delta pattern and the secondary in a star pattern, depending on the purpose of the transformer. Any transformer used to supply three phases, or more is referred to as polyphase [6].

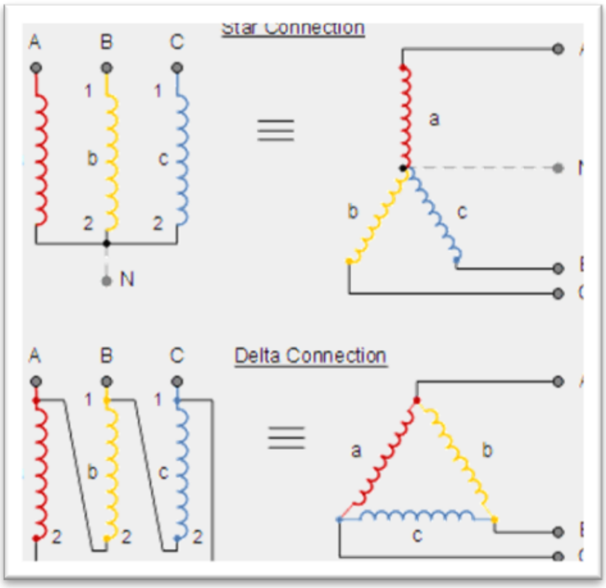

Figure 2.2 Connection Three-phase transformer

2.4 Protection on Transformer

2.4.1 Accessories Equipment

In A wide range of accessories are used to protect and keep an eye on power transformers, some of which are used because they are required and others which are not.

i) Liquid-Level Indicator: Since the liquid medium is essential for cooling and insulating, a liquid-level indicator is a typical component on transformer tanks that are filled with liquid. The standard form of this indicator is a round-faced gauge attached to the tank's side, complete with a float and float arm that move a dial pointer in response to the liquid level [7].

ii) Pressure-Relieving Devices: Transformer tanks have pressure-relieving systems installed to lower internal pressure that could accumulate under operating conditions. These devices are intended to keep the tank safe. On larger transformers, numerous pressure-relief systems can be required due to the enormous volumes of oil [7].

iii) Liquid-Temperature Indicator: Using a probe installed through the side of the transformer tank, liquid-temperature indicators monitor the temperature of the internal liquid at a location close to the top of the liquid [7].

iv) Winding-Temperature Indicator: To approximate the winding's hot spot, a winding-temperature simulation technique is used. Direct measurement of winding temperature is difficult hence an estimate is needed. Like how power transformers are employed, a current transformer is positioned to generate a current that is proportional to the load current that is passing through the transformer. Through a circuit that essentially raises the temperature inside, replicating the winding temperature, the top liquid temperature reading receives energy from the current transformer. This approach makes advantage of the winding gradient, a measurement of the temperature differential between liquid and windings [7].

v) Sudden-Pressure Relay: A sudden- (or rapid-) pressure relay is intended to alert the user of an internal issue that could result in an unexpected increase in pressure. These relays can work in a liquid or gas environment and can be mounted on the top or side of the transformer [7].

vi) Desiccant (Dehydrating) Breathers: Desiccant breathers use a material like silica gel to allow air to enter and exit the tank, removing moisture as it passes through. Most tanks are capable of some free breathing, and provided this mechanism is kept in excellent working order, it can provide some level of control over the quality of the air entering the transformer [7].

2.5 Transformer fault

2.5.1 Short Circuit Fault in Windings

A system short circuit can happen if the neutral point is earthed between any two lines or across any two lines. A system short circuit will result in overcurrent's, whose size depends on the system MVA, the voltage feeding the fault or the shorted-circuit voltage, and the impedance of the circuit up to the fault. Short turns and winding motion may result from short circuits. Currents with large amplitudes are typically produced by short circuits close to transformers. Extreme mechanical stress is thus placed on the core and coil assembly. Failures are not usually brought on by mechanical forces. Sometimes there is only a small amount of serious damage, which is not recognized and prevents continuing service [8].

2.5.2 Short Circuit Forces

Thermal, dielectric, and mechanical factors all influence how well insulation performs. The stresses brought on by short circuits, electrical and thermal breakdown mechanisms, and other factors can harm transformers. The capacity of a power transformer to tolerate all the asymmetrical short circuit currents without losing its acceptability for regular operating circumstances is known as its short circuit withstand capability. Due to the steadily rising unit ratings of transformers and corresponding rise in short circuit levels of networks, the transformer's ability to tolerate short circuits has emerged as one of the most important features of its design. Peak asymmetrical currents from the short circuit might reach 15–18 times the rated current, and symmetrical short circuit currents could be in the range of 6-7 times the rated current [8].

2.6 Previous project

2.6.1 Monitoring parameters of power transformers in the electrical power system through smart devices.

The development of tools and technologies for tracking a power transformer's performance has reached a high degree. To prevent breakdowns and improve reliability, the monitoring system enables ongoing research into the operational work of power transformer parameters. Power transformer monitoring is unquestionably beneficial for enhancing the supply reliability of electrical power systems and users. Given that monitoring involves a substantial number of parameters and transformer elements, an overview of the monitoring of some of the most important parameters has therefore been considered in the current example. Partial discharges, oil and winding temperatures, bushing currents, tap changer, moisture analysis, and dissolved gas analysis are therefore some of the monitoring variables included in the study. Additionally, the article contains information on how these parameters performed throughout a range of time frames and loading regimes. Additionally, reports of incidents that relate to the transformer's operational performance and are a solid basis for diagnostic and preventative measures in transformers are supplied [9].

The Internet of Things (IoT) revolutionized a few industries, and energy management and monitoring are one of its important applications. Transformers are essential for the distribution and transmission of electrical electricity. However, in this project, we used the Blynk app as a platform to monitor the transformer and deliver notifications when something happened via smartphone. As was previously stated in this journal, all parameters simply appear in a piece of paper known as a report. Transformer monitoring may be made easier to access, more affordable, and more effective by utilizing IoT and the Blynk app. With the use of real-time data, remote access, and proactive alarms, maintenance staff are better equipped to act quickly, lowering the likelihood of failure, cutting down on downtime, and maximizing transformer lifespan. IoT sensors are strategically installed on the transformer to measure different parameters. These sensors can be connected to microcontrollers or IoT development boards capable of collecting data from the sensors.

2.6.2 Event Monitoring of Transformer Discharge Sounds based on Voiceprint.

To increase the timeliness and diagnostic capability of intelligent monitoring of substation equipment operation, this paper examines the operation inspection and anomaly diagnosis of transformers in substations. It also conducts an application study of artificial intelligence-based sound recognition technology in transformer discharge diagnosis. In the context of sound recognition, automatic discharge sound detections are implemented in this study using a sound parameterization method. The pre-processed sound samples are utilized to recover the mel-frequency cepstrum coefficients (MFCCs), which are traits used to train Gaussian mixture models (GMMs). Lastly, trained GMMs are used in substations to identify discharge sounds rather than transformer sounds. The test results demonstrate that auditory anomaly detection based on MFCCs and GMMs can be used to precisely identify anomalous discharge in the high scenario of transformers [10].

In a previous journal, it was mentioned that voiceprints may be used to monitor transformer discharge sounds. Discharge sound is transformers will generate a loud "buzz" sound under large loads, and if an internal connection breaks down or there is a breakdown, electrical discharge will cause the transformers to emit a loud "squeak" sound. To monitor a transformer effectively, various sensors can be employed to capture different parameters. Three commonly used sensors for transformer monitoring are the ACS712 current sensor, ultrasonic sensor, and DHT11 temperature and humidity sensor. The ACS712 is a current sensor capable of measuring the electrical current flowing through a conductor. An ultrasonic sensor utilizes sound waves to measure distances or detect objects' presence within its range. The DHT11 sensor is a cost-effective and widely used sensor for measuring temperature and humidity. It can provide accurate readings within a specified range. These sensors, namely the ACS712 current sensor, ultrasonic sensor, and DHT11 temperature and humidity sensor, provide valuable insights into the condition of a transformer.

2.6.3 IoT Based Distribution Transformer Health Monitoring System

The goal of this study is to obtain the transformer's real-time status. Transformers play a significant part in the power system; thus, it is crucial to keep an eye on their health to ensure the continuous operation of any distribution network. This study outlines a health monitoring system powered by the Internet of Things (IoT). Thingspeak was used to display the output data when NodeMCU was selected as the processor for sending the sensor data. Adopting IoT technology in a transformer could aid in maintaining a steady supply of power. This inexpensive technology, which can be installed in the transformer to be remotely monitored and help anticipate life expectancy as well as assess health status, can be used to monitor the transformer. The purpose of this study is to obtain the current condition of transformer [11].

With the help of the IoT analytics platform service ThingSpeak, you can gather, visualize, and examine real-time data streams online. By leveraging online services like Twitter and Twilio, you can submit data to ThingSpeak from your devices, instantly visualize live data, and issue alarms, but monitoring a transformer using a smartphone via the Blynk app provides a convenient and accessible way to keep track of its parameters in real-time. By integrating IoT technology, sensors, and the Blynk app, users can remotely monitor the transformer's health and performance. Install appropriate sensors on the transformer to measure key parameters such as temperature, oil level, humidity, voltage, and current. These sensors can be connected to microcontrollers or IoT development boards capable of collecting and processing data. Furthermore, Connect the microcontroller or IoT development board to the internet using Wi-Fi, cellular data, or Ethernet. This connection allows the device to communicate with the Blynk app and cloud platform.

2.6.4 Condition Monitoring of Distribution Transformer Using Internet of Things (IoT)

To lower the primary voltage to a level that customers can use, transformers are required in the distribution and transmission of energy. Given that distribution transformers are relatively expensive in the electrical business, this research provides a system that tracks several distribution transformer properties. The two units are the monitoring unit and the remote terminal unit (RTU). The remote terminal unit uses the PIC 18F4550 to assess variables like current, temperature, oil level rise and decrease, vibration, and humidity. Prior to sending alert messages to mobile devices and storing them in system memory using an analogue to digital converter (ADC), the system processes all monitoring parameters and examines them for anomalies. All parameter values are sent via GPRS to the monitoring node. If an emergency arises right away, a message is sent to the corresponding engineer via

GSM, and we can also receive an alert about it on a website via GPRS. Near the remote terminal unit buzzer will beep and LCD gives notification about emergency condition [12].

In a previous journal it was mentioned that the monitoring unit and the remote terminal unit (RTU) are the two units. It will send a message if an emergency arises right away via GSM, and we can also receive an alert about it on a website via GPRS. Near the remote terminal unit buzzer will beep and LCD gives notification about emergency condition. In this project ESP32 as a microcontroller. A dependable and effective method of transformer monitoring is provided by the ESP32 microcontroller, which is part of the Internet of Things. The ESP32 is a potent and adaptable microcontroller with Wi-Fi and Bluetooth integration, making it appropriate for Internet of Things applications. You may successfully monitor and manage a transformer from a distance by utilizing the functionality and connectivity possibilities of the ESP32.You may obtain effective monitoring, early problem detection, and remote management capabilities by using the ESP32 as a microcontroller to monitor a transformer via IoT. The ESP32's adaptability and networking options

2.6.5 Design of Online Monitoring System for Distribution Transformer Based on Cloud Side End Collaboration of Internet of Things

Due to hardware and software constraints, the existing online distribution transformer monitoring system has the defect of a poor response time. As a result, it is advised to build a cloud-side end-to-end collaborative online monitoring system for distribution transformers. The online monitoring system for distribution transformers was built on the cloud-based, cooperative Internet of Things paradigm. The software module consists of the communication protocol module, the monitoring and alarm module, and the data processing module for transformers. The hardware unit consists of the wireless communication unit, the microprocessor selection unit, and the transformer data acquisition unit. The transformer's online monitoring system is made possible by the hardware and software developments. The experimental results indicate that the response time of the design system is shorter when compared to the existing system, fully demonstrating that the monitoring performance of the design system is better and making it appropriate for vigorously promoting and using [13]. The reaction time of the design system is 0.98-1.44 s.

2.6.6 Design of Online Monitoring System for Distribution Transformer Based on Cloud Side End Collaboration of Internet of Things

Since transformers are essential parts of electrical power systems, monitoring their health is vital. Transformers are essential for the transmission and distribution of electrical energy because they can change the voltage level of electrical energy. A failed transformer can result in numerous power outages, equipment damage, and other issues. Transformer health may be routinely monitored to spot any problems before they become serious ones, which can assist avert outages and other disturbances. Furthermore, by spotting and fixing problems before they worsen, routine monitoring can help transformers last longer. This study proposes an Internet of Things (IoT) based continuous Health Index (HI) monitoring system. It is also possible to incorporate the suggested model into a transformer's Digital Twin (DT) [14].

A transformer is a type of magnetostatic device that uses the electromagnetic induction principle to change one voltage level into another. This apparatus makes up as much as 60% of the overall cost of a high-voltage power substation, making it one of the most significant and costly parts of a power system [15]. A transformer's longevity and efficiency can be increased by its ideal design alone [16], but ongoing maintenance is also necessary to keep the transformer from failing. The power transformer plays a crucial function in a grid, hence ongoing monitoring of this component is necessary for predictive maintenance and asset management. There are two types of transformers: mineral oil-immersed transformers and cast resin dry-type transformers, which are distinguished by the insulating and cooling media used. We assess an oil-immersed transformer's Health Index (HI) in this research. HI is a technique for calculating the transformer's overall condition using several test and data sets, including visual inspection, laboratory testing, and operation data.

CHAPTER 3

METHODOLOGY

3.1 Introduction

. This chapter discussed the major component of this project, methods and techniques used to ensure project goals are achieved. It also described the steps involved as well as details of the main components. Any discoveries about the hardware and software that will be used is compared and clarified to gain more understanding about their impact to this project and how it will be executed significantly. Flowchart and block diagram of the project was made to specifically shows the execution of the project and the connection between the device and module. This help to visually demonstrated the program.

3.2 Planning

Planning is the first stage to start any project and this stage, it will show the specific end goal that should be obtain and how the progress plan should be followed. In this stage, information gathering about the hardware and software that will be involve in this project should be collected to guarantee the work can be done effectively. Besides, planning also require a working work plan that should be the guideline from the start of the project until the end. This will systematically help to achieve and do the process with proper timeline and help to avoid stretching any activities from the due date.

3.3 Flowchart

The program flowchart uses several graphical diagrams to draw the sequence of the program in this project. From the figure 3.1, the sequence is beginning at “Start” and finish at “End”. The programme flowchart begins with a system analysis and connects to the Blynk application. After that, at the Blynk app have interface that will appear and provide the three transformers' total current, transformer oil level, temperature, and load voltage (L1, L2, L3) for each transformer. When overcurrent occurs, the user will receive a notification on their smartphone. If this transformer is functioning normally, it won't alert you and will carry on as usual. Oil level and temperature are only being monitored in this system.

As soon as the transformer is turned on, the system is initialised, and an automated connection to the Blynk app via smartphone. The smartphone has an interface that displays the three-phase transformer's overall current as well as the voltage for each phase, oil level, and temperature. Following that, it will read and send data to the Blynk app and LCD. The Blynk app will show data every second, however the LCD won't show anything until ten seconds have passed. Additionally, the Blynk app has a trigger load value that allows us to specify an overcurrent threshold of 1 to 3 Amp. This figure is derived from the overall current of every project component. To reset the system, use the "Press to reset" button function.

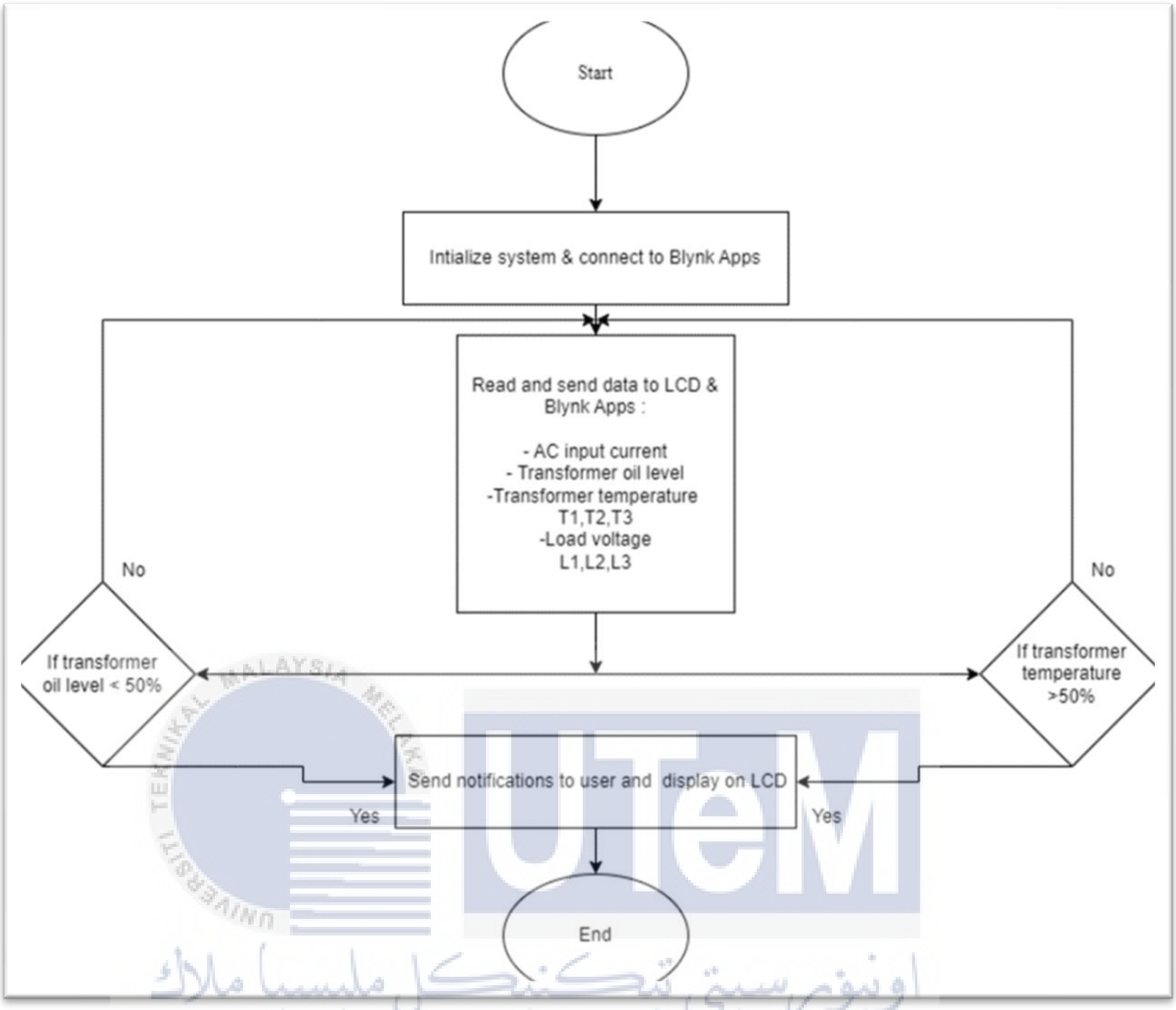

Figure 3.1 Flowchart

3.4 Software/ Application Software

3.4.1 Arduino Software

Arduino Software may program any Arduino whether Arduino Uno, Pro Mini and many more. It also can be used to program ESP32. Then, ESP32 will execute the program to the circuit or project desired. This software has some common in coding or instruction with C Compiler. Installing the "Arduino core" for ESP32 is usually required for developers to use the ESP32 with the Arduino IDE. The tools and libraries required to create ESP32 projects with the Arduino IDE are included in the Arduino core for ESP32.

Figure 3.2: Arduino IDE

3.4.2 Blynk Software

Blynk is a new platform that quickly creates interfaces from android or iOS devices for monitoring and controlling hardware project. Figure 3.3 displayed the interface used for this project. Users need to create project dashboard and organize virtual buttons, graphs, sliders, and other widgets on the screen to create these interfaces. Plus, widgets may turn pins on and off or display data from sensor or any peripheral devices. It does support microcontroller such as Arduino boards, ESP32, Raspberry Pi and more.

Figure 3.3 Blynk Interfaces

3.5 Hardware

3.5.1 ESP 32

The ESP32 is primarily designed for use in IoT, wearable technology, and mobile applications. The ESP32 has established itself as the top chip or module for IoT developers and amateurs. Tensilica Xtensa 32-bit LX6 is the microprocessor used by ESP32. This utilises a core or two. It can process up to 600 DMIPS (Dhrystone Million Instructions Per Second) at a clock frequency of up to 240MHz. The ESP32's wireless connectivity allows for connection to built-in Wi-Fi. Up to four 16 MiB external QSPI flashes and SRAMs with hardware encryption based on AES are supported by ESP32 for use as external flash and SRAM.

When it comes to the Internet of Things (IoT), ESP32 has various uses. Embedded devices may communicate with routers and send data thanks to the module's dual core and Wi-Fi antenna. processing fundamental data from analogue and digital sensors to far more intricate calculations. ESP32 can connect to a smartphone using Bluetooth or Wi-Fi, among other wireless protocols. When two devices are connected by Wi-Fi, the connection can normally be kept if both are within the coverage area of a reliable Wi-Fi network and have enough power. Depending on how close the devices are to one another and how active the network is, the connection may endure for several hours, days, or even weeks.

It acts as the brain for this project and executes tasks based on programs uploaded into it. Besides that, all sensors like ultrasonic sensor, DHT11 for measure temperature and humidity, ACS712 for current sensor and voltage sensor will be connected to ESP32. The ESP32 will utilize the proper libraries and code snippets to read data from each sensor after it is linked to all the sensors. The ESP32 has several connection methods, including Wi-Fi and Bluetooth, but this project primarily employed Wi-Fi to enable sending sensor data to a smartphone via the Blynk app and other devices, like the 20 x 4 that were used in this project for display.

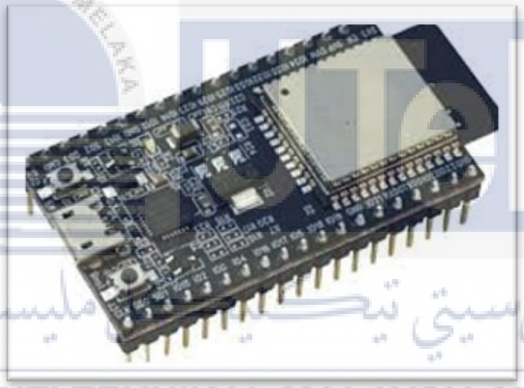

Figure 3.4 ESP 32

3.5.2 Transformer 240 >12 VAC

Transformer 240 >12V AC transform a 240V AC (alternating current) voltage to 12V AC, It a step-down transformer. The transformer will reduce the voltage from 240V to 12V while maintaining the alternating current waveform. Steps to achieve choose a transformer with a primary (input) voltage rating of 240V AC and a secondary (output) voltage rating of 12V AC. In this project, a 12V DC bulb was used as the load, and an AC to DC converter had already been used to convert the AC output to the Dc output. Connect the transformer's primary side to a 240V AC power source. Typically, the major side has two terminals or wires. Make sure the connections are well-insulated and secure. Connect your load or circuit that needs a 12V AC supply to the secondary side of the transformer. Two wires or terminals will also be present on the secondary side.

In this project, three single phase transformers will simulate three phase transformers, with each transformer standing in for the red, yellow, and blue phases. Each transformer will supply a load of a 12V DC bulb. To supply 12V DC to the load, an AC to DC converter has been utilized to convert the transformer's AC output to DC. Focused more on commercial elements like office buildings, shopping centers, hotels, and other parts of mixed-use complexes, which, as we know, used greater load on DC than AC. The primary side of the transformer connects to the socket, which receives the AC voltage input. The wiring from the socket to the primary side of the transformer should be done according to electrical safety guidelines. The secondary side of the transformer provides a lower AC voltage output. This side connects to the load or circuit.

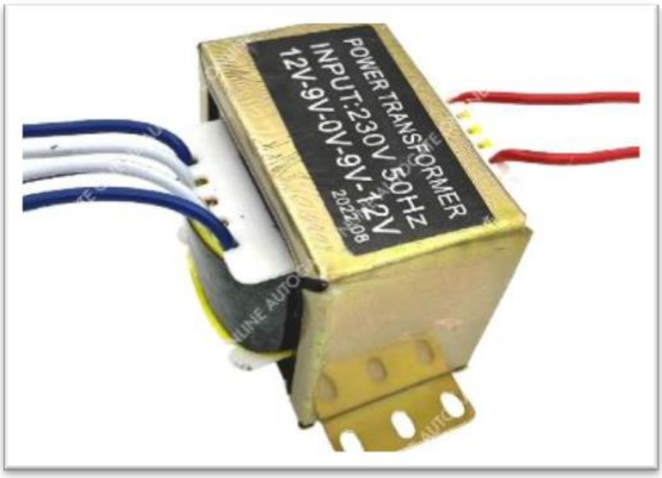

Figure 3.5 Transformer.

3.5.3 ACS 712 (current sensor)

The ACS712 is a current sensor module based on the Hall effect that can measure both AC and DC currents. It offers a non-intrusive way to measure current without making direct electrical contact with the conductor. Common uses for the ACS712 sensor module include power monitoring, energy management systems, motor control, and robotics. The ACS712 is available in different variants with varying current measurement ranges, such as 5A, 20A, and 30A. The ACS712 provides an Analog output voltage that is proportional to the sensed current. The ACS712 module requires a power supply within a specified voltage range, typically between 4.5V and 5.5V [17].

The ACS712 module has three pins: VCC, GND, and OUT. In this project, connection for ACS 712 (current sensor) VCC pin, connect the VCC pin of the ACS712 to a stable and regulated power supply within the specified voltage range which is 5V. After that, connect the GND pin of the ACS712 to the ground reference of your circuit. It should be connected to the same ground as the rest of your components. Then, the OUT pin of the ACS712 provides an Analog voltage output that is proportional to the sensed current. To measure the total current of a three-phase transformer using the ACS712 current sensor. Determine the Current Rating, identify the current rating of the three-phase transformer. After that, ACS 712 already been chosen because this module and handle the maximum current rating of three-phase transformer. The ACS712 is available in different current rating options. Then, for the wiring connection connect the ACS712 module in series with one of the phases of the transformer. Cut the line conductor and connect the ACS712 module in series with the cut wire. Ensure that the current flows through the ACS712 module. Power Supply for ACS712 provide a stable and regulated power supply within the specified voltage range of the ACS712 module (typically between 4.5V and 5.5V)

Figure 3.6 ACS 712

3.5.4 LCD 20x4

A flat panel display technology called an LCD (Liquid Crystal Display) is widely employed in a variety of electronic gadgets. It makes use of the abilities of liquid crystals to manipulate light transmission and produce images or text. LCDs are widely utilized in a variety of devices that need visual output, including televisions, computer monitors, cell phones, digital cameras, calculators, and many others.

A microcontroller and an LCD (Liquid Crystal show) work well together to show data and design user interfaces for electronic devices. When an LCD is attached to a microcontroller, a variety of applications can easily incorporate visual feedback, text, and graphics. The LCD display connected to a microcontroller is shown in this overview.

The three-phase transformer's total current is displayed on an LCD 20x4 in this project. Voltage for each phase transformer follows. Temperature for each phase of the transformer, and finally, the transformer's oil level.

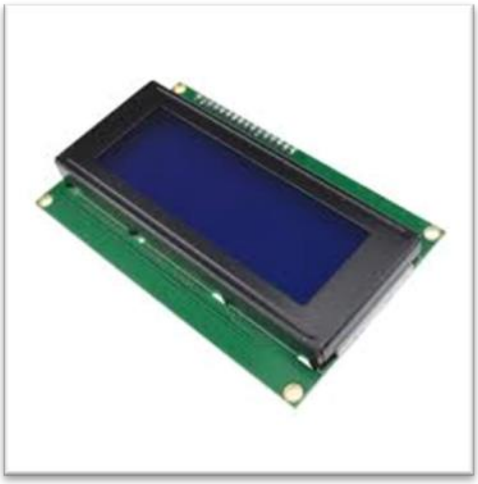

Figure 3.7 LCD 20x4

3.5.5 DHT 11 (temperature and humidity sensor)

Popular digital temperature and humidity sensors like the DHT11 offer an affordable way to measure environmental factors. It is frequently utilized in many different applications, including as home automation, HVAC systems, and weather stations. The DHT11 sensor measures humidity and temperature using a thermistor and a capacitive humidity sensor, respectively. Measure humidity with a 5% accuracy over the range of 20% to 90%. It offers a 0°C to 50°C temperature measurement range with a 2°C accuracy. A microcontroller and the DHT11 sensor communicate with each other via a unique one-wire digital interface.

In this project DHT11 will be used to measure temperature for each transformer. Each transformer has own DHT11. Overheating in transformers can occur due to various factors. Overloading, if the load on the transformer exceeds its rated capacity for an extended period, it can lead to overheating. Then, poor cooling if the cooling system, such as fans or cooling oil, is not functioning effectively or if the cooling fins are blocked by debris or dust, it can result in inadequate heat dissipation and lead to overheating. DHT11 will be a stand-alone system in this project because it won't be connected to the load; instead, it will be installed on each transformer. It can be used to explain overheating or not by placing the DHT11 adjacent to hot or cold objects, for example. From there, we can determine whether the temperature is excessive or not.

For the connection DHT11 sensor typically has four pins: VCC, GND, DATA, and NC (no connection). Power supply, connect the VCC pin of the DHT11 to a suitable power supply voltage of 5V from the microcontroller. After that, connect the GND pin of the DHT11 to the ground (GND) of the microcontroller to establish a common reference voltage.

Then, Connect the microcontroller's digital input/output (I/O) pin to the DHT11's DATA pin. The microcontroller and DHT11 communicate in both directions thanks to this pin. This system's main advantages are easy to use, less energy usage, economical, more convenient to control temperature, and user-friendly [18].

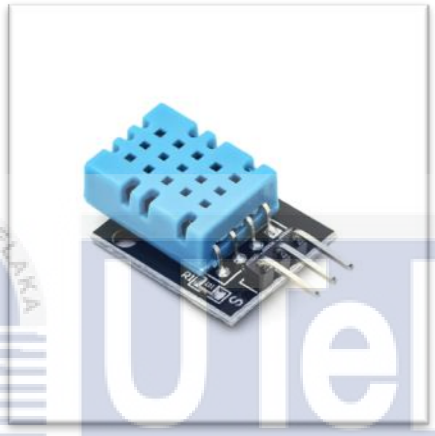

Figure 3.8 DHT11

3.5.6 AC to DC Converter.

An electronic device that transforms alternating current (AC) power into direct current (DC) power is referred to as an AC to DC converter, also known as a rectifier. It is frequently utilized in many situations where DC power is required, including battery charging systems, electronic gadgets, and power sources. The most fundamental type of AC to DC converter is a diode rectifier. It is composed of diodes arranged in a certain configuration, such as a half-wave or full-wave rectifier. The diodes limit the direction in which electricity can flow, essentially converting the AC input into a pulsating DC output.

We need to utilize an AC to DC converter to convert the transformer's output from VAC to DC because the load for this project is VDC and the transformer's output is VAC. A full-wave rectifier has been employed in this project. Using a group of diodes, such as a bridge rectifier, a full-wave rectifier converts the positive and negative sides of the AC input waveform into a continuous DC output. Full wave rectifiers convert both sides of the AC waveform as opposed to half-wave rectifiers, producing a smoother DC output with less ripple, a higher average output voltage, more efficiency, and a better power factor.

Figure 3.9 AC to DC Converter

3.5.7 Ultrasonic sensor

Ultrasonic communication is a completely new method of exchanging data between IoT devices and mobile phones. Communication between them is inaudible, and equipment requirements are minimized: microphone and speakers [19]. An ultrasonic sensor is a piece of equipment that measures the distance to a target item using ultrasonic sound waves and then converts the sound's reflection into an electrical signal. Compared to audible sound, which is the kind of sound that people can hear, ultrasonic waves move more swiftly. The two main components of an ultrasonic sensor are the transmitter, which generates the sound using piezoelectric crystals, and the receiver, which hears the sound after it has travelled to and from the target.

Ultrasonic sensors have been used in this project to measure oil level on transformer. Monitoring the oil level in a transformer is crucial for maintaining its proper functioning and preventing potential issues. Correct oil level maintenance enables effective cooling and prevents overheating. Increased operating temperatures brought on by a low oil level might shorten the transformer's lifespan and perhaps cause failure. Like the DHT11, the ultrasonic sensor in this project is a standalone unit. It is only connected to the microcontroller, which will use it to run the circuit's programme. Simply fill a jar with oil to demonstrate the ultrasonic sensor's ability to detect the oil's level.

Figure 3.10 Ultrasonic sensor

3.5.8 DC Voltage regulator

Despite changes in the input voltage or load conditions, a DC voltage regulator is an electrical circuit or device that controls and maintains a constant DC output voltage. It frequently serves as a consistent and dependable source of DC voltage for powering electronic equipment across a range of applications. A device that keeps the DC output voltage for the VDC supply constant on a transformer is known as a DC voltage regulator for VDC (Voltage Direct Current). Regardless of changes in the load or variations in the input voltage, DC voltage regulators provide a consistent and steady output voltage. Even when the input voltage varies or fluctuates, voltage regulators maintain the proper output voltage level.

Output Voltage Adjustment depending on the specific requirements, the DC voltage regulator may offer an adjustable or fixed output voltage. An adjustable regulator allows users to set the desired output voltage within a certain range. A fixed regulator provides a specific predetermined output voltage. The DC voltage regulator used in this project has minimum and maximum output voltage controls. The variable voltage will stay within its range. A smartphone will alert someone as soon as the output voltage exceeds or falls outside of the range. DC voltage regulator, load, and voltage sensor must all be connected in parallel. In other way, LCD also will display which phase already in over voltage.

Figure 3.11 DC Voltage Regulator

3.5.9 Voltage Sensor

A voltage sensor, also known as a voltage detector or voltage sensor module, is an electronic device used to measure and monitor electrical voltage levels in a circuit or system. It is commonly employed in various applications to ensure proper voltage levels, detect abnormalities, or trigger actions based on voltage thresholds. Voltage sensors are designed to measure the electrical potential difference, or voltage, between two points in a circuit. They can measure both AC (Alternating Current) and DC (Direct Current) voltages.

In this project we use resistive voltage dividers to measure voltage. A signal generated from voltage sensors reflects the measured voltage. In this case, the output signal is Analog. Analog value is converted to ADC voltage using a calculation that takes the 3.3V reference voltage into account. The voltage sensor requires 3.3V for power, but it can go higher, or handle loads up to 25V. After that in this calculation include 4095.0 this value, we get from 2 power of 12, 12 its bits that we use in this microcontroller which is ESP32. Once we have ADC voltage, we can utilise it to determine input voltage. Voltage sensor, load, and DC voltage regulator must all be connected in parallel. This voltage sensor will sense the value of output voltage if the value still in the range nothing happens but over voltage it will give notify through smartphone and in other way, LCD also will display which phase already in over voltage.

Figure 3.12 Voltage sensor

3.6 Block Diagram of the Project

Development of a monitoring system on transformer using microcontroller block diagram is shown figure 4.3. It required 3 single phase transformers to act as three phase transformers. Each transformer will act as red, yellow, and blue phase. Supply from socket which is 240V AC direct to ACS712 (current sensor) this sensor will measure total current for all 3 transformers. This transformer is step down transformer (240 > 12V AC). After that from AC output to DC used AC to DC converter. Voltage regulator, an adjustable regulator allows users to set the desired output voltage within a certain range. Then, voltage sensor to measure voltage that had been used by the load. 12V DC is a load that used for this purpose. Ultrasonic sensor and DHT11 is a standalone system each sensor has their own function. Ultrasonic sensor to measure oil level on transformer and DHT11 to measure temperature and for each transformer.

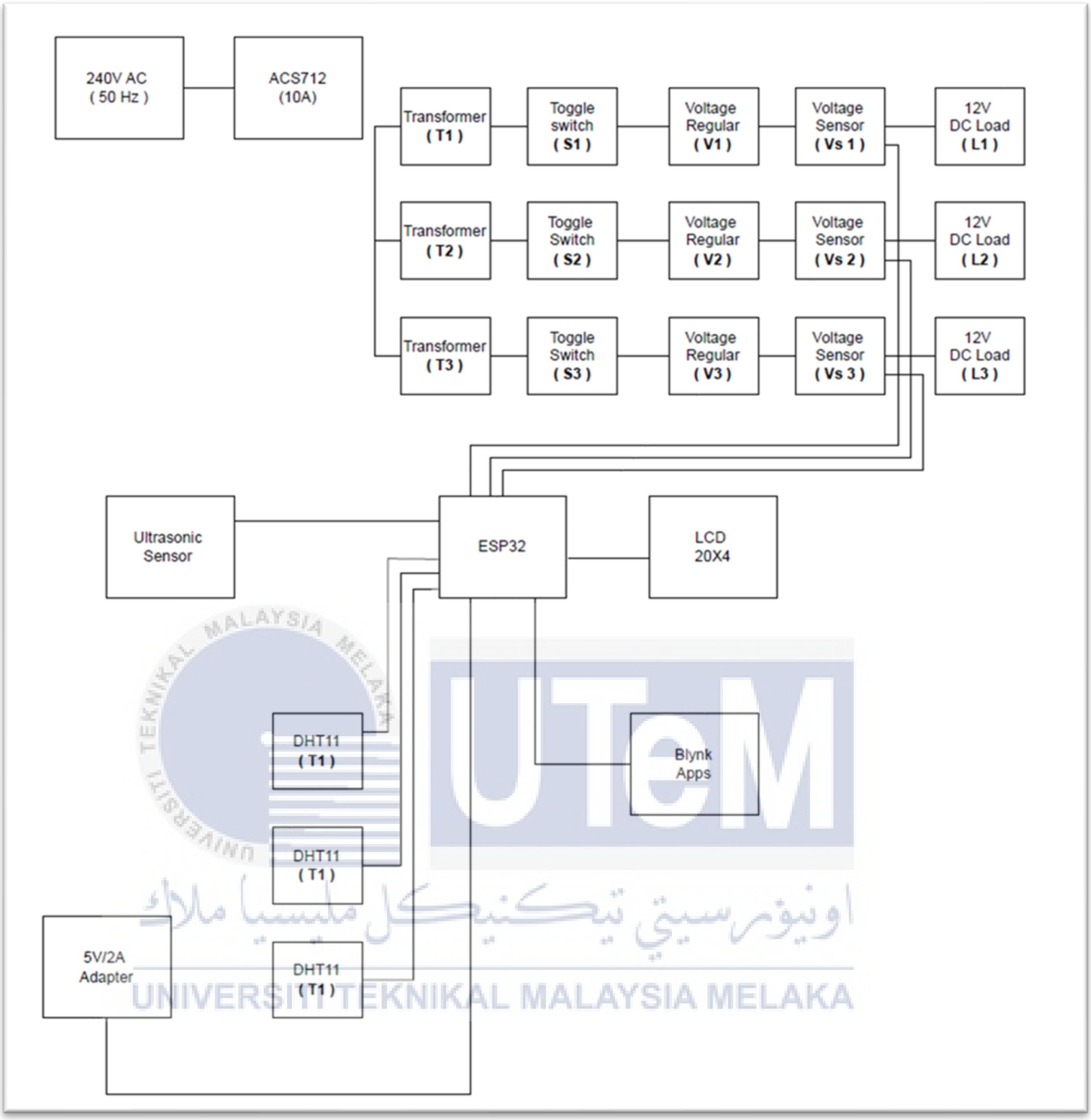

Figure 3.13 Block Diagram

3.7 Blynk App Interface.

Blynk is a platform that facilitates the development of Internet of Things (IoT) mobile applications [20]. It makes it simple to design a user interface for managing and keeping an eye on linked devices. The user interface of the Blynk app is made to be simple to use and intuitive. Widget appearance and functionality can be changed to suit the needs of a project due to the Blynk app's fully configurable interface. The Blynk app is also updated and improved frequently, so the interface might change over time.

3.7.1 Create Blynk Interface for Monitoring 3-Phase Transformer.

Create a Blynk account by sign up for a Blynk account if don't have one. Create a New Project by open the Blynk app and click on "New Project." Enter the project name "IOT Transformer" and select the suitable hardware, as this project makes use of an ESP32.Select the ESP32 microcontroller. To monitor voltage in each phase, temperature, total current, oil level, and other variables, add widgets and gauges as an interface. Reset button: This button resets the entire system to obtain a fresh reading whenever something goes wrong. A slider is used to regulate the load current when it is triggered, and a graph is displayed when overcurrent conditions arise.

To customise a widget, click on it to change its properties. Each widget's virtual pin should be set. The Arduino code will utilise this virtual pin to adjust labels, colours, and other configurations as required. Organise the Widgets Arrange the dashboard's widgets in a way that makes sense and is easy to use. Next, create Arduino code and give each widget a virtual pin. In Arduino programming, make use of the Blynk library. Put the required pins in place and include the Blynk authentication token. Upload the Arduino code to ESP32 and run the Blynk app by open the Blynk app and select project.

FIRMWARE CONFIGURATION

```
#define BLYNK_TEMPLATE_ID "TMPL6k57LlRZS"
#define BLYNK_TEMPLATE_NAME "IOT Transformer"
#define BLYNK_AUTH_TOKEN "WAqQkIQirPZRog-PxGFQdIHrZFQ_02dy"
```

Template ID, Template Name, and AuthToken should be declared at the very top of the firmware code.

Figure 3.14 Blynk Library

```
// for Blynk function (Unique ID User)
#define BLYNK_TEMPLATE_ID "TMPL6k57LlRZS"
#define BLYNK_TEMPLATE_NAME "IOT Transformer"
#define BLYNK_AUTH_TOKEN "WAqQkIQirPZRog-PxGFQdIHrZFQ_02dy"
```

Figure 3.15 Blynk library in Arduino coding.


```
// Blynk datastream are limit to 10 data for free version
#define vPin_TotalLoadCurrent  V0
#define vPin_VoltageLoad_1st   V1
#define vPin_VoltageLoad_2nd   V2
#define vPin_VoltageLoad_3rd   V3
#define vPin_TempTrans_1st     V4
#define vPin_TempTrans_2nd     V5
#define vPin_TempTrans_3rd     V6
#define vPin_OilLevelTrans     V7
#define vPin_ResetButton       V8
#define vPin_triggerValue      V9
```

Figure 3.16 Virtual pin for each widget.

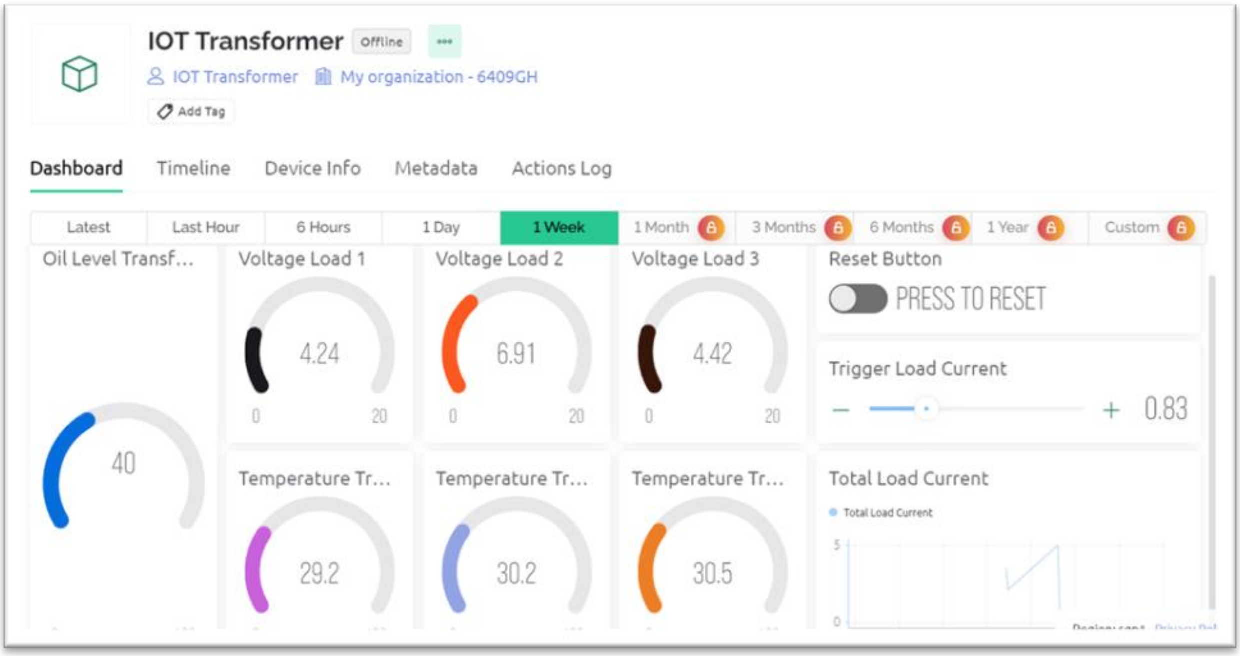

Figure 3.17 Blynk Interface on Desktop.

Simply download the Blynk app from the Apple Store or Google Play Store to use the same interface and project while viewing it on a phone. Use the same account that you used to log in on the desktop. The project that was previously set up will show up after you log in. Click on the project to start automatically monitoring it from your mobile device.

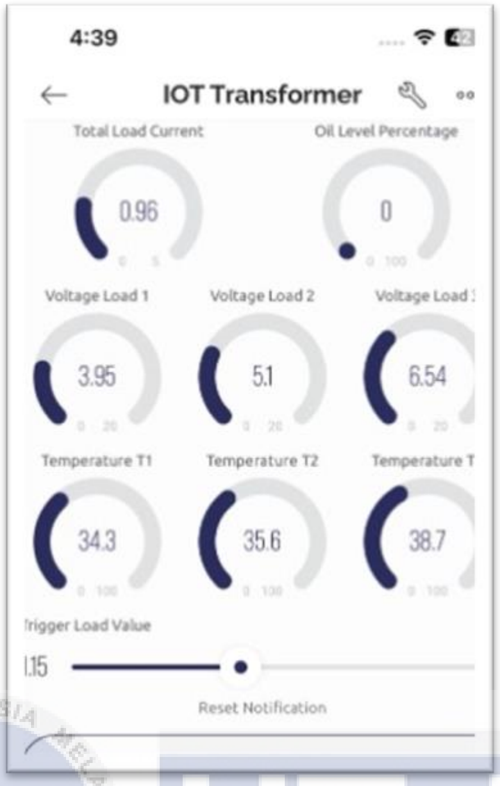

Figure 3.18 Blynk Interface on Mobile Phone.

Table 3.1 Advantage of Blynk App.

Advantage	Description
User-Friendly Interface	Users with different levels of technical expertise can utilise Blynk because of its user-friendly interface.
IoT Device Compatibility	Many IoT devices are supported by Blynk, making it easy for users to manage and keep an eye on a variety of devices.
Customizable Widgets	With a range of widgets, including buttons, sliders, and graphs, users can customise dashboards to fit their own needs.
Real-Time Data Monitoring	offers real-time data monitoring and enabling users to receive live updates and feedback from connected devices.
Multi-Platform Compatibility	compatible with multiple platforms, including iOS and Android, providing a consistent user experience across different devices.

3.8 Telegram Bot

On the messaging app Telegram, a Telegram bot is a unique kind of account that is run by software rather than by a real person. Bots can communicate with people and carry out several functions autonomously. With the help of Telegram's Bot API (Application Programming Interface), developers can build bots and incorporate them into the Telegram network. Telegram bots are becoming more and more popular since they are simple to make, adaptable, and have a lot of uses. A Telegram bot is utilised in this project to provide notifications in the event of an overcurrent. This Telegram bot additionally displays the overcurrent value.

3.8.1 Create Bot in Telegram for Monitoring 3-Phase Transformer.

Engaging with the BotFather on the Telegram platform is necessary to create a Telegram bot. Telegram offers a unique bot called BotFather to assist users in building and managing their own bots. Launch the Telegram app on your PC or mobile device. Enter "BotFather" into the Telegram search field, then choose the official BotFather account. To start a conversation with BotFather, click the "Start" button located at the bottom of the screen. To start a new bot, type /newbot. Comply with the guidelines that BotFather has provided: Select a name for your bot that ends in "bot". Select a username that ends in "bot" for your bot. After everything is finished, BotFather will offer you a special API token for your bot. You'll need this token for authentication, so save it.Copy the API token provided by BotFather. This token is your bot's authentication key.

```
// Library for Telegram
#include <UniversalTelegramBot.h>
#include <ArduinoJson.h>

// Initialize Telegram BOT
#define BOTtoken "6326039106:AAGzxAO53EkJCbYkNfeawBOuUP7WQPCz5vg"  // your Bot Token (Get from Botfather)

// Use @myidbot to find out the chat ID of an individual or a group
// Also note that you need to click "start" on a bot before it can
// message you
#define CHAT_ID "337494771"

WiFiClientSecure client;
UniversalTelegramBot bot(BOTtoken, client);

void initTelegram() {
  // Initialize for telegram notification
  client.setCACert(TELEGRAM_CERTIFICATE_ROOT); // Add root certificate for api.telegram.org
  bot.sendMessage(CHAT_ID, "Bot started up", "");
}
```

Figure 3.19 Define Telegram BOT in Arduino.

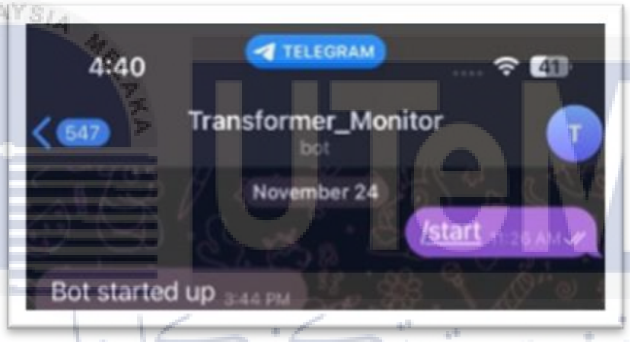

Figure 3.20 Transformer Monitor Bot.

3.9 Arduino Coding.

Arduino may be used for a wide range of tasks, including reading sensor data, controlling various lights and motors, and interacting with computer software [21]. Arduino coding involves programming microcontrollers, specifically those on Arduino boards, using the Arduino programming language. Arduino is a popular open-source electronics platform designed for hobbyists, students, and professionals to create interactive projects and prototypes. Arduino is built on open-source principles, providing an accessible and flexible platform for hardware and software development. The Arduino IDE is a user-friendly development environment for writing, compiling, and uploading code to Arduino boards. It supports the Arduino programming language, which is based on C/C++.

```
// Define i2c LCD
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 20, 4);

// Initial For LCD
int statusLCD;
bool TurnON = true;
bool TurnOFF = false;

void initLCD() {
  lcd.begin();
  lcd.backlight();
  lcd.setCursor(0, 1);
  lcd.print("Status WIFI : ");
  lcd.setCursor(0, 2);
  lcd.print("   Connecting    ");
  delay(2000);
  Blynk.begin(auth, ssid, pass); // connecting wifi to link with Blynk Server/domain
  lcd.setCursor(0, 2);
  lcd.print("   Connected!     ");
  delay(2000);
  lcd.clear(); // Clear display on LCD Screen

  lcd.setCursor(0, 1);
  //lcd.print("                    ");
  lcd.print("      3 Phase       ");
  lcd.setCursor(0, 2);
  lcd.print("    Transformer     ");
  delay(2000);
```


Figure 3.21 Coding to Declare LCD Function.

```
// Define DHT11 Temperature and Humidity Sensor
#include "DHT.h"

#define DHTPIN_1st 2
#define DHTPIN_2nd 4
#define DHTPIN_3rd 5

#define DHTTYPE DHT11

DHT dht_1st(DHTPIN_1st, DHTTYPE);
DHT dht_2nd(DHTPIN_2nd, DHTTYPE);
DHT dht_3rd(DHTPIN_3rd, DHTTYPE);

// float temperature
float t_1st = 0.0;
float t_2nd = 0.0;
float t_3rd = 0.0;

// float humidity
float h_1st = 0.0;
float h_2nd = 0.0;
float h_3rd = 0.0;

void initDHTSensor() {
  dht_1st.begin();
  dht_2nd.begin();
  dht_3rd.begin();
}
```

Figure 3.22 Coding to Declare DHT11 Function.

```
// Define voltage sensor
#define voltageSensor_1st_Pin 34 // Analog input pin for voltage sensor
#define voltageSensor_2nd_Pin 35 // Analog input pin for voltage sensor
#define voltageSensor_3rd_Pin 32 // Analog input pin for voltage sensor

// Floats for ADC voltage & Input voltage
float adc_voltage_1st = 0.0;
float adc_voltage_2nd = 0.0;
float adc_voltage_3rd = 0.0;
float in_voltage_1st = 0.0;
float in_voltage_2nd = 0.0;
float in_voltage_3rd = 0.0;

// Floats for resistor values in divider (in ohms)
float R1 = 30000.0;
float R2 = 7500.0;

// Float for Reference Voltage
float ref_voltage = 3.3;

// Integer for ADC value
int adc_value_1st = 0;
int adc_value_2nd = 0;
int adc_value_3rd = 0;

void initVoltageSensor() {
  pinMode(voltageSensor_1st_Pin, INPUT);
  pinMode(voltageSensor_2nd_Pin, INPUT);
  pinMode(voltageSensor_3rd_Pin, INPUT);
}
```


Figure 3.23 Coding to Declare Voltage Function.

```
// Define current sensor
#include "ACS712.h"

ACS712 sensor(ACS712_05B, 33);
//ACS712_20A for 20 Amp type
//ACS712_30A for 30 Amp type

float I_Total = 0.0;
float triggerValue;

void initCurrentSensor() {
  sensor.calibrate();
}
```

Figure 3.24 Coding to Declare Current Sensor Function.

```
// Define Ultrasonic Sensor
#include <NewPing.h>

#define TRIGGER_PIN  13  // Arduino pin tied to trigger pin on the ultrasonic sensor.
#define ECHO_PIN     12  // Arduino pin tied to echo pin on the ultrasonic sensor.
#define MAX_DISTANCE 200 // Maximum distance we want to ping for (in centimeters). Maximum sensor distance is rated at 400-500cm.

NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE); // NewPing setup of pins and maximum distance.

float distanceInCM;
int percentageValue;
//=============================================================================================
//Sync and Restore data from blynk server
BLYNK_CONNECTED() {
  //get data stored in virtual pin from server
  Blynk.syncVirtual(vPin_triggerValue);
```

Figure 3.25 Coding to Declare Ultrasonic Sensor Function.

In Arduino coding, defining components involves specifying the properties and behaviour of the hardware elements connected to the microcontroller board. This is done using constants, variables, and functions to interact with various components such as LEDs, sensors, displays, and more. Figures 4.11 through 4.15 display the coding for each component connected to the ESP32 microcontroller. The first step is to declare each component and specify the pin that each one connects to the microcontroller (ESP 32). This process is necessary for the component to function.

```
void readVoltageSensor() {
  // Read the Analog Input
  adc_value_1st = analogRead(voltageSensor_1st_Pin);
  adc_value_2nd = analogRead(voltageSensor_2nd_Pin);
  adc_value_3rd = analogRead(voltageSensor_3rd_Pin);

  // Determine voltage at ADC input
  adc_voltage_1st  = (adc_value_1st * ref_voltage) / 4095.0;
  adc_voltage_2nd  = (adc_value_2nd * ref_voltage) / 4095.0;
  adc_voltage_3rd  = (adc_value_3rd * ref_voltage) / 4095.0;

  // Calculate voltage at divider input
  in_voltage_1st = adc_voltage_1st / (R2 / (R1 + R2));
  in_voltage_2nd = adc_voltage_2nd / (R2 / (R1 + R2));
  in_voltage_3rd = adc_voltage_3rd / (R2 / (R1 + R2));

  // Print results to Serial Monitor to 2 decimal places
  Serial.print("1st Input Voltage = ");
  Serial.print(in_voltage_1st, 2);
  Serial.print("v, 2nd Input Voltage = ");
  Serial.print(in_voltage_2nd, 2);
  Serial.print("v, 3rd Input Voltage = ");
  Serial.print(in_voltage_3rd, 2);
  Serial.print("v");

  // Sent data to Blynk
  Blynk.virtualWrite(vPin_VoltageLoad_1st, in_voltage_1st);
  Blynk.virtualWrite(vPin_VoltageLoad_2nd, in_voltage_2nd);
  Blynk.virtualWrite(vPin_VoltageLoad_3rd, in_voltage_3rd);
}
```


Figure 3.26 Coding of Process Voltage Sensor.

```
void readCurrentSensor() {
  I_Total = sensor.getCurrentAC();
  if (I_Total <= 0.45) {
    I_Total = 0;
  } else {
    I_Total = I_Total;
  }
  notificationText = "Over Load Current Are Detected!!";
  notificationText += ", load current: " + String(I_Total) + "A.";

  if (I_Total >= triggerValue) {
    statusLCD = TurnON;
    if (statusNotify == 0) {
      Blynk.logEvent(ALERT, notificationText);         // sent notification to blynk
      bot.sendMessage(CHAT_ID, notificationText, ""); // sent notification to Telegram
      statusNotify = 1;
    }
  } else {
    // Do Nothing Here
  }

  if (statusLCD == TurnON) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("  Over Load Current ");
    lcd.setCursor(0, 1);
    lcd.print("   are DETECTED !!  ");
    lcd.setCursor(0, 2);
    lcd.print("Total Load Current:-");
    lcd.setCursor(0, 3);
    lcd.print("       " + String(I_Total) + "Ampere    ");
    delay(5000);
```

Figure 3.27 Coding of Process Current Sensor.


```
    lcd.clear();
    statusLCD = TurnOFF;
  } else {
    // Do Nothing Here
  }

  // Display data to serial monitor
  Serial.print(", Total Current : ");
  Serial.print(I_Total);
  Serial.println(" A");

  // Sent Data to Blynk
  Blynk.virtualWrite(vPin_TotalLoadCurrent, I_Total);
}
```

Figure 3.28 Coding of Process Current Sensor.

```
void readDHT11Temperature() {
  // Reading temperature or humidity takes about 250 milliseconds!
  // Sensor readings may also be up to 2 seconds 'old' (its a very slow sensor)
  h_1st = dht_1st.readHumidity();
  h_2nd = dht_2nd.readHumidity();
  h_3rd = dht_3rd.readHumidity();
  // Read temperature as Celsius (the default)
  t_1st = dht_1st.readTemperature();
  t_2nd = dht_2nd.readTemperature();
  t_3rd = dht_3rd.readTemperature();
```

Figure 3.29 Coding of Process DHT11.

```
void readUltrasonicSensor() {
  distanceInCM = sonar.ping_cm();

  // Mapping value from lenght to percentage
  percentageValue = map(distanceInCM, 12, 2, 0, 100);

  if (percentageValue <= 0) {
    percentageValue = 0;
  }
  else if (percentageValue >= 100) {
    percentageValue = 100;
  }
  else {
    percentageValue = percentageValue;
  }
```


Figure 3.30 Coding of Process Ultrasonic Sensor.

```
void displayDataOnLCD() {

  if (statusLCD == TurnOFF) {
    // Display Voltage Load 1, 2 & 3 data on LCD Display
    lcd.setCursor(0, 0);
    lcd.print("VL1: ");
    lcd.print(in_voltage_1st);
    lcd.print(" ");
    lcd.setCursor(10, 0);
    lcd.print("VL2: ");
    lcd.print(in_voltage_2nd);
    lcd.print(" ");
    lcd.setCursor(0, 1);
    lcd.print("VL3: ");
    lcd.print(in_voltage_3rd);
    lcd.print(" ");

    // Display Temperature data on LCD Display
    lcd.setCursor(0, 2);
    lcd.print("T1 : ");
    lcd.print(t_1st, 1);
    lcd.print(" ");
    lcd.setCursor(10, 2);
    lcd.print("T2 : ");
    lcd.print(t_2nd, 1);
    lcd.print(" ");
    lcd.setCursor(0, 3);
    lcd.print("T3 : ");
    lcd.print(t_3rd, 1);
    lcd.print(" ");
```


Figure 3.31 Coding of Process LCD.

From figure 4.16 to 4.21, working with hardware components in Arduino coding requires a few steps, starting with the declaration of variables and constants and ending with the use of functions to communicate with hardware. Constants are values that are specified using the const keyword and are used consistently throughout the programme. Variables are values that can vary while the programme is running and are specified with a data type. When the Arduino is powered on or reset, the setup function is run once. It's utilised for setup duties, pin configuration, and component initialization. The setup function is followed by the loop function, which is run repeatedly. It includes the program's core logic, outlining the continuous loop interactions between the Arduino and other components.

It is possible to define additional functions to encompass duties or operations. The setup or loop routines then invoke these functions. Arduino libraries offer pre-written code that makes difficult jobs easier to do. The #include directive is used to include them in the code. Decisions based on specific conditions are made using conditional statements. Loops enable the programme to run a chunk of code repeatedly when doing repetitive tasks.

Table 3.2 Different between #define and Output Coding.

#define	Output Coding
Macro definition for constant values.	Directly assigns values to variables.
#define NAME value.	const dataType NAME = value;
#define LED_PIN 13.	const int LED_PIN = 13;
Limited flexibility as it is a simple.	More flexible as it allows for dynamic.
Can make code more readable by using meaningful names.	Provides a clear assignment of values within the specific context.
Can be harder to debug as values are replaced during preprocessing.	Easier to debug since variables have explicit names and types.

Table 3.3 Advantage of Arduino Coding.

Advantage	Description
Simplicity	Arduino is user-friendly for novices since it employs an IDE and a simpler programming language.
Community Support	A vibrant and helpful community for project sharing, advice-seeking, and troubleshooting.
Rich Hardware Ecosystem	A large selection of shields and hardware compatible with Arduino for a range of uses.
Cross-Platform Compatibility	The Arduino IDE is compatible with many settings and is available for several operating systems.
Low-Cost Hardware	Due to their low cost, Arduino boards are a good option for both educational and hobbyist applications.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, which is results and discussion, the analysis will be made according to the data that have been collected and by observation of the development of monitoring system on three-phase transformer. The hardware designed and software that have been implemented were explained. The function of this system was tested in the prototype form and explained. Several limitations of this project also were discussed in this chapter.

4.2 Results in Hardware.

When the project first turns on, the load will be in the lowest range of 0–20V. The Blynk app and Telegram will immediately connect to this system. Nevertheless, we must first construct transformer_monitor as a bot on Telegram before connecting it to this system.Send a message or begin connecting this system to Telegram after that. Second, as soon as we activate this project, this telegram will link automatically.

Figure 4.1 Display in telegram.

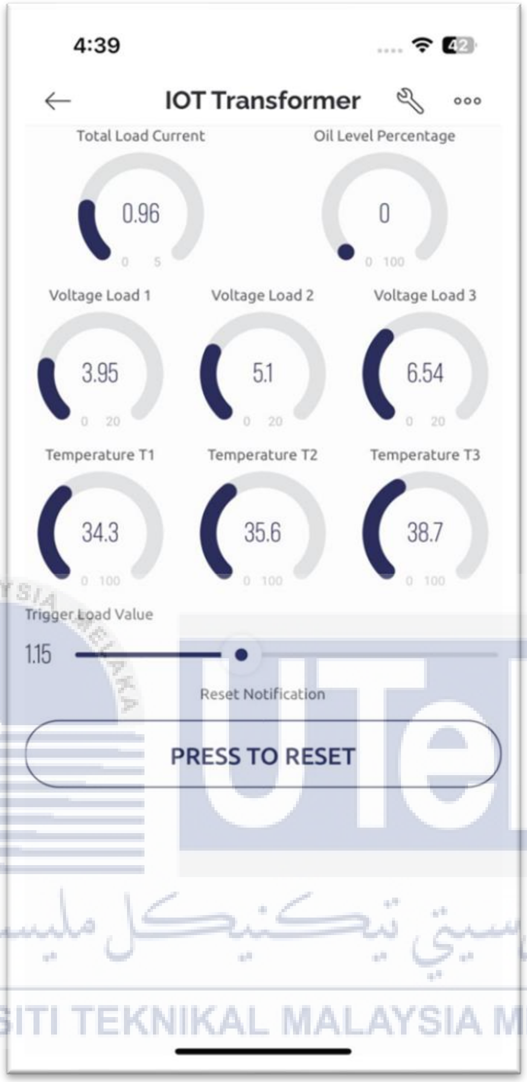

Figure 4.2 Display in Blynk App.

The Blynk app will display a few parameters and functions. We can regulate the load value to trigger in this system. We may set the function to trigger wherever we want because it is already set up to operate up to 3 Amp.To reset the system, use the reset button function. This app's data will be read and shown for one second

4.2.1 Normal Condition.

Under standard operating conditions, the Blynk app simply shows the overall current value, transformer 1, 2, 3, oil level, and temperature for the transdormer 1, 2, 3, as shown in figure 4.2. On the other hand, with Telegram, the display stays unchanged as seen in Figure 4.1 as long as there is no overcurrent. LCD is shown in a typical scenario in Figure 4.3.

Figure 4.3 Display in LCD.

4.2.2 Overcurrent Condition.

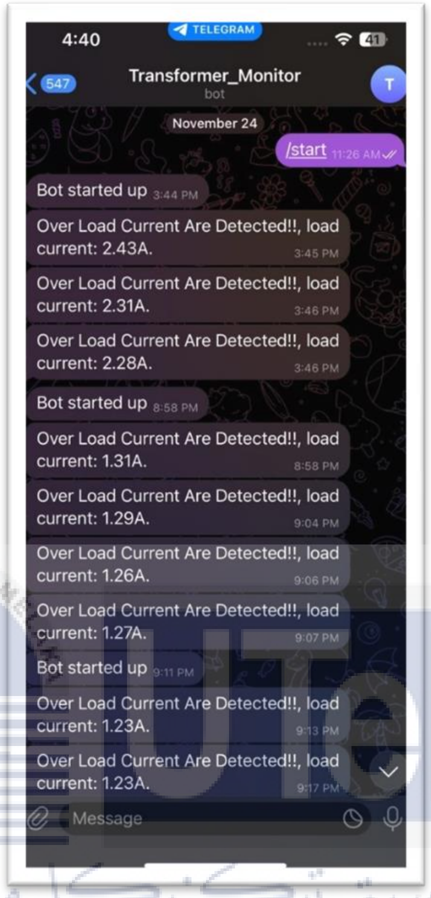

Figure 4.4 Display in telegram when overcurrent.

This will show up in Telegram in the event of an over-load current. It will display the number of overcurrent events.It will show up as notifications, but we can enter Telegram to see more information, as seen in figure 4.4.

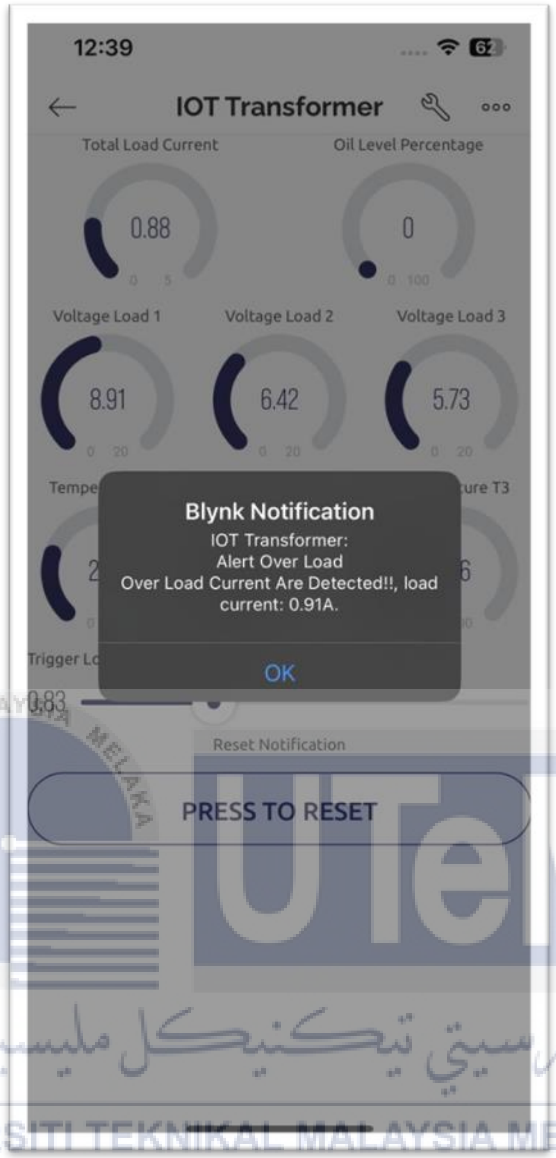

Figure 4.5 Display in Blynk app when overcurrrent.

This method will use the Blynk app to notify our smartphone when an overcurrent occurs. The Blynk app's timeline information displays the overcurrent in detail.This project will notify users when an overcurrent occurs, but it will just monitor the temperature and oil level.

Figure 4.6 Example of overcurrent situation.

Figure 4.6 indicates that we will receive notifications from the Blynk and Telegram apps when an overcurrent occurs.Following then, the LCD will show overcurrent. This is due to the ESP32 microcontroller used by the Blynk and Telegram apps, which automatically establish a connection with the system. More details: prior to this, we are aware that the Blynk app will display data for one second, but the LCD will reveal the data after 10 seconds.

4.3 Normal Condition: Oil level and temperature

In this scenario as known oil level for this 3phase transformer and temperature for transformer 1,2,3 is a stand-alone system. It is solely linked to the microcontroller, which will utilise it to execute the programme for the circuit. To show that the ultrasonic sensor can detect the oil's level, just fill a jar with oil. Because DHT11 will be mounted on each transformer rather than being connected to the load, it will function independently in this project. By arranging the DHT11 next to hot or cold things, for instance, it can be utilised to explain if overheating occurs or not. We can then decide whether the temperature is too high. These two systems are only being monitored; they are not experiencing any unusual issues. When discussing the monitor system, figures 4.3 and 4.4 might be consulted.

The supervision of three-phase transformers is made easier by implementing Internet of Things-enabled sensors to monitor temperature and oil level. These sensors send real-time data to a cloud based IoT platform via technologies like thermocouples and ultrasonics. The platform analyses the data and sends out alerts when predetermined thresholds are crossed. Automated notifications guarantee timely reactions to anomalous conditions, and an intuitive mobile application or web interface permits remote access to historical trends and monitoring data. Predictive maintenance algorithms improve overall system reliability, and their integration with current SCADA systems enables smooth data flow. Throughout the monitoring process, energy efficiency and safe communication are guaranteed using low-power Internet of Things devices and strong cybersecurity procedures.

4.4 Data Analysis

Table 4.1 Input Voltage for Transformer 1,2,3, and Total Current.

1st Input Voltage (v)	2nd Input Voltage (v)	3rd Input Voltage (v)	Total Current (A)
5.11	4.03	5.04	0.70
4.79	3.54	3.57	0.68
6.41	4.44	4.06	0.69
4.10	5.67	4.82	0.76
6.50	4.68	6.10	0.63
6.79	4.34	4.36	0.90
4.66	4.73	3.86	0.68
4.53	4.36	4.19	0.75
3.78	4.31	4.68	0.66
5.55	6.58	6.69	0.66

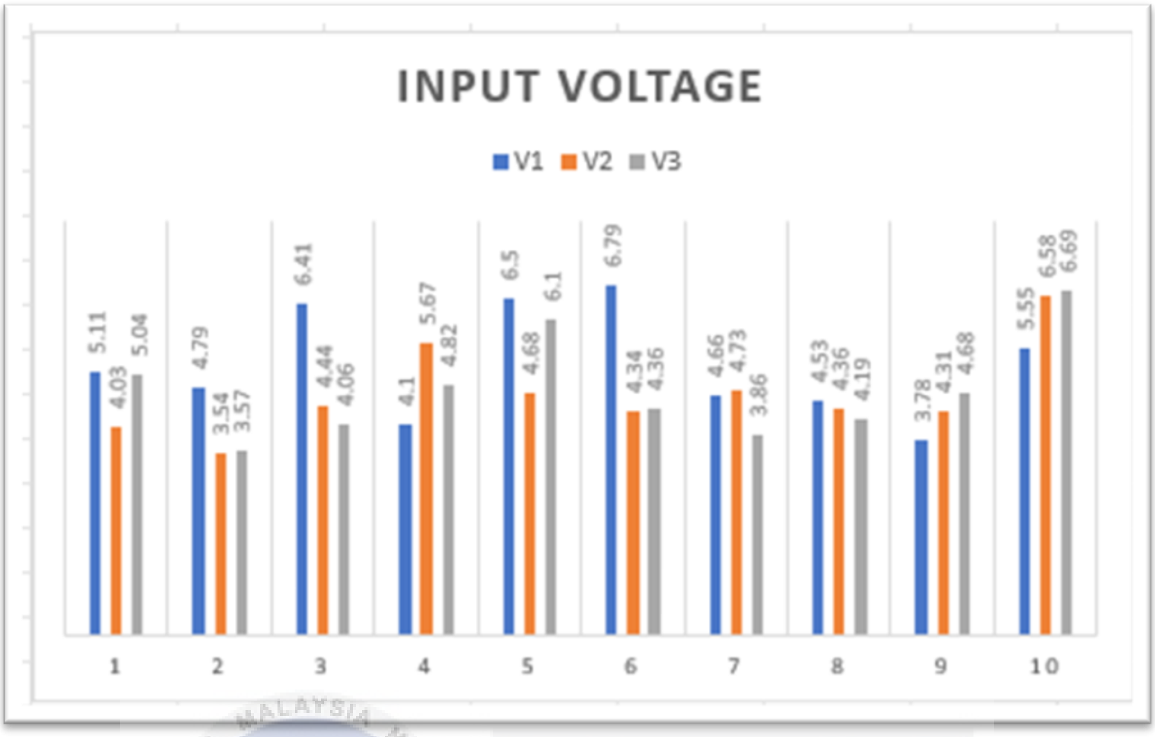

Figure 4.7 Chart of Input Voltage for Transformer 1,2,3.

Because the input voltage can be adjusted to the appropriate level for each phase, the output voltage results are not constant or within a similar range. The value range for each phase's input voltage is 0–20 volts. Using the same input voltage, we can set each phase even if figure 4.7 shows that each phase had a different value. The input voltage that supplies each phase can also be monitored via the Blynk app and LCD.

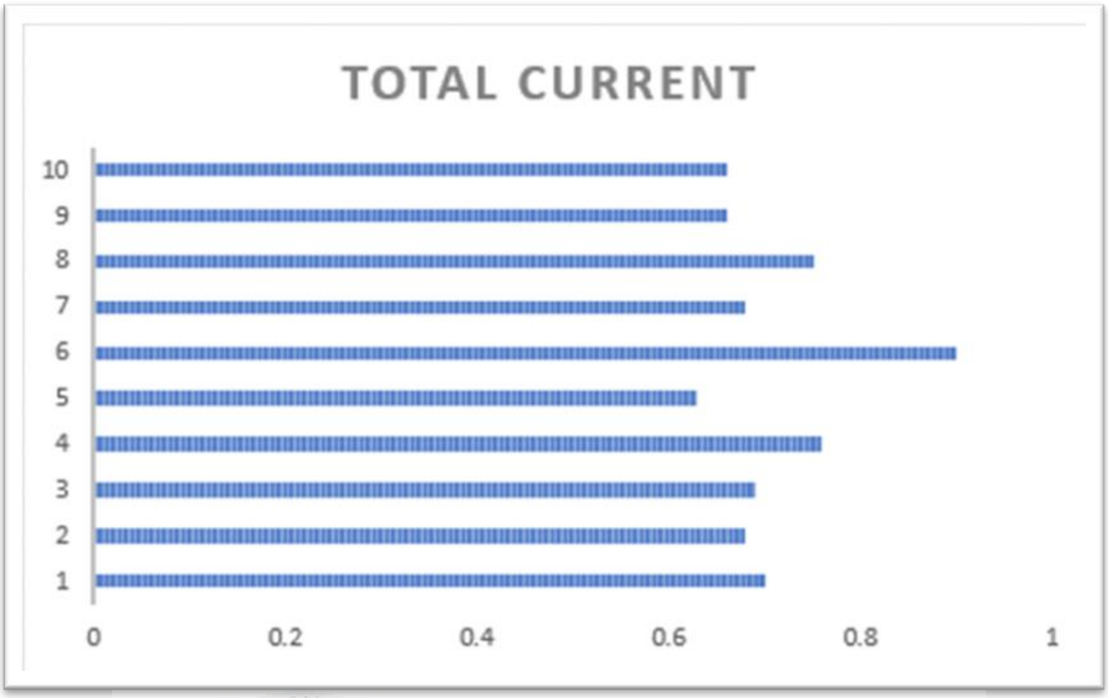

Figure 4.8 Chart of Total Current for 3-phase Transformer.

The total current value is the product of the current values of all the components that were utilised. Since it is known that each component has a current value, the overcurrent value in this instance can be adjusted between 1 and 3 amps. Knowing the current value of each component before setting this value allows you to declare the overcurrent value later. We can set 1 Amp to 3 Amp as overcurrent conditions after calculating the sum of all current values.

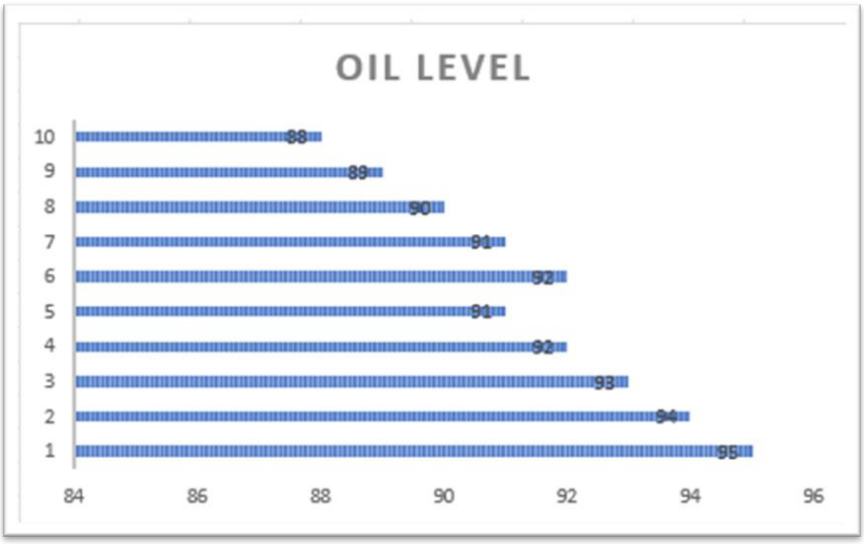

Figure 4.9 Chart of Oil Level for 3-phase Transformer.

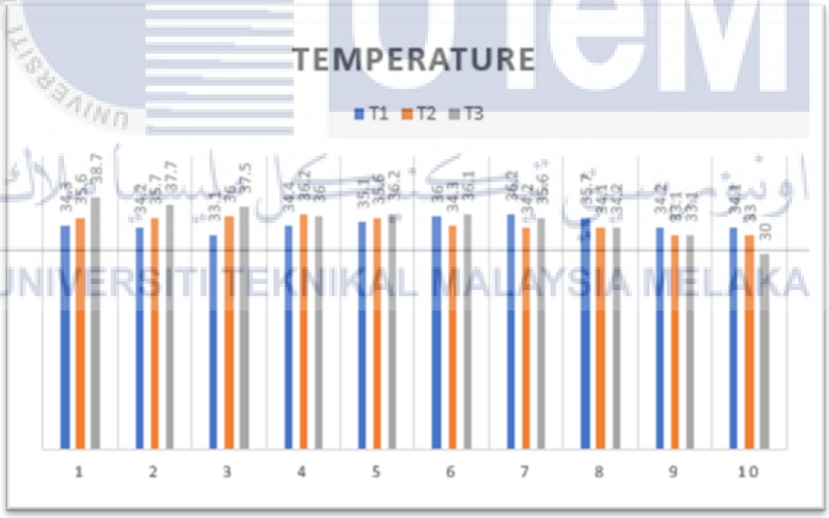

Figure 4.10 Chart of Temperature for Transformer 1,2,3.

Oil level and temperature for transformer 1,2,3 that received from monitoring, for transformer temperature result got from surrounding temperature. Next, check the oil level by adding and subtracting oil to obtain the desired level and ensure the ultrasonic sensor is operating properly. These two sensors function independently.

4.5 Discussion

Industries need to use Internet of Things (IoT) technology to monitor 3-phase power systems to ensure steady operations. IoT enables prompt real-time data availability, facilitating effective decision-making and remote action. It also encourages more sustainable energy management. Even with compatibility and security issues, there are long-term advantages like decreased downtime and increased productivity that make it beneficial. Artificial Intelligence (AI) and edge computing are two future innovations that will help with faster processing and better system performance. It is anticipated that standardisation will improve compatibility. All things considered, the convergence of 3-phase systems with IoT is increasing industry connectivity and efficiency.

The Blynk app's ability to monitor transformers for overcurrent problems creates a vital link between real-time data access and preventive maintenance. When the transformer is linked to Internet of Things (IoT) devices, the Blynk app gives real-time updates on its operational state. The software instantly alerts operators in the event of an overcurrent condition, allowing for rapid intervention to avert potential damage or failures. By enabling prompt responses to abnormal situations, this relationship improves the transformer's reliability by lowering the chance of downtime and its related expenses. Moreover, by actively monitoring overcurrent situations using the Blynk app, companies may apply preventive actions, ensuring the longevity and efficiency of the transformer and, subsequently, the overall stability of the power distribution system. The mutually beneficial relationship between transformer functionality and monitoring technologies emphasises how crucial it is to use IoT and app-based solutions to preserve the functionality and general health of vital electrical infrastructure.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The development of the project to create a system for monitoring transformers using a microcontroller will conclude in this chapter. As the project moves on, the goals that were outlined in the first chapter should be considered.

5.2 Conclusion

In conclusion, creating a transformer monitoring system utilizing a microcontroller is a critical step in guaranteeing the effective and dependable operation of power distribution systems. By putting in place such a system, it can continuously monitor and assess numerous transformer parameters, allowing for the early discovery of problems or unusual behaviours. Furthermore, compared to conventional manual approaches, a microcontroller-based monitoring system can provide increased accuracy and precision. It can accurately and repeatedly measure crucial characteristics like voltage, current, temperature, and oil level. Engineers can make knowledgeable choices about the upkeep, repair, or replacement of the transformer's parts because of this level of precision.

Monitoring a 3-phase transformer through the Internet of Things (IoT) provides significant advantages in terms of real-time data acquisition, remote access, and proactive maintenance. By integrating IoT technologies into the monitoring system, users gain insights into the transformer's operational status, enabling timely responses to potential issues and optimizing performance. By utilizing IoT for 3-phase transformer monitoring, total efficiency, downtime, and reliability are all increased. Through the utilization of insights obtained from ongoing monitoring, stakeholders can make well-informed decisions that guarantee the transformer system's longevity and optimal performance.

Table 5.1 Advantage of Monitoring via IoT.

Advantage	Description
Real-Time Data Acquisition	Continuous monitoring of voltage, current, and temperature.
Remote Access and Control	Access critical transformer data from anywhere.
Early Fault Detection	Immediate identification of anomalies for preventive action.
Energy Efficiency	Optimization of energy consumption and load balancing.
Proactive Maintenance	Predictive analytics for scheduling timely maintenance.
Enhanced Safety	Early detection contributes to a safer operating environment.
Historical Data Analysis	Storage of historical data for trend analysis and optimization.

Table 5.2 Different between Monitoring via IoT and Traditional.

Aspect	IoT-Based Monitoring	Traditional Monitoring
Connectivity	Utilizes internet connectivity for real-time data access from anywhere.	Localized monitoring with limited remote access capabilities.
Data Accessibility	Real-time access to comprehensive data through cloud platforms.	Limited access, typically requiring physical presence at the site.
Data Storage	Data is stored in the cloud, allowing for large-scale storage and historical analysis.	Relies on local storage with potential limitations on data retention.
Real-Time Alerts	Immediate alerts and notifications for anomalies or faults.	Relies on periodic manual checks and may lack real-time alerting.
Maintenance	Predictive analytics enable proactive maintenance scheduling.	Reactive maintenance based on periodic inspections or issues.
Energy Efficiency	Optimizes energy consumption based on real-time load and usage data.	Limited ability to optimize energy efficiency due to lack of real-time data.

Scalability	Easily scalable for monitoring multiple transformers across locations.	Limited scalability and may require additional infrastructure for expansion.
Cost Efficiency	Initial setup costs may be higher but offers long-term cost savings.	Typically, lower initial setup costs but may incur higher operational costs.
Security	Requires robust cybersecurity measures for data protection.	Security measures limited to physical access controls and network security.
Ease of Integration	Integration with other IoT devices and systems is feasible.	Integration may be limited to traditional monitoring equipment.
Overall Flexibility	Offers flexibility in terms of device compatibility and customization.	Limited flexibility and adaptability to changing monitoring needs.

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APPENDICES

Appendix A Ganchart