SMART MONITORING: IOT ENHANCED FAULT DETECTION TECHNIQUES FOR SINGLE-PHASE INDUCTION MOTOR

By

MD. TANVIR AL ISLAM
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AZMERI MAISHA ZAMAN
20221004
MUNIRUN NESSA
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NAFUNA MARGARET
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A Final Year Design Project (FYDP) submitted to the Department of Electrical & Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science (B.Sc) in Electrical & Electronic Engineering

Department of Electrical and Electronic Engineering
BRAC University

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Academic Technical Committee (ATC) Panel Member

Dr. Md Golam Sorwar Hossain (Chair)
Professor, Department of EEE, BRAC University

Md Saif Kabir (Member)
Lecturer, Department of EEE, BRAC University

Mohammed Thushar Imran (Member)
Lecturer, Department of EEE, BRAC University

Department of Electrical and Electronic Engineering
BRAC University

Declaration

It is hereby declared that

1. The Final Year Design Project (FYDP) submitted is my/our original work while completing my/our degree at Brac University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material that has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

Student’s Full Name & Signature:

MD. TANVIR AL ISLAM 2022128	AZMERI MAISHA ZAMAN 20221004
MUNIRUN NESSA 20321022	NAFUNA MARGARET 22321073

Approval

The Final Year Design Project (FYDP) titled " IOT ENHANCED: FAULT DETECTION TECHNIQUES FOR SINGLE-PHASE INDUCTION MOTOR "
submitted by

1. MD. TANVIR AL ISLAM (20221028)
2. AZMERI MAISHA ZAMAN (20221004)
3. MUNIRUN NESSA (20321022)
4. NAFUNA MARGARET (22321073)

of FALL, 2024 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science (B.Sc) in Electrical & Electronic Engineering on January 2024

Examining Committee:

Academic Technical Committee (ATC):
(Chair)

____

Md Golam Sorwar Hossain (Chair)
Professor, Department of EEE, BRAC University

Final Year Design Project Coordination Committee:
(Chair)

____

Dr. Abu S.M. Mohsin
Associate Professor, Department of EEE
BRAC University

Department Chair:

____

Dr. Md. Mosaddequr Rahman
Professor and Chairperson, Department of EEE
BRAC University

Ethics Statement

We thus state and certify that this Final Year Design Project titled "SMART MONITORING: IOT ENHANCED: FAULT DETECTION TECHNIQUES FOR SINGLE-PHASE INDUCTION MOTOR " complies with requirements for completion of the Final Year Design Project set by the BRAC University Authority and the Department of Electrical and Electronic Engineering of BRAC University in partial fulfillment of the requirement for the degree of Bachelor of Science (B.Sc.) in Electrical & Electronic Engineering. This project report has been compiled with the help of all the members of the group including our findings, designs, test results and details of our prototype. All the resources and literature reviews have been cited properly with the guidance of our ATC Panel.

The plagiarism index of our project report is found to be _____ after consulting with the Ayesha Abed Library of BRAC University for a similarity check.

Abstract/ Executive Summary

Faults in single-phase induction motors, commonly used in domestic and industrial applications, can lead to reduced efficiency, downtime, and increased maintenance costs. This project explores the development of an IoT-based system to detect and diagnose motor faults in real time. The system uses sensors to monitor critical parameters such as speed, voltage, current, vibration, and temperature the system provides intelligent analysis for fault detection. The proposed solution is scalable, cost-effective, enabling timely interventions and reducing operational disruptions. Additionally, it aligns with sustainable practices by improving energy efficiency and minimizing waste. This approach enhances motor reliability, extends equipment lifespan, and contributes to advancements in industrial automation and maintenance strategies.

Keywords: Iot; Fault detection; Induction motors; Real time monitoring; Energy Efficiency

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1.1 Introduction

Single-phase induction motors are mostly used in industrial as well as domestic applications due to their robustness, simplicity, and cost-effectiveness. However, their consistent functionality is often compromised by faults that lead to increased maintenance costs, downtime, and damage to the equipment. Therefore, detecting faults early and diagnosing them is crucial to enhance motor performance and efficiency, reduce operational risks, and extend equipment lifespan[1].

Integrating the Internet of Things(IoT) in fault detection systems provides an innovative approach to monitoring the performance of single-phase induction motors. We can improve the accuracy and speed of fault detection by enabling IoT-enabled solutions which will allow real-time data acquisition, remote monitoring, and intelligent analysis. The system can detect anomalies in parameters such as current, voltage, speed, temperature, and vibration by leveraging sensors and communication technologies[1].

This project specifically explores IoT-enhanced fault detection techniques designed for single-phase induction motors. The project mainly focuses on developing a system that integrates sensor-based monitoring and data analysis to identify potential faults accurately and efficiently. The study aims to enhance motor reliability, minimize downtime, and optimize maintenance strategies by implementing a scalable and cost-effective IoT-based solution[1].

1.1.1 Problem Statement

Single-phase induction motors are essential components in both industrial and domestic applications, agriculture and textile industries. Despite their robustness, these motors are highly prone to a range of faults that can degrade their performance and lead to critical failures. Issues like overheating, current leakage, bearing wear, winding short circuits, and voltage imbalances are common, often developing gradually and going undetected until they result in significant system downtime, costly repairs, or reduced productivity[2].

Currently, fault detection and maintenance of these motors are dependent on manual inspections, periodic maintenance schedules, and basic monitoring systems. These methods are traditional and often detect the issues only after significant damage is done. Moreover, the inability to monitor performance in real time makes it challenging to prevent faults effectively. Therefore, this reactive approach increases maintenance costs as well as disrupts operational workflow causing inefficiencies and economic losses[2,3].

There is an increasing demand for intelligent fault detection solutions as industries transition towards smarter technologies. By enabling continuous monitoring, real-time data acquisition and remote diagnostic-based systems present a transformative opportunity to address these challenges. However, single-phase induction motors remain limited to various constraints though IoT adoption is growing in many industrial sectors. These include the complexity of integrating advanced fault detection algorithms, the cost of deploying IoT infrastructure, and the difficulties in processing and analyzing the vast amounts of data generated by IoT sensors[3].

The solutions that already exist for fault detection often rely on conventional threshold-based monitoring, which may fail to account for the dynamic and multifaceted nature of motor faults. Advanced techniques such as machine learning and data-driven analytics, hold promise but are not yet widely implemented due to challenges in ensuring accuracy, scalability, and adaptability in real-world environments. Furthermore, the lack of a standardized framework for IoT-enhanced fault detection makes it difficult to ensure interoperability across different systems and industries[3]. Proposing an IoT-enhanced fault detection system this project addresses these pressing challenges specifically designed for single-phase induction motors. The objective is to create a solution that not only monitors motor performance in real time but utilizes intelligent algorithms to detect faults with high precision and predict potential failures before they occur. This project aims to bridge the gap between conventional fault detection methods by addressing both technical and economic barriers. The main aim is to improve operational reliability, minimize downtime, and contribute to the development of more efficient and resilient motor-driven systems[2,3].

1.1.2 Background Study

Single-phase induction motors are widely used in various applications, including household appliances, small machinery, and industrial processes. Their simplicity, low cost, and durability make them an essential component in electrical systems. However, like all machines, they are prone to faults that can lead to reduced efficiency, mechanical failures, and downtime. Common faults in single-phase induction motors include stator winding faults, rotor faults, bearing faults, and insulation failures. Early detection of these faults can prevent catastrophic failures and reduce maintenance costs[1,2]. The integration of the Internet of Things (IoT) with induction motors offers a modern approach to fault detection and condition monitoring.IoT-based solutions provide real-time monitoring, data collection, and analytics that enable fault detection, enhancing the overall lifespan and performance of the motors. This project aims to design, develop, and validate a fault detection system for single-phase induction motors using IoT technology[2]. For real-time monitoring, various types of sensors can be integrated with motors, like current sensor, temperature sensor, voltage sensor, vibration sensor, and speed sensor. The data from these sensors are processed via microcontrollers which form the foundation of the IoT system. These microcontrollers, along with communication modules, enable the transmission of sensor data to the cloud for analysis[1,2]. In addition to hardware, software tools are required for analyzing the collected data which includes proteus and Blynk software. The integration of IoT for fault detection in single-phase induction motors offers an innovative solution for condition monitoring and fault detection. By leveraging advanced technologies like sensors it is possible to design a robust system that detects potential faults early, reducing downtime and maintenance costs. The knowledge of motor behavior, signal processing, and IoT architecture gained through independent research and literature review was essential for the success of this project[2,3].

1.1.3 Literature Gap

Despite extensive research on fault detection techniques for single-phase induction motors, significant gaps remain in the development and practical implementation of advanced, real-time monitoring systems. Traditional approaches, such as manual inspections and scheduled maintenance are still prevalent but fail to provide early fault detection capabilities. While IoT-based solutions have gained traction in recent years, their application to single-phase induction motors has been limited. Most studies focus on three-phase motors or general industrial equipment, leaving a gap in addressing the unique challenges of single-phase motors . Additionally, existing IoT-based fault detection systems often rely on static thresholds or conventional statistical methods, which lack the adaptability and precision required for dynamic and complex fault conditions . While machine learning and artificial intelligence techniques have shown promise in fault detection, their integration with IoT for real-time and scalable solutions remains under-explored. Furthermore, there is a lack of research focusing on cost-effective, scalable systems that can easily integrated into existing infrastructure, particularly for small and medium-sized enterprises. This gap highlights the need for a comprehensive IoT-enhanced fault detection system tailored to single-phase induction motors combining advanced data analytics, real-time monitoring, and practical implementation strategies[4,5].

1.1.4 Relevance to current and future Industry

The integration of IoT-enhanced fault detection for single-phase induction motors is highly relevant to both current and future industrial needs. In today's manufacturing and service sectors, operational efficiency and cost-effectiveness are paramount.IoT-based systems support this by enabling real-time monitoring, reducing unexpected downtimes, and improving system reliability. This is especially significant as industries adopt lean operations and require equipment to perform optimally under continuous usage[4].

Looking forward, the role of IoT in industry is set to expand, with smart factories incorporating scalable and interconnected systems. The ability to monitor and manage single-phase induction motors remotely fits seamlessly into the broader IoT ecosystem. Moreover, the increasing adoption of fault detection is expected to enhance the precision and adaptability of these systems, enabling industries to prevent failures even in complex operational environments. This technology is also poised to benefit small and medium enterprises, which are often underserved by traditional high-cost monitoring solutions[4,5].

Furthermore, as sustainability becomes a global priority, IoT-based fault detection systems contribute by improving energy efficiency, reducing operational waste, and supporting the transition to greener industrial practices. These advancements make IoT-enhanced trends in automation digital transformation and sustainable development[5].

1.2 Objectives, Requirements, Specification and constant

1.2.1. Objectives

1. Develop a system for continuously monitoring critical parameters of single-phase induction motors to detect faults in real time.
2. Implementation of an algorithm to detect early signs of common faults (overheating, short circuits, bearing issues) and prevent motor failures for better performance.
3. Develop an IoT-based system to remotely monitor real-time parameters (voltage, current, temperature, speed, and vibration) and alerts using IoT technology via a web or mobile interface.
4. Addressing the faults early, minimize maintenance costs, and avoiding expensive emergency repairs for single-phase induction motors.

1.2.2 Functional and Nonfunctional Requirements

Functional Requirements:

1. Collect real-time data from temperature, humidity, voltage, current, and vibration sensors and ensure accurate and reliable sensor readings.
2. Display current sensor readings, maintenance detection and system status informed by sending notifications and enable user interaction for settings and manual overrides.
3. Send the notification alerts in case of detection requirements.
4. Log sensor data to a microSD card for historical analysis and troubleshooting.
5. Implement power-saving measures to ensure efficient use of resources and also consider low-power modes when the system is idle.

Non-functional Requirements:

1. Ensure real-time processing and responsiveness and high accuracy in fault detection
2. The system is robust and resistant to sensor errors, so implement error-checking mechanisms to detect and handle anomalies.
3. The system handles a scalable number of sensors and devices.
4. Provide clear and concise information to the user.
5. Implement encryption for data transmission and storage.
6. The system will be easy to maintain and troubleshoot, with software updates for improved performance and security.

1.2.2 Specifications

System Specifications:

Table 1: System level specification

System	Specification
Fault Monitoring Area	Monitor single-phase induction motors in residential or commercial environments
Operating Time	24/7 continuous operation for real-time fault detection
Sensor Data Collection	Collect temperature, vibration, current, speed and voltage data
Data Depth and Frequency	Collect sensor data at 1-second intervals
Weight and Dimension	Compact and lightweight, easily installed near motors

The table outlines the specifications for a real-time fault monitoring system designed for single-phase induction motors in residential or commercial environments. It operates continuously (24/7), collecting key motor parameters like temperature, vibration, current, speed, and voltage at 1-second intervals. The system is compact, lightweight, and easy to install near motors. It emphasizes accurate sensor placement for effective monitoring, uses Wi-Fi for IoT-based remote data transmission, and provides a mobile app and web dashboard for easy visualization of motor health and fault data.

Additional Considerations:

Sensor Placement: Sensors should be placed at key motor points to ensure accurate measurement of critical parameters such as temperature, vibration, current, and voltage.
IoT Connectivity: Utilize Wi-Fi functionality for remote monitoring and real-time data transmission to a local storage.
User Interface: Provide a mobile app and web dashboard for easy visualization of motor health metrics and fault status, enabling remote monitoring.
Power Supply: The system must be powered by battery to ensure uninterrupted data collection during power outages.
Fault Detection Accuracy: Algorithms must detect common faults like overheating, unbalanced loads and mechanical issues (bearing faults) with a high degree of accuracy.
Maintenance Alerts: Automated alerts should be sent to the maintenance team when potential motor faults are detected, allowing for timely intervention.

Table 2:Component level Specification:

Components	Model	Specifications
Temperature sensor	DS18B20	3V~5.5V, Less Than 60-µA Current; Rated for Full −55°C to 125°C Range
Current sensor	ACS712-30A	4.5V~5.5V DC, Measure Current Range: -30A~ 30A, Sensitivity: 100mV/A
Vibration sensor	801S	Operating voltage: 5V, Interface: Analog and Digital, Size: L: 20mm* 32mm *11mm output valid signal is high, the light goes out; sensitivity adjustable (fine tuning); vibration detection range, non-directional;
Voltage sensor	ZMPT101B	Voltage input range : 0-250 V Voltage detection range : 0.02445 V-25 V Voltage analog resolution : 0.00489 V Output Interface : "+ " connected 5/3.3V, "-" connected GND, "s" connected Arduino AD pins AC input interface : red terminal positive with VCC, negative with GND
Processing Unit	ESP8266	Operating Voltage: 3.3V Input Voltage: 7-12V Digital I/O Pins (DIO): 16 Analog Input Pins (ADC): 1 Operating Voltage: 3.3V Input Voltage: 7-12V Digital I/O Pins (DIO): 16 Analog Input Pins (ADC): 1
Processing Unit	Arduino Uno	Microcontroller: ATmega328P Operating Voltage: 5V, Input Voltage (recommended): 7-12V, Input Voltage (limit): 6-20V, Digital I/O Pins: 14 (of which 6 provide PWM output), PWM Digital I/O Pins: 6, Analog Input Pins: 6

		DC Current per I/O Pin: 20 mA, DC current for 3.3V Pin: 50 mA Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader, SRAM: 2 KB (ATmega328P), EEPROM: 1 KB (ATmega328P), Clock Speed: 16 MHz LED_BUILTIN: 13 Length: 68.6 mm,Width: 58.4 mm, Weight: 25 g
Speed Sensor	Infrared Obstacle Avoidance IR sensor moduel_LM393	Detection distance: 2 ~ 60cm, Detection angle: 35°, Working Voltage:3.3 V to 5 V. 3mm screw holes for easy mounting
Battery	ZY202302	Battery Type: Rechargeable Sealed Lead- Acid Capacity (mAh): 4.5Ah Voltage (V): 6V Form Factor: 18650 cylindrical cell Charging Method: Wired charging via Micro-USB Protection Circuit: Included for overcharge, over-discharge, and short circuit protection Energy Density: 250 Wh/L Cycle Life: 500 cycles Operating Temperature Range: -10°C to 40°C Compliance: Complies with UN/DOT 38.3 for transportation Connector: JST or compatible connector for charging
Relay	LY2-J IEC255	DC 24V Relay PIN: 8 Pin 10A 250V AC 10A 28V DC A relay is an switching device which is operated electrically, relay have a set of input terminals for single or multiple control signals and also have a set of operating contact

LCD Display	LCD Display 16X2	OperatingVoltage 4.7V-5.3V,Current Consumption 1mA.
Induction Motor	JX6324-3	Power 180W,Operating voltage 220V, Current Max 1.44A, RPM 1300r/min, Frequency 50Hz, Temperature -25~70 degree celsius

1.2.3 Technical and Non-technical consideration and constraint in design process

Technical Consideration and Constraint in the Design Process

1. **Sensor Selection and Accuracy:** Accurate and reliable sensors are critical for monitoring parameters such as voltage, current, speed, temperature, and vibration. The choice of sensors must balance cost performance, ensuring they can function within the motor operating environment while providing precise data for fault detection. Sensors must also be capable of withstanding harsh conditions such as high temperatures, humidity, and mechanical vibrations.
2. **Security and Privacy:** As the system transmits sensitive operational data over networks, securing the data from cyber threats and ensuring privacy are significant concerns. Implementing robust encryption and secure communication protocols is necessary to protect the system and its users.

Non-technical Consideration and Constraints in the Design Process

1. **User Training and Adoption:** Introducing IoT-based monitoring systems may require training for operators and maintenance staff to ensure they can effectively use the system, interpret alerts, and perform corrective actions.
2. **Maintenance and Support:** Non-technical factors, such as long-term maintenance software updates and system support must be considered

1.2.4 Applicable compliance, standards, and codes

IEEE 802.11:- Defines standards for wireless networking protocols commonly used in IoT devices

NFPA 79:- Electrical Standard for Industrial Machinery

API 510:- Pressure Vessel Inspection Code, the American Petroleum Institute (API) publishes standards and recommended practices for the oil and gas industry, including guidelines for the maintenance and inspection of equipment.

ISA-95:- Provides guidelines for the integration of enterprise and control systems, which may apply to the development of fault detection in manufacturing and industrial settings.

ISA-95:- Provides guidelines for the integration of enterprise and control systems

IEC 60204:-(Safety of machinery–Electrical equipment of machines) Provides principles and guidelines for risk management

IEEE P7006:- Standard for Personal Data AI Agent

1.3 Systematic Overview/summary of the proposed project

The proposed project focuses on developing an advanced fault detection system for single-phase induction motors using IoT technology. Single-phase motors are commonly used in various industrial and domestic applications, but they are prone to failures such as overheating, bearing wear, and electrical short circuits. Traditional methods for detecting these issues are largely manual or rely on periodic maintenance, which may not catch problems before they cause significant damage. The primary goal of this project is to create a system that continuously monitors key operational parameters, such as voltage, current, speed, temperature, and vibration to detect early signs of potential failures in real-time.

To achieve this, the project will utilize IoT sensors to collect data from the motors, which will then be processed by a fault detection algorithm designed to identify anomalies indicative of common motor faults. The system will be equipped with capabilities for real-time monitoring and will provide alerts through a web or mobile interface, allowing operators to take prompt corrective action. By using IoT technology, the system can be accessed remotely, offering greater flexibility for users and reducing the need for on-site inspections. The benefits of this system are clear, it can help prevent costly motor failures, reduce downtime, and minimize maintenance costs by identifying and addressing before they become severe. The project aims to enhance motor performance and operational efficiency, making it particularly valuable in industries where continuous operation is crucial, and unplanned downtime can result in significant financial losses. Through this IoT solution, the project aligns with modern industrial trends toward fault detection, helping organizations reduce the risk of unexpected breakdowns and optimize their maintenance schedules. The integration of advanced analytics and real-time monitoring is a key step forward in making fault detection smarter and more proactive. By addressing both technical and nontechnical challenges, this project seeks to provide a cost-effective, scalable, and easy-to-integrate solution for real-time motor monitoring, improving both the lifespan and efficiency of single-phase induction motors.

1.4 Conclusion

The development of IoT-based fault detection for single-phase induction motors presents a significant step forward in industrial maintenance and reliability. By continuously monitoring critical parameters this system can detect early signs of common motor faults. The integration of real-time monitoring and fault detection through IoT technology offers substantial benefits including reduced downtime, lower maintenance costs, and enhanced motor performance. As industries increasingly adopt automation and smart technologies this IoT-enhanced solution aligns with broader trends in fault detection , contributing to more efficient and resilient industrial operations. By addressing both technical and non-technical challenges, the project provides a scalable, cost-effective solution that ensures the longevity and reliability of single-phase induction motors.

Chapter 2: Project Design Approach [CO5, CO6]

2.1 Introduction

The design of an Internet of Things (IoT)-based fault detection system for single-phase induction motors is necessary to address common motor issues such as heat damage, overloading, and mechanical flaws. This study discusses 2 methods of design to design and implement a robust and efficient system. The various design methods we chose for this task, their operations, their distinctions, and the elements that contribute to a certain design's superiority have all been covered in this chapter.

2.2 Identify multiple design approaches

The first approach offers a more basic and cheap method of real-time fault identification by specializing on tracking significant parameters which comprises temperatures, current, and vibrations. In contrast, Design Approach 2 strengthens on the first concept by integrating further metrics consisting of speeds and the voltage and implementing the use of relays for offsite motor control under severe fault condition identification. Both methods take consideration of possibility, cost, and flexibility while attempting to guarantee quick fault identification, reduce interruptions, and optimize motor effectiveness.

2.2.1 Manual control design approach

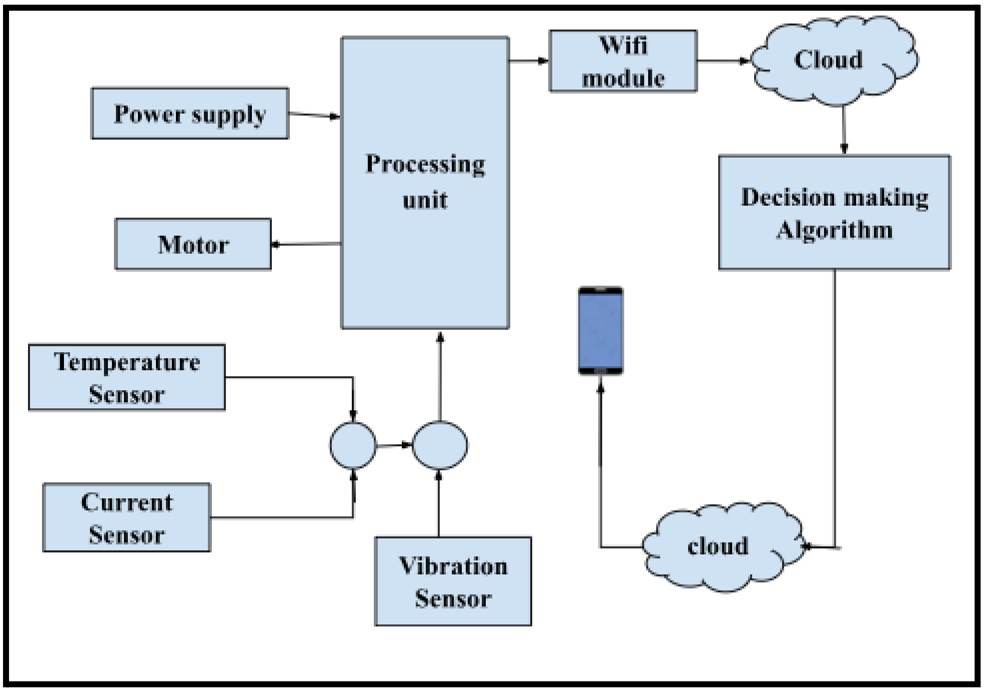

Fig 1:Manual control design approach

In the first design, several sensors are connected to the preprocessing unit. These sensors

gather data such as temperature, current, and vibration related to machine motor faults and health. While the temperature, vibration, and current sensors provide digital signals. All the signals collected by the sensors are transmitted to the processing unit, which functions as the system's brain. In order to power the sensors, processing unit, and other necessary modules, we utilize a rechargeable battery. When it needs to be recharged, the process is simple and straightforward. Additionally, we have integrated an AC single-phase induction motor into the system to enable real-time testing and data processing of temperature, current, and vibration fluctuations during system operation.
The processed data is transmitted from the processing unit to the cloud, which serves as a remote storage system and facilitates communication through the wifi module.
This connection links the local device to a remote server via an internet connection. In the cloud, the decision-making algorithm is used to detect motor fault conditions based on data that has already been uploaded. The results are then displayed on the display unit. The decisions made by the system are transmitted to the user's mobile phone via SMS. Additionally, the system provides detailed updates such as current sensor readings, temperature measurements, and motor vibration intensity values. These updates are displayed on both the system's dedicated display unit and the corresponding mobile application. This allows for comprehensive fault detection and monitoring, ensuring that any potential issues can be quickly identified and addressed

2.2.2 Actuation and Remote Control Design Approach

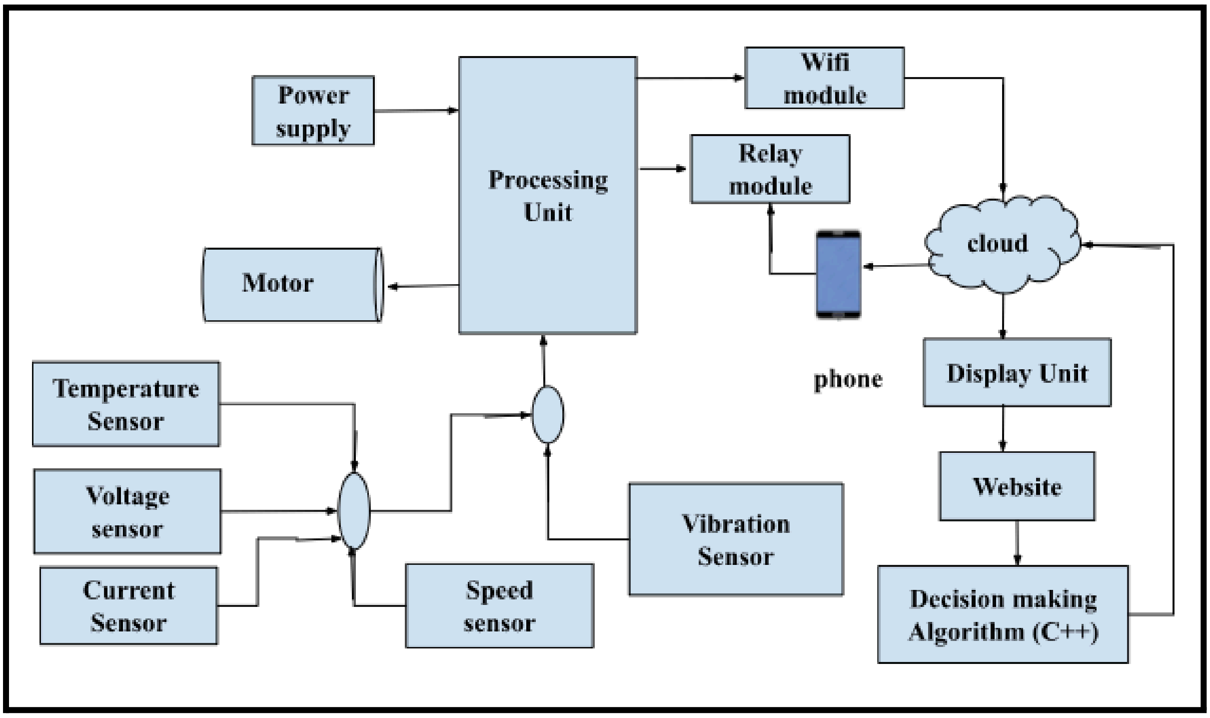

Fig 2: Actuation and Remote Control design approach

Data collection in the second design was done like that in design 1 with one important divergence. Design 2 also considers parameters of voltage and speed as additional other motor parameters for the determination of health against the single-phase induction motor, and also proposes an actuating system with its major component—a Relay controlling the whole system shutdown or fault detection end.

Once the data is collected through sensors, it comes to the processing unit for processing where decisions are made. These decisions, as a result, appear on the screen of the unit and also go to the cloud for storage and communication. The said communication is enabled through the help of the Wi-Fi module that facilitates Internet connectivity between the local device (processing unit) and the remote server.

The detection process utilizes decision-making algorithms that are stored in the cloud. Users can stay updated by accessing these updates through a web application or a mobile application. All alerts, including alarms, SMS, and emails, will be sent directly to the user's phone.

The IoT relay module device, equipped with Wi-Fi connectivity, establishes a connection with a mobile application by utilizing a hotspot and a system processing unit. This configuration enables remote access and control of the connected machine, providing the capability to activate or deactivate the motor in the event of extreme fault conditions detection. Acting as an intermediary between the hardware and the software, the relay module functions as a switch, allowing for the seamless shutdown of the system and the implementation of necessary precautions upon the detection of a fault.

Working on the relay for this design

Relays are electrically powered switches that enable a high-power circuit to be controlled by a low-power signal. It operates on the electromagnetic principle. When just a little current is applied to an electromagnetic coil inside the relay, a magnetic field is produced. A metal armature is pulled by this magnetic field, opening or closing the contacts in the circuit. usually open (NO) and usually closed (NC) are the two basic contact types found in relays. When a usually open relay is not activated, the circuit is open; but, as soon as current passes through the coil, the pull of magnets closes the contact, permitting current to pass through the circuit outside. Energizing the coil in a typically closed relay breaks the circuit, which is the default state. Depending on the type of relay, a spring mechanism reopens or re-closes the contacts by returning the armature to its initial position when the current to the coil is cut off.

2.3 Analysis of Multiple Design approach

Cost:

Both design approaches have relatively similar costs, as the hardware and sensor components used are largely the same. In design approach 1 we need only the three sensors like temperature sensor, current sensor, vibration sensor, and also a LCD display to show the output. However in design approach 2, as here we select five sensors, additional speed and the vibration sensor, a relay system, and show the output in a mobile application or in a website and software integration for remote access, which added slightly higher initial investment in this design. Finally, we can say that, though there are some changes of components between the designs, the cost varies between 9,000 to 10,000 Taka. However, we can conclude that Design 1 costs less money in comparison with Design 2.

Efficiency:
Design Approach 2 is an improved version of Design Approach 1 due to the introduction of a relay system, allowing for better control over the system and fault detection through monitoring voltage and speed, among other parameters. Additionally, the approach lets users control motor operations remotely with a mobile application, enabling prompt actions in cases of overheating or current fluctuations. In contrast, Design Approach 1 is less efficient as it only displays the results of the decision-making algorithm without offering users real-time control over the system.

Usability:
Design Approach 1 is easier to use since it requires only a display unit to view motor performance and notifications via a mobile application. This simplicity makes it user-friendly even for those unfamiliar with complex technical systems. However, its lack of remote control functionality limits its practicality in scenarios requiring immediate intervention. On the other hand, Design Approach 2 offers more extensive control features but is more complex. Users must interact with a web-based platform, mobile app, and relay system to manage the motor remotely, which may be cumbersome for non-technical users.

Manufacturability:
From a manufacturing standpoint, Design Approach 1 is simpler to implement because it involves fewer components and less complex software requirements. Its functionality primarily focuses on data collection and display without necessitating cloud integration or remote access. Conversely, Design Approach 2 is more challenging to manufacture due to the need for advanced knowledge of IoT systems, cloud access, and mobile application development, making its implementation more resource-intensive.

Impact:
Both designs contribute similarly to motor maintenance and operational stability. However, Design Approach 2 has a greater environmental and operational impact due to its higher power consumption. Its additional functionalities, such as sensors, a relay system, and mobile applications, require more energy. In comparison, Design Approach 1, with its simpler framework, has a lower energy footprint.

Sustainability:
In terms of sustainability, Design Approach 1 is more environmentally friendly due to its lower power requirements and simpler construction. In contrast, Design Approach 2, while

offering more features, consumes more energy, which could present a long-term sustainability issue, especially in regions where energy resources are scarce or expensive.

Maintainability:
Design Approach 1 is easier to maintain because it has fewer components and simpler operations. The absence of a relay system and cloud-based functionality reduces potential failure points. In contrast, Design Approach 2, while offering better system control, is harder to maintain due to its complexity. Issues with the mobile app, relay system, or cloud connectivity could lead to system downtime, and maintaining these additional components would require more technical expertise.

Optimization of the Selected Design Solution
The selected design will be optimized using Design Approach 2 since it has higher functionality and efficiency. Optimization can be done to reduce the complexity and power consumption while retaining its advanced features.
One way to do this is to optimize the data processing and IoT relay system. Instead of constant cloud-based decision-making, a more localized processing solution could be in place to reduce the reliance on cloud access and thus reduce power consumption. Besides, a low-power relay system could be implemented that would minimize the energy required for the shutdown of motors in case of faults. The user interface could be simplified by providing a more intuitive mobile app that requires fewer inputs from the user while still delivering notifications and control options. From a manufacturability perspective, there is a reduction in overall cost and simplification of manufacturing, since sensors, ADCs, and relays are standard, commercially available components. The approach can also go down to developing the mobile application to be light and power-efficient; this would then minimize the on-phone processing tasks to keep all phones functional across low-range devices, too. Finally, further improvements in the field of sustainability can be achieved by using sensors and communication protocols that are more energy-efficient. The utilization of components that support sleep mode when not working would also support the sustainability aspect of the system, ensuring very minimal consumption of energy at times of low motor activity. With consideration given to both designs, Design Approach 2 was preferred in terms of enhancement in functionality and efficiency while performing well in remote controls. However, to ensure broader usability and sustainability, the system should be optimized by reducing power consumption and simplifying user interactions. These improvements will make the system more accessible to a wider audience while maintaining the advanced fault detection and control features necessary for effective motor management.

Comparison of the two design techniques

Table 3:Comparison between both design approaches

Criteria	**Design Approach 1**	**Design Approach 2**
Data Acquisition	Data is acquired through various sensors in digital or analog form. The analog data is fed to the processing unit through an Analog to analog-to-digital converter (ADC).	Data is acquired through various sensors in digital or analog form. The analog data is fed to the processing unit through an Analog to analog-to-digital converter (ADC).
Data Processing	The obtained data is processed by the processing unit, which also uses a C++ programming method to make instantaneous decisions.	The obtained data is processed by the processing unit, which also uses a C++ programming method to make instantaneous decisions. The data collected after this decision is then sent to the web for additional decision-making, and the results are sent to the user as notifications
User Interface	The decisions generated by the algorithm are displayed on an LCD display that is connected to the processing unit. Users can also view real-time. notifications through the mobile application.	The decision made by the algorithm is delivered to the user's mobile phone through SMS and a mobile Application. The decisions can also be viewed through the website via the PC. Users can easily interact with the system remotely when the faults are detected with the help of the mobile application which provides the feature(configured with the relay) for shutting down the system.
Decision-Making Algorithm	To determine decisions, a C++ programming algorithm is employed. Decisions for fluctuation in temperature, current instability flow within the motor as well as faulty motor vibration during the machine performance. Output the motor's faulty signal for real detection	To determine decisions, a C++ programming algorithm is employed. Decisions for fluctuation in temperature, current instability flow within the motor as well as faulty motor vibration during the machine performance. Output the motor's faulty signal for real detection

IoT Relay	Not having a Relay, this calls for manual shutting down of the system.	The relay is present and is required for interfacing the remote control of switching on/off of the motor incases of extreme parameter values or detection of faults through a mobile application.
Power Source	Relatively low power because of fewer components involved as compared to design 2	Relatively high power consumption to implement and run all the hardware and software components
Implementation	Easier to implement since it does not require complicated logical knowledge as compared to design 2.	Relatively harder to implement as it necessitates actuation knowledge and skills as well as cloud-based understanding and web access for decision-making purposes and also mobile application is necessary.
Usability	Easy to use since it requires only a display unit application.	Harder to use since it requires web access, a mobile application, and control of the system by using a relay.
Functionality	Its functioning is restricted as it only displays decisions made and provides no room for user interface.	It has more functionality Through user interaction with, a web-based app, and a mobile application.
Efficiency	Less efficient as it can only offer display output with no control of the system in case of fault detection.	More efficient as a lot of details are shown through mobile and web-based applications. It also offers control of the system in case of fault detections due to the presence of the relay. Other one-phase induction motor metrics, comprising speed and voltage, are accounted for as well.
Cost	Relatively same	Relatively same

2.4 Conclusion

By carefully analyzing both design approaches, it would appear that each has special advantages, suited for particular requirements. Design Approach 1 is focused on monitoring crucial features such as temperature, current, and vibration and is notable for its simplicity and affordability. This approach is ideal for consumers who choose price over sophisticated capability or for smaller-scale applications. Its lack of extra parameter monitoring and control capabilities, however, limits its applicability in more intricate or demanding situations.

In contrast, Design Approach 2 provides a much more comprehensive and flexible solution. In this approach, much more data are included, such as voltage and speed, which greatly enhances the understanding of motor health.

Additionally, it enhances operation versatility and safety when immediate action can be taken by users in the event of critical failure, the relay system that is added for remote control of the motor. This design, while somewhat more complicated and somewhat more expensive, provides more advanced functions suitable for business and industrial applications where accurate control and monitoring are called for. Thus, since Design Approach 2 holds much more value over functionality and different scenarios, ultimately the better option proves to be of the latter category.

In spite of these specific distinctions, nevertheless, both systems do hold extraordinary potential for expanding a lot in single-phase induction motor maintenance and reliability studies. The application results in reduced upkeep costs and minutes wasted by motors grounded for service. Such designs pave the way forward not just in improving such machines but developing generally much wiser and efficacious motor operation/management systems in particular. These designs assure that the project is committed to providing innovative and helpful solutions for the demands of the industry and the ever-growing demand for defect detection systems provided by the IoT.

Chapter 3: Use of Modern Engineering and IT Tool. [CO9]

3.1 Introduction

The sophisticated solution for fault detection in single-phase induction motors will include modern technical and IT tools in the solution. Complex systems could be designed, simulated, implemented, and monitored while keeping functional and dependable use of these technologies. Tools like Proteus will be needed in modeling circuit design to confirm the behavior before actual execution to avoid many errors and expenses. Similarly, IoT platforms like Adafruit IO allow for continuous monitoring and control of motor variables through friendly interfaces, while hardware platforms like Arduino allow for smooth integration of sensing along with processing units. The employment of this state-of-the-art technology ensures modern engineering methods and further enhances the efficiency of the project.

3.2 Select appropriate engineering and IT tools

3.2.1 Software tool selection

Proteus Software

Proteus is a development tool in electronic circuit modeling, mostly used for integrated system evaluation and prototype testing. A user can study and test functions of the circuit in a virtual method without having actual hardware simply because of their ability to enhance the virtual modeling of parts included, which range from microcontrollers down to sensors or relays.

Proteus was selected among other tools like TinkerCAD because it can emulate both digital and analog circuits, as well as embedded systems. With the rich library of parts and its capability for the Internet of Things, the team was able to create accurate models of the systems to ensure that the design met all the technical requirements. This is particularly suitable for complex projects due to the full simulation capability.

Arduino IDE

The freely available Arduino Integrated Development Environment (IDE) can be used to write, compile, and upload code onto Arduino-compatible circuit boards. It has libraries to make hardware interface easier and accepts C and C++ programming. Through code, developers may interact effectively with the hardware owing to the IDE's straightforward, intuitive user interface.

The Arduino IDE was selected due to its ease of use, adaptability, and hardware-specific optimization. The Arduino IDE is a great option for both novice and expert users since it provides a lightweight environment with a large library and a large community for assistance, unlike alternatives like PlatformIO. Because C++ offered effective real-time operations that were essential to the project's success, its compatibility with the language further expedited development.

C++ Language

A popular exceptionally well programming language for integrated and system-wide applications is C++. It is perfect for programming processing units applications such as fault detection systems since it allows for real-time computation and minimal memory modification.

Because C++ performs better in contexts with limited resources, it was selected above equivalents consisting of Python or Java. It provides low-level hardware interface features, very much required for proper sensor and relay management. Due to the object-focused capabilities of our group, we were able to write well-structured and reusable programming code, hence perfect for implementing sophisticated fault identification algorithms.

Adafruit IO

Adafruit IO is an example of an Internet of Things platform which can be used to connect devices, visualize the data coming from sensors, and send commands to hardware by the use of dashboards and custom user interfaces. Because it uses both REST and MQTT protocols, it may also be applied to real-time applications. It is also very popular due to its free features and user-friendly interface. Adafruit IO was chosen due to its ease of use and flexibility, since it was relatively easy to make the hardware and software components used in the endeavor compatible with this system. Compared to other systems such as Blynk, Adafruit IO has a no-cost tier, which is sufficiently functional for project needs without additional costs. This system turned out to be an ideal choice for this project as it had intrinsic widgets and interfaced perfectly with Arduino hardware, further enhancing the usefulness of the system.

Blynk server/IoT

Blynk is a smartphone software for making Internet of Things dashboards used in the monitoring and controlling of devices. Since it supports remote and actual time monitoring of the motor's condition from any location, it would be an excellent fit for this project. Blynk simplifies the development of an intuitive user interface by allowing users to click and drop widgets such as gauges, charts, and switches. These can display current information from the sensors that are connected to an Arduino, giving users important information about how well the motor is operating and alerting them in the event that a problem is found. What differs in Blynk compared to other IoT systems is ease of design and simplicity in how it is set up. Even the mobile user interface doesn't require any sort of coding. In this regard, it's just perfect for swift development and saves time to concentrate your efforts on improving the logic behind the defects recognition rather than wasting time creating some unique mobile application. It also integrates events and alerts in Blynk for instant notifications any time a fault is detected, adding more reliability to this project. Blynk allows interfacing with a wide array of microcontrollers, including Arduino. It does not require much complexity in network configuration, meaning the design of the system should not be overly worried about complex configurations in networking. It is designed to support several communication protocols such as Ethernet, GSM, and Wi-Fi; it is also intended to be adaptable to a wide range of IoT devices.

3.2.2 Hardware Tool Selection

Waterproof DS18B20 Temperature Sensor: Digital temperature sensor for a long, waterproof, stainless steel probe end. It interfaces via a 1-Wire protocol, which requires little wiring, and gives precise temperature measurements between -55°C and +125°C. It is perfect for use in abrasive or liquid situations because it is waterproof. Because of its waterproofing design, which ensures dependability in situations where contacting liquid or moisture is likely, this sensor was selected above substitutes such as LM35 or thermocouples. Its digital output makes integration easier by doing away with the requirement for extra ADC modules.

Current sensor(ACS712ELCTR-30A): A Hall-effect-based current sensor, the ACS712 can accurately measure currents that reach ±30A. A microprocessor can simply comprehend whatever analog voltage that results, which is proportionate to the current flow.
Since it isolates the circuit's high-power and low-power parts, this sensor gets preference versus shunt-based current sensors for safety. It is perfect for this application because of its small size and dual AC/DC current measurement capabilities.

Vibration sensor(801S): A very sensitive tool for detecting quiverings and vibrations in machines is the 801S vibration sensor. It has a digital output used for monitoring abnormal motor vibration conditions. The 801S was selected due to its ruggedness, low cost, and ease of integration. Unlike other variants, it provides a simple but reliable means of detecting mechanical anomalies such as imbalance or loose parts. It is suited for this project due to its analog output, which ensures compatibility with microcontroller-based systems.

Voltage Sensor
The ZMPT101B is an AC sensing module that includes integrated transformer isolation. It, therefore, provides very accurate voltage readings and safety. Instantaneous power system monitoring can also be conveniently performed by this sensor. It monitors the supply voltages for voltage variations and outputs analog voltages proportional to the applied voltages in the ZMPT101B. It provides isolation characteristics; hence, for precision and compact size, it has been used instead of any other voltage sensors. It is very reliable in fault determination, as it can provide stable and accurate AC voltage readings consistently. Besides, going by its compatibility with microcontrollers such as Arduino, it ensures that the necessities of the projects are met without a hitch in implementation.

Speed Sensor
LM393 Infrared Obstacle Avoidance IR Sensor Module—a sensor that measures the pulses generated from a spinning motor shaft, using an infrared emitter and receiver for measuring rotational speed. It would be ideal for induction motors with the ability to provide accurate real-time speed. Many of the applications it has in the measurement of speed result from its low cost, reliability, accuracy, and ease of use.

Processing Unit
ESP8266, ARDUINO UNO: Arduino UNO acts as the main processor in collecting and

processing information, while ESP8266 is a microcontroller with Wi-Fi capability. They work in combination to manage sensor data and facilitate IoT operations. While the ESP8266 offers Internet of Things functionality like remote monitoring via Wi-Fi, the Arduino UNO is relatively easy to program and functions flawlessly with sensors. This setup is more affordable and easier to use for this project than alternatives such as Raspberry Pi.

Relay (LRLY2COILDPDT)
The LRLY 2 COIL DPDT double-pole double-throw relay shall be used to turn the motor on or off in case of a fault because it has the ability to handle high current loads. This relay has been chosen as opposed to single-pole due to its capability to isolate many circuits for redundancy and safety. It is reliable in protecting the motor against critical failures.

Battery ZY202302
The system is powered by a rechargeable battery called the ZY202302, which was designed to provide electrical components with a steady power supply.It ensures uninterrupted functioning in the event of a power loss. Because of the ability to cope with both the current and voltage demands of the circuit, such a battery was chosen. It is smaller, rechargeable, effects efficiency of energy and offers consistent power in contrast to non-rechargeable batteries.

Induction motor(JX6324-3): A single-phase induction motor called the JX6324-3 is employed to evaluate and verify the fault detection system. In the project, it acts as the main load.
This motor was selected based on its strong resemblance to the common motors seen in practical applications. It is perfect for modeling genuine fault scenarios and operational settings due to its predefined specifications.

3.3 Use of modern engineering and IT tools

3.3.1 Description of Software Tools

Proteus Software
Prior to the physical implementation of designs for circuits, Proteus was widely used for validation and modeling. It made it possible to build a virtual environment in which precise modeling and testing of the functioning of sensors, relays, and the processing unit was possible. Prior to moving on to hardware integration, this step was essential for spotting and fixing design issues early on and guaranteeing the system's viability and dependability.

How to use proteus

1. install Proteus and Launch the work area
2. Make a new project and provide the circuit's parameters (e.g., components, voltage levels).
3. Add parts from the library, such as relays, microcontrollers, and sensors.

4. To create a particular circuit, join the parts with virtual wires.
5. If necessary, create or import programming code and add it into the simulation.
6. Evaluate the circuit's operation by running the simulation, looking at the outputs, and spotting any problems.

Arduino IDE

The Arduino IDE was utilized to develop, compile, and upload the programming code to the microcontroller known as the Arduino in order to develop the software design fault detection system. The tool made it possible to carry out real-time operations like data processing and collection while guaranteeing smooth connection between the hardware elements, such as sensors and relays. The team was able to concentrate on creating functionalities with no being distracted by excessively complicated programming environments because to the IDE's simple UI.

How to use Arduino IDE

1. With the genuine Arduino web page, install the Arduino IDE.
2. Use a USB cable to link the Arduino chip to the computer.
3. Go into the Tools menu and pick the right board and port.
4. Click the checkbox symbol to confirm that the code is correct after writing or loading it in the editor.
5. Press the arrow symbol for uploading the code onto the Arduino board.
6. To inspect the results or debug, utilize the Serial Monitor, which is available through the Tools menu.

Blynk console

The continuous information gathered from sensors within the fault identification system was managed and tracked using the Blynk IoT platform. Through an intuitive interface, it allowed users to remotely monitor vital motor parameters. Furthermore, through an easy-to-use interface, Blynk enabled IoT functions such as relay activation for remote motor control and alarm sending. This improved the system's functionality by providing offsite supervision of faults and actual-time interaction.

How to use Blynk console

1. Get the Blynk app on your phone or go to the website and register.
2. Choose the right hardware (such as an ESP8266 or Arduino UNO) then begin a new project.
3. Create an authentication token, which can be received in the mail as well be visible on the website
4. To track and manage the motor characteristics, dashboard widgets like switches, gauges, and graphs are added
5. Write code using the Arduino IDE, incorporating the Blynk library, and enter the virtual pin assignments, Wi-Fi login information, and authentication token.
6. Put the program together and upload it to the ESP8266 or Arduino microcontroller.

7. To examine actual time sensor information and use the widgets to control the motor, launch the Blynk app or web dashboard.
8. Configure the app to notify users when specified fault levels are surpassed.
9. Keep an eye on the dashboard to make sure everything is working properly and to get notifications of any unusual motor conditions.

C++ Language

The fault detection system's code was written using the C++ programming language. Its responsibilities included establishing the reasoning behind the collection, processing, analysis, and judgment of sensor data. The system was able to handle real-time activities very efficiently by using C++ and also ensured that errors were identified and reported in case thresholds were crossed.

How to Write and Use C++

1. The development platform to be used could be the Arduino IDE or any other editor for writing the C++ program code.
2. Declaration of global variables to store levels of thresholds and data from sensors.
3. Tasks such as data collection, processing, and identification of faults can be organized through functions.
4. Use conditional statements to trigger some actions in case sensor values exceed certain limits.
5. Compile the code in order to check for errors and then upload it into the microcontroller, where it can be executed.

Adafruit IO:

Adafruit IO was used for handling data gathered from sensors throughout the system, and this was monitored in real time. Users may remotely continuously observe vital motor metrics including temperature, vibration, and current owing to its user-friendly dashboard. Furthermore, the platform made it possible to incorporate IoT functions like getting alerts and managing the system via an intuitive user interface.

How to use Adafruit IO

1. Create an account on the Adafruit platform
2. Create feeds to store information about variables like current or voltage.
3. For real-time visualization, create a dashboard and include widgets (charts, gauges, etc.) connected to the feeds.
4. Create code on the Arduino IDE to use the MQTT protocol to transmit sensor data to Adafruit IO.
5. To set up email or SMS notifications based on threshold situations, use the Triggers function.
6. Keep an eye on the dashboard to see real-time data and get notifications when abnormalities are found.

3.3.2 Description of Hardware Tools

Temperature sensor(DS18B20): The induction motor's temperature of operation is monitored by the DS18B20 waterproof temperature sensor. This aids in keeping an eye on overheating situations, resulting in can seriously harm the motor. In situations when the motor becomes subjected to fluids or moisture, the sensor's precise, real-time temperature readings are very helpful in guaranteeing the motor's dependability and the lifespan.

Current sensor(ACS712ELCTR-30A): The current passing through the motor is measured by the ACS712 current sensor. It finds anomalies like imbalanced current or overcurrent, which might point to possible problems like short circuits or winding problems. This sensor is essential for preventing damage and improving safety by making sure the motor runs within safe electrical bounds.

Vibration sensor(801S): The vibrations from motion are tracked by the 801S vibration sensor. It assists in identifying problems that can cause motor breakdowns or ineffectiveness, such as imbalanced loads, bearing deterioration, or alignment concerns. Regular inspection and early fault diagnosis are made possible by the sensor's actual time vibration information.

Voltage sensor(ZMPT101B): The AC voltage applied to the motor is measured by the ZMPT101B voltage sensor. It keeps an eye on voltage variations or decreases that can have a negative impact on the motor's efficiency and effectiveness. By ensuring that the motor runs at a steady voltage, the sensor guards against electrical harm.

Speed sensor(LM393 Infrared Obstacle Avoidance IR Sensor Module): The motor shaft's rotational speed is measured by the LM393 IR speed sensor. It makes sure that the motor runs between the intended speed ranges and looks for outliers like over speeding or slowing down, which could be signs of more serious problems. This data is essential for preserving the motor's functionality and effectiveness.

Processing unit(ESP8266, Arduino Uno): Acquisition of data, analyzing, and communication are carried out by the processing units, which include the Arduino UNO and ESP8266. While the ESP8266 offers Internet of Things features like continual tracking and controlling devices over Wi-Fi, the Arduino UNO manages the collection and analyzing of data collected by sensors. They collaborate to establish the system's conceptual core, allowing for smooth functioning and compatibility.

Relay(LRLY2COILDPDT): By turning the motor either on or off in response to fault identification indications, the relay regulates the motor's functioning. In order to safeguard against damage amid catastrophic faults, it serves as a safety mechanism by cutting the motor's connection to the power source. Through accurate control throughout the motor's performance, the relay guarantees the system's stability and reliability.

Battery(ZY202302): The system is powered by a backup ZY202302 battery, which affirms continuous functioning even in the event of a power loss. Regardless of the event that the primary power source is not available, it keeps the sensors, computational units, and networking modules operating, enabling ongoing fault identification and tracking.

Induction motor(JX6324-3): The fault detection system is tested and validated using the JX6324-3 single-phase induction motor as the load. By simulating actual motor working circumstances, the system is able to precisely monitor variables including voltage, current and speed. The motor is necessary to show the designed system's efficacy and usefulness.

3.4 Conclusion

The foundation of modern problem-solving in technical projects is made up of engineering and information technology tools that provide a link between conception and execution. Engineers can more accurately and efficiently test, model, and execute complex systems because of these technologies. During this project, the design's feasibility was verified by performing simulation using tools such as Proteus, and its hardware integration was made easy with Arduino. In order to maintain system accessibility and functionality, Adafruit IO was used to improve interaction with users and facilitate real-time monitoring. By integrating these technologies, the project depends on modern facilities techniques, which guarantee both creativity and feasibility in single-phase induction motor failure detection.

Chapter 4: Optimization of Multiple Design and Finding the Optimal Solution. [CO7]

4.1 Introduction

In the field of engineering, optimization is a crucial procedure to make certain the selected solution satisfies the intended goals underneath the restrictions. For this project, several design approaches were suggested. To find the best and most effectual solution, various strategies had to be evaluated. We were able to improve the performance of the suggested designs through the optimization process by taking into account elements like cost, efficiency, usability, maintainability and scalability. The objective was to choose the finest option that would meet the needs of the project while guaranteeing excellent scaling and reliability.

4.2 Optimization of multiple design approach

4.2.1 Manual control design approach

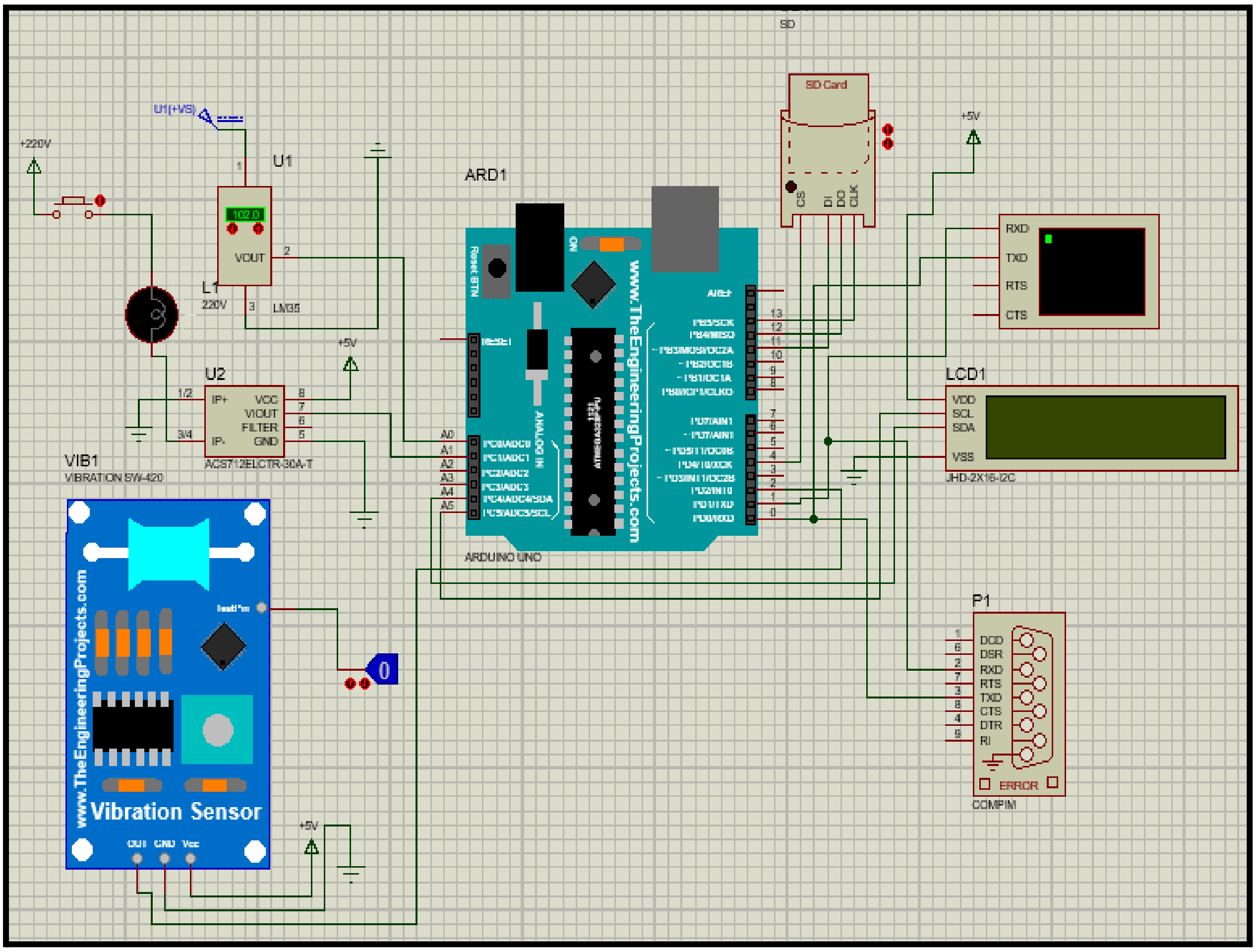

Fig 3 : Schematic diagram for design approach 1 in Proteus

In design approach 1, we aimed to design and implement a system that can only monitor a few single-phase induction motor parameters like temperature, current, and vibration. We have used a SW-420 vibration sensor to monitor the values of the motor vibrations. LM35 is our temperature sensor, and ACS712-30A is the current sensor. COMPIM is used as a wifi module in this case because Proteus could not offer us a properly functioning ESP8266 wifi module. We have also used an SD card for storing our data. This means that we can continuously collect and store our data collected from the sensors on this SD card and later can be transferred anywhere, or even be used for making predictions in the future. This makes it easy for the users to view their historical data.

All the sensor data collected is displayed on the LCD and also sent to the Blynk server via a wifi module which provides internet connectivity, this server is used for storage and decision-making based on the decision-making algorithm set in there. The decisions made are displayed on the web application and also all alerts are sent to the user's mobile phone as sms or email.

Under normal operating conditions: The sensors monitor vibration, temperature, and current when the motor is operating normally. Every parameter is guaranteed to be within its typical operating range by the system. The gathered data is transferred to the cloud for additional processing after being shown on the LCD. The vibration, current, and temperature all remain within ±5g on the x, y, and z axes, current below 1.44A and the Temperature range is maintained between -25°C and 70°C respectively. The motor is confirmed to be operating correctly because the system stays stable and data is continuously collected.

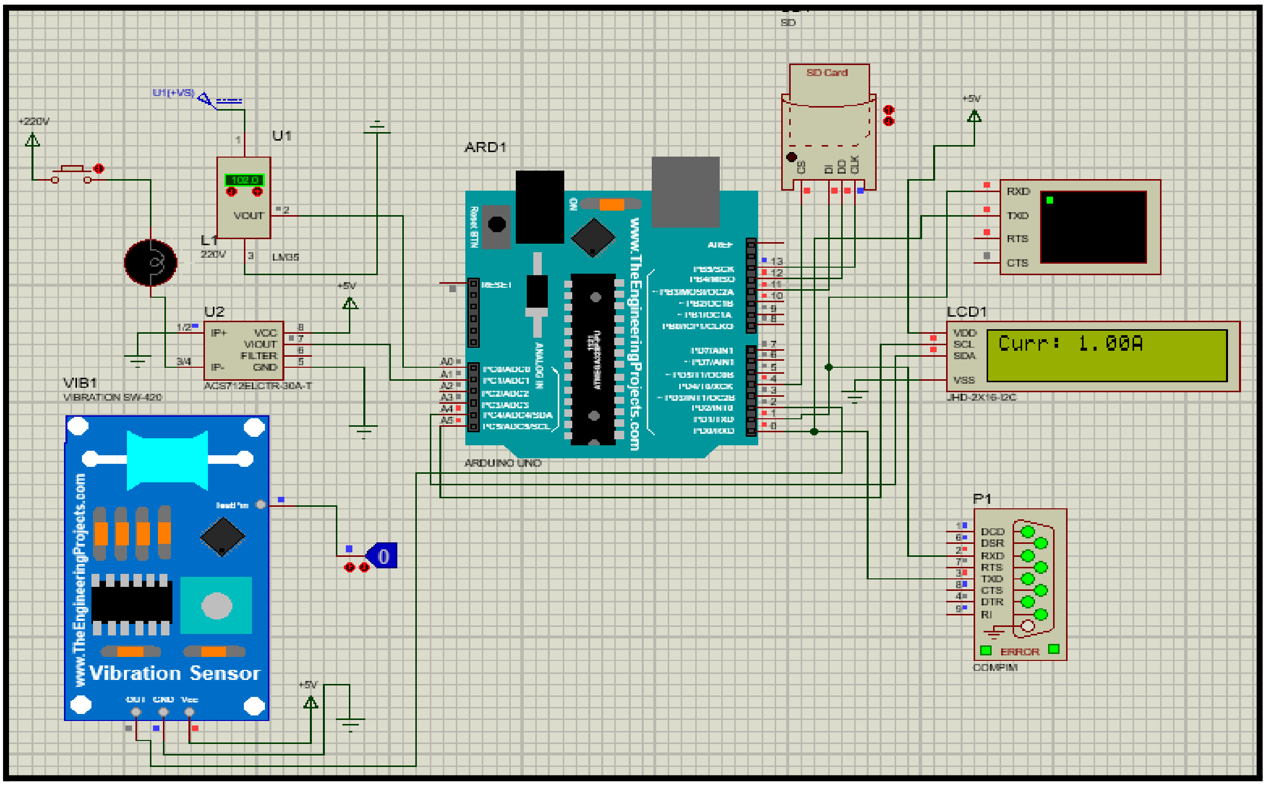

Fig 4: Data collection and displaying output LCD, normal temperature

Fig 5 : Sensor Data collection and displaying output on Adafruit 10 website

During cases of fault detection: In this case, the system recognizes when any parameter exceeds the threshold that has been set. For instance, the system will immediately identify an anomaly if the vibration is greater than 5g. After analyzing the data, the algorithm indicates that there may be a motor malfunction. The user receives automatic notifications about the issue through email or SMS. The user may easily visualize the data using the data's display on the LCD, mobile app, and web dashboard. Corrective action can be conducted before any serious harm occurs because of the system's real-time defect detection and quick alerting capabilities. This demonstrates how proactive the system is in averting vehicle malfunctions.

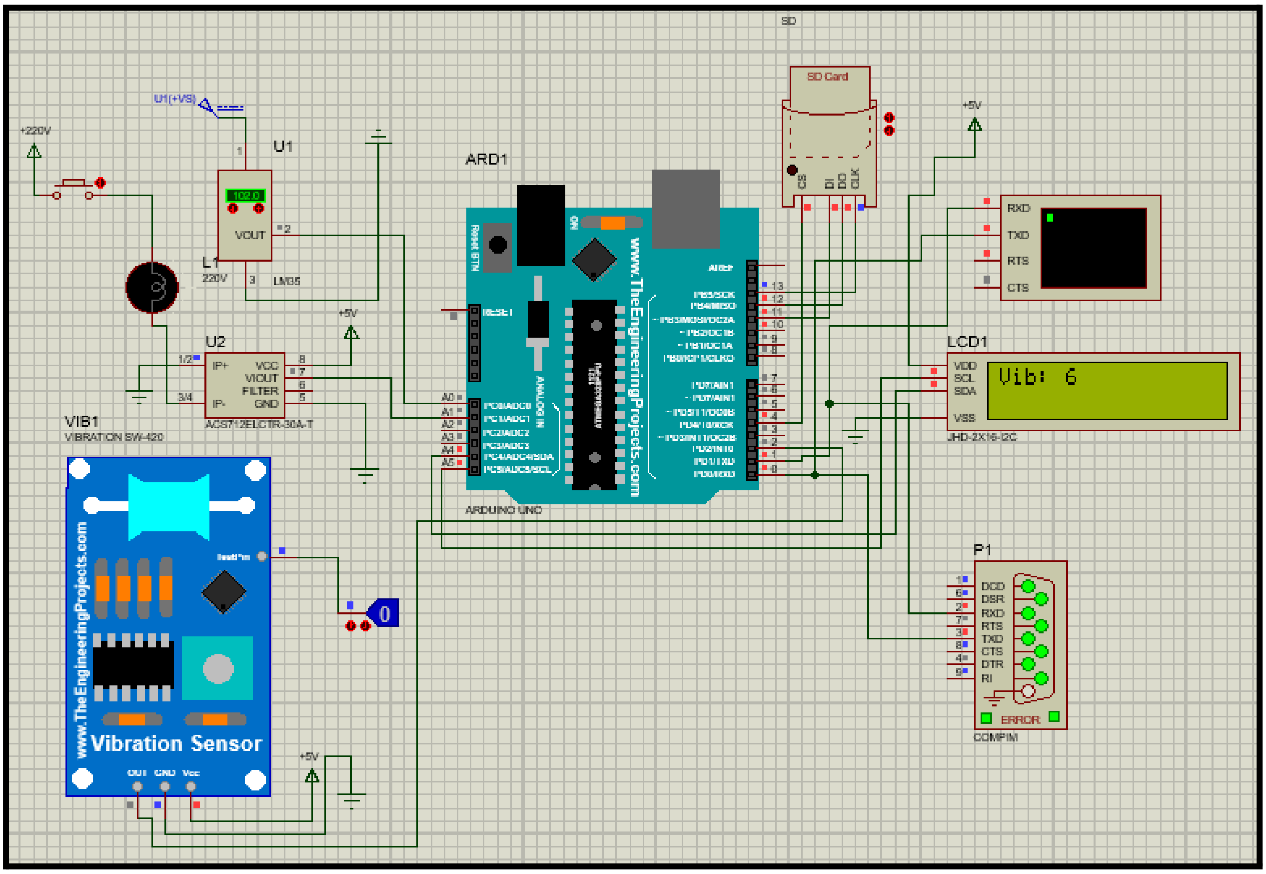

Fig 6 : Sensor Data collection and displaying output on LCD

In this case, the normal operating vibration for our motor is from -5g to5g, now that the motor is exceeding this normal range, a notification informing of a mail is being sent to the user warning him/her about the extreme vibration values and that immediate action is required to prevent motor failures. The very results will keep being displayed in the mobile app as well as the website.

Fig 7 : Website display of sensor values

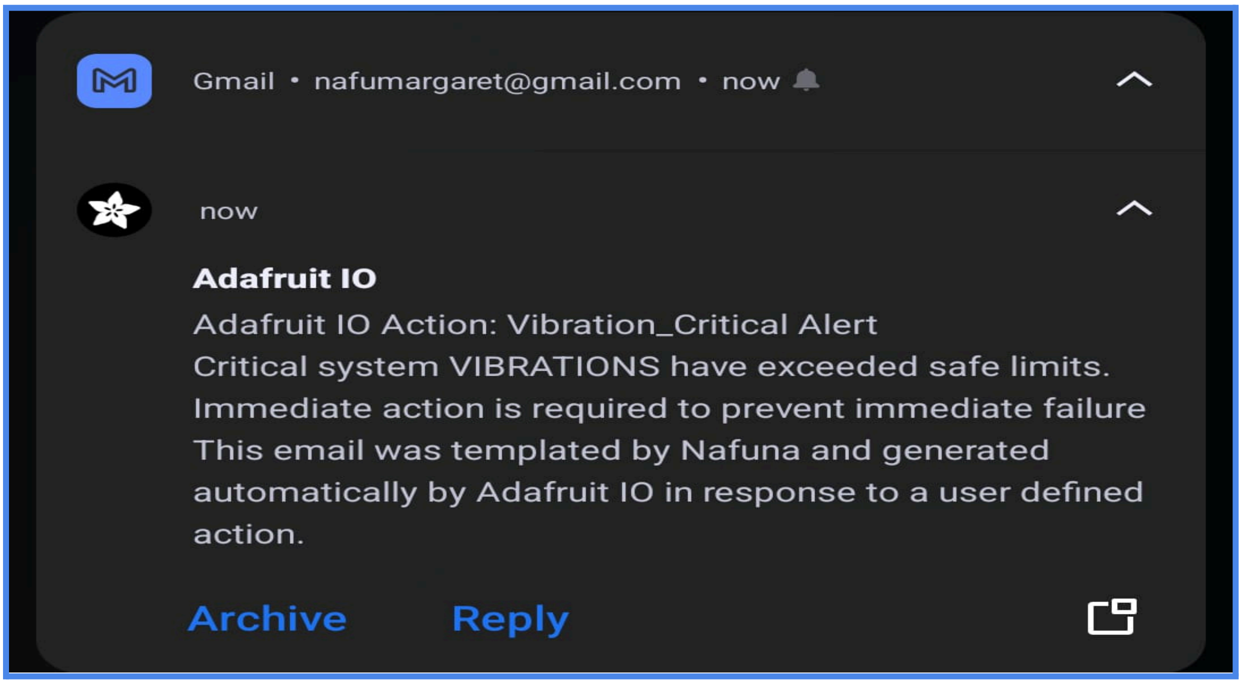

Fig 8: In app email notification

In the same manner, upon exceeding the normal motor temperature operating range to 91.31 degrees celsius, the user receives a notification containing a mail alerting him about the critical temperature values which need immediate attention.

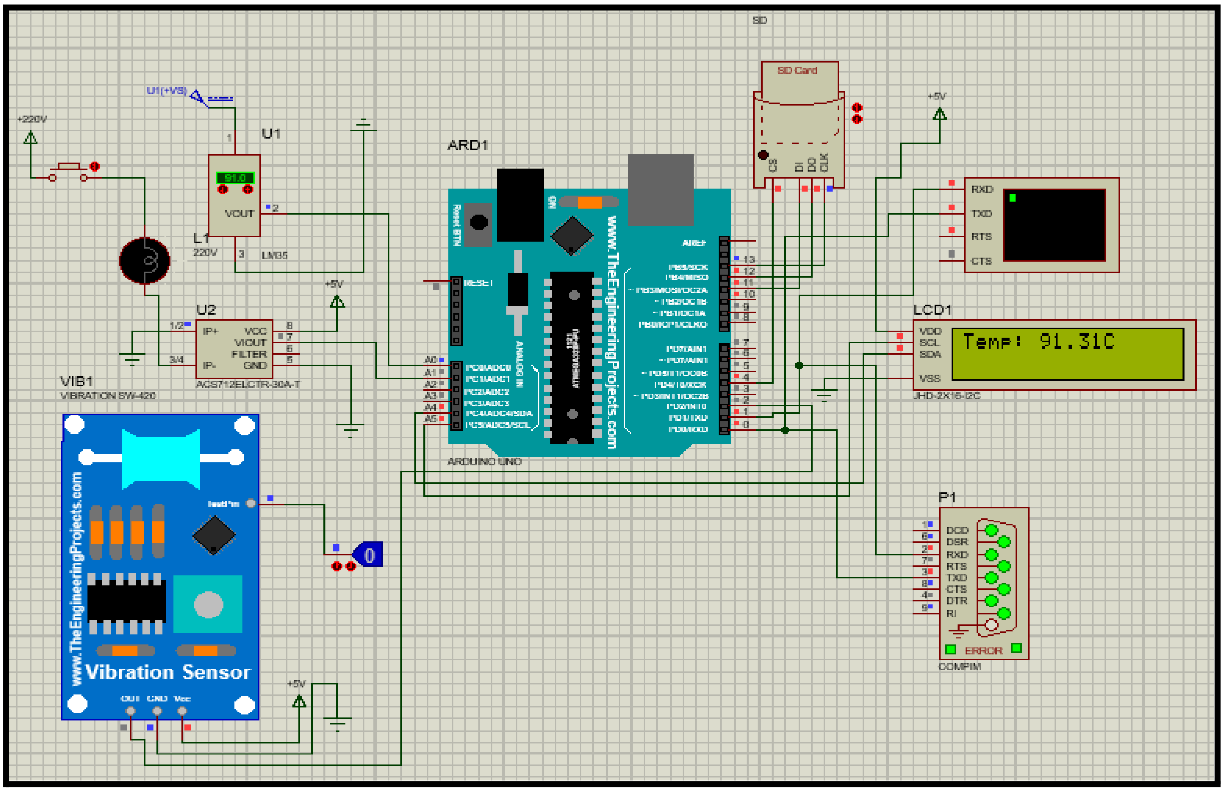

Fig 9 : Sensor Data collection and displaying output on LCD

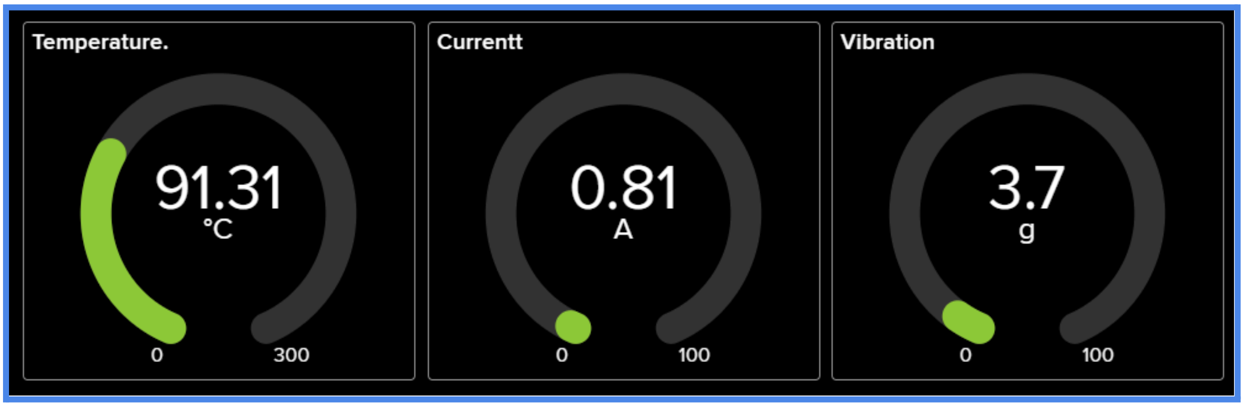

Fig 10: Website display of sensor values

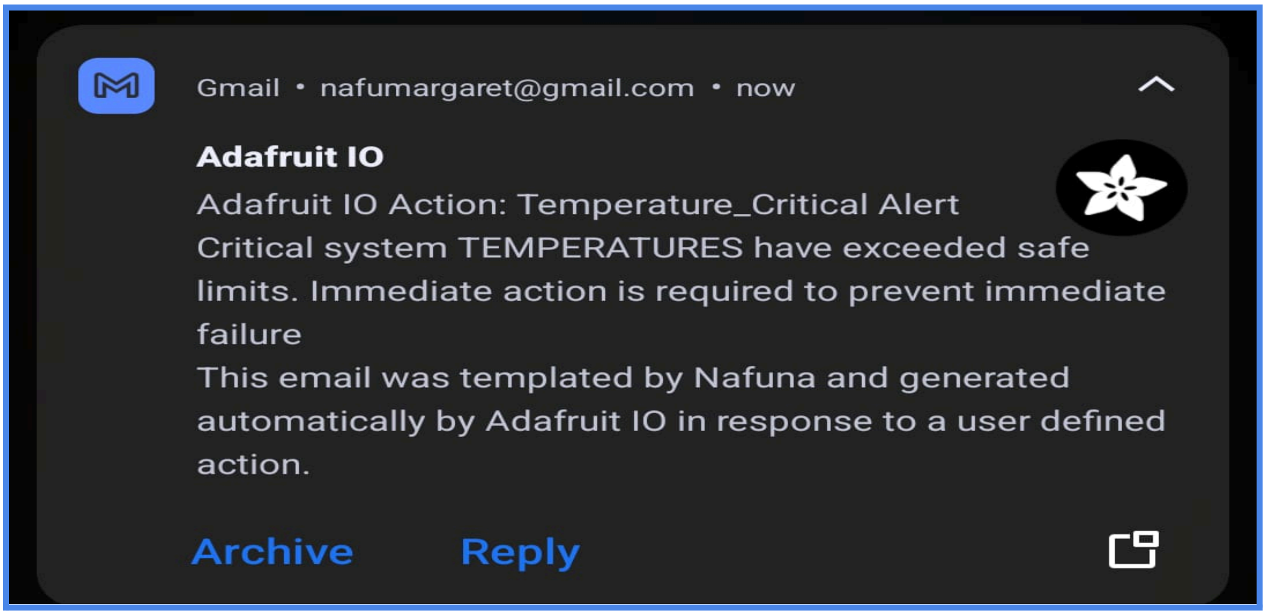

Fig 11 : In mobile email notification

4.2.2 Actuation and remote control design approach

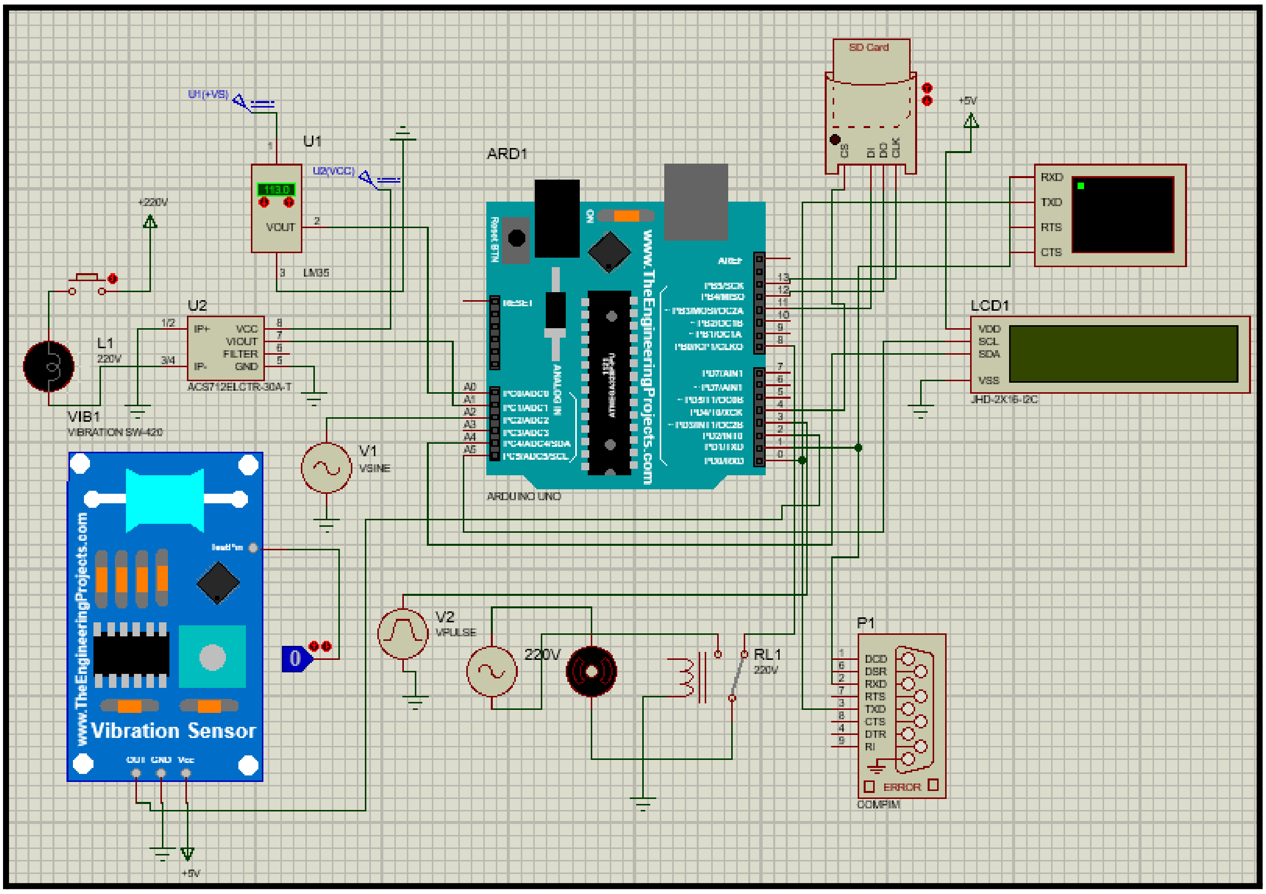

Fig 12: Schematic diagram for design approach 2 in Proteus

In Design 2, we aim to develop and implement a single-phase induction motor fault detection system that considers additional motor parameters such as speed and voltage, which are crucial for determining the motor's health status. The system will also feature an actuation system for remote control of the motor, allowing for the shutdown of the entire system in the event of extreme fault detection, all with the help of a switch. The temperature, current, and vibration sensors used in this design are similar to those in design 1. Since Proteus does not have/ offer us speed and voltage sensor modules, we have used Vpulse as a speed sensor and V sine as a voltage sensor. Accordingly, we did not find any single-phase induction motor module for proteus, so we utilized a single-phase DC motor in proteus which also works as a single-phase AC motor. All sensor signals are collected in the same way as in Design 1 and sent to the processing unit. From the processing, this data is displayed on the display unit, also stored in the SD card, and sent to the cloud via a wifi module. The detection process utilizes decision-making algorithms that are stored in the cloud. Users can stay updated by accessing these updates through a web application or a mobile application. All alerts, including alarms, SMS, and emails, will be sent directly to the user's phone. In the cases of fault detections, notifications are sent to the user and the user can take action by simply turning off the switch provided in the mobile application or web application. Turning off the switch means that the relay is being turned off and so the entire system is going to shut down.

Under normal range of operation: Design 2 improves upon Design 1 by measuring temperature, current, vibration, and more characteristics including voltage and speed. Within its typical voltage range of up to 220V and speed range of 1300 to 1600 rpm, the motor runs smoothly. The collection, processing, and display of all sensor data on the LCD, mobile application, and web interface verify that the motor is functioning within safe parameters. Even when the motor is situated in a difficult-to-reach location, the user can still conduct continuous monitoring by using the mobile app to obtain this data remotely. The efficacy of the system is boosted by its expanded ability to track more motor parameters, which offers a more comprehensive view of motor health.

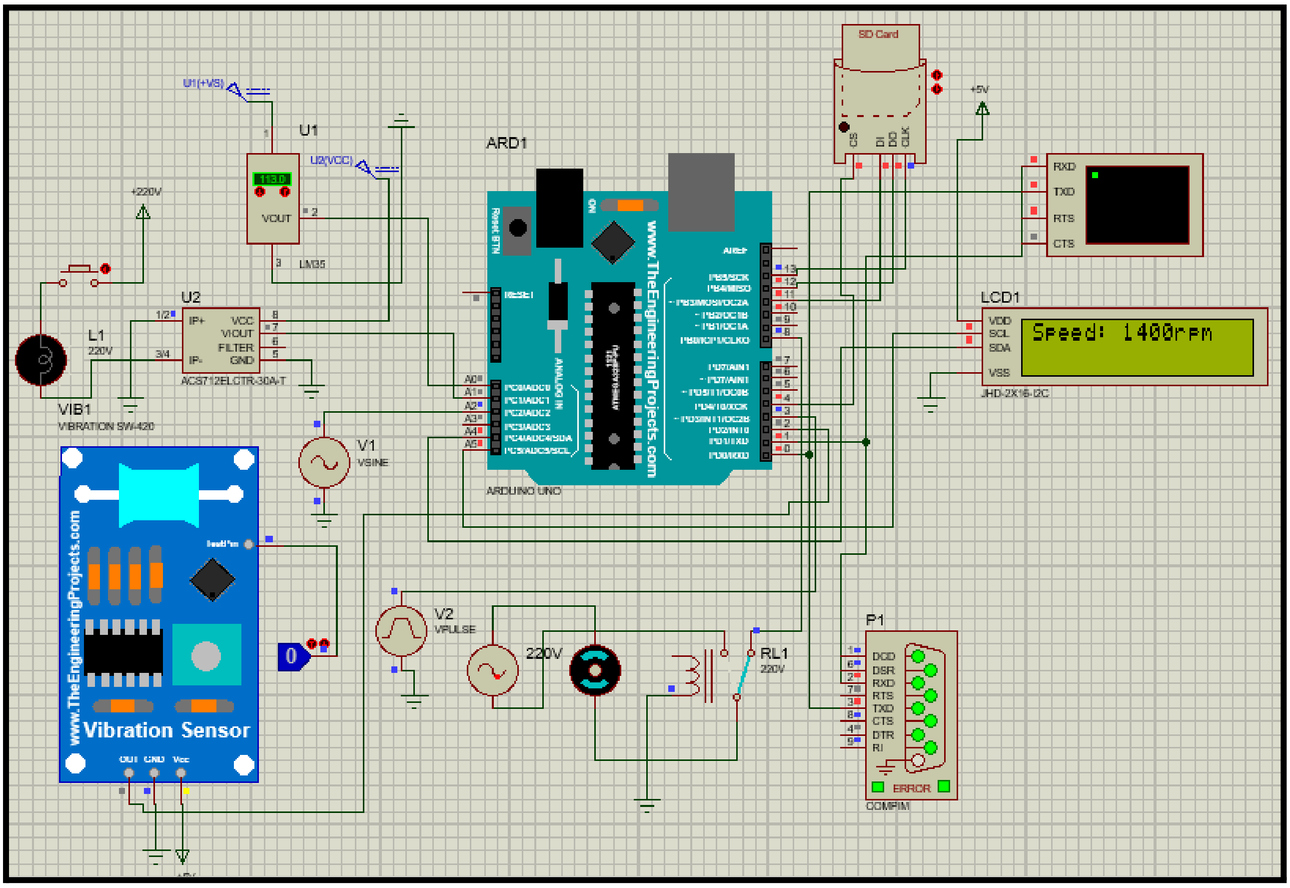

Fig 13 : Sensor Data collection and displaying output on LCD

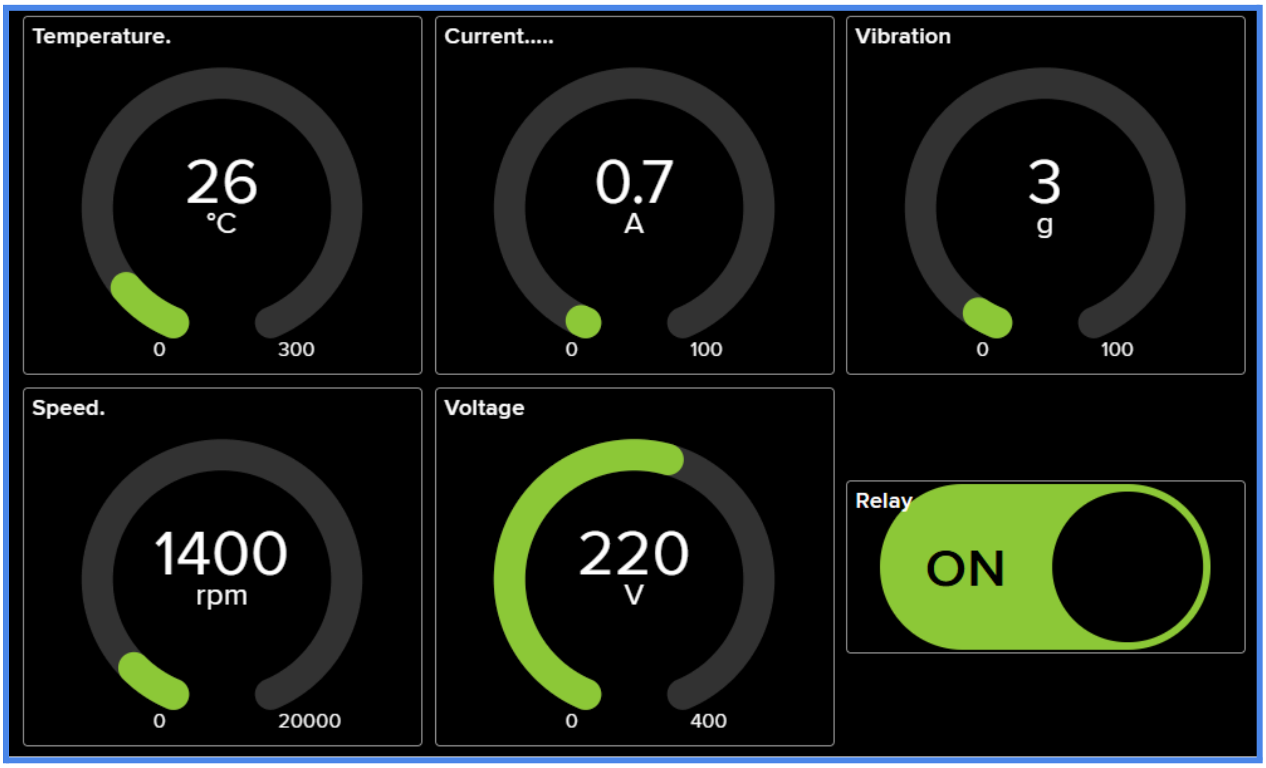

Fig 14 : Website data visualization

During cases of fault detection: The system identifies anomalies and initiates alarms when parameters like voltage or speed go above their typical operating ranges. For example, the system notifies the user of a malfunction through email, and the mobile app if the voltage increases above 220V or the motor speed reaches 1600 rpm. Through the use of a relay system, this design not only enables the user to send messages but also remotely stops the motor. The user can stop additional damage to the motor by deactivating it through the web dashboard or mobile app.

During normal operations, the relay is on and ringing meaning the system is also operating normally. Now, when any of the parameter values exceed the normal range, a notification is sent to the user informing him of the parameter that has exceeded the range. The user then opens the mobile app or the website and there, he is provided with a feature(Relay/switch) that enables him to shut down the entire system. Once the relay is off, the system will be completely down, not operating and the necessary actions are done so as to restore the parameter to the normal ranges. This test case highlights the effectiveness and safety advantages of the second design since it allows for prompt action to safeguard the motor in addition to detecting faults.

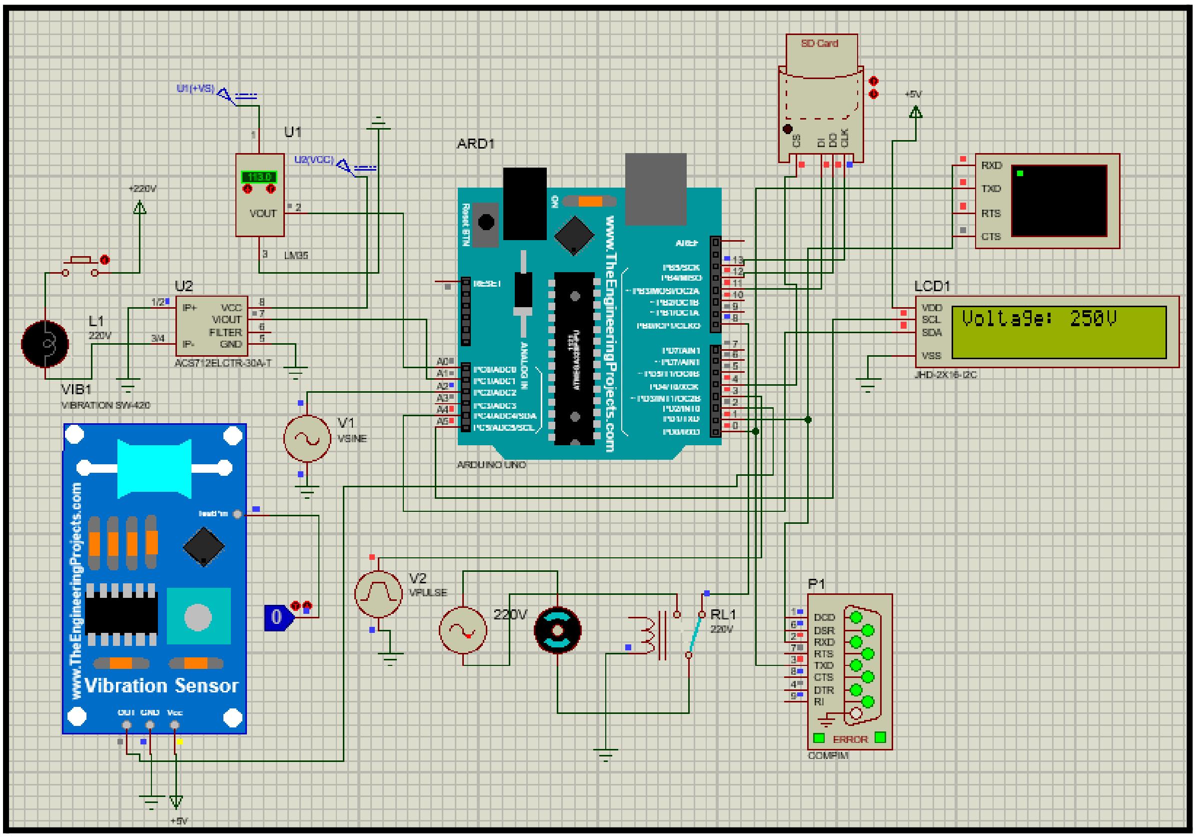

Fig 15 : Sensor Data collection and displaying output on LCD

The normal voltage range is up to 220V. From the LCD, it is clear that this voltage 250V is above the normal range. So now a mail is sent to the user and the user will shut down the system by switching off the relay.

Fig 16: Website data visualization

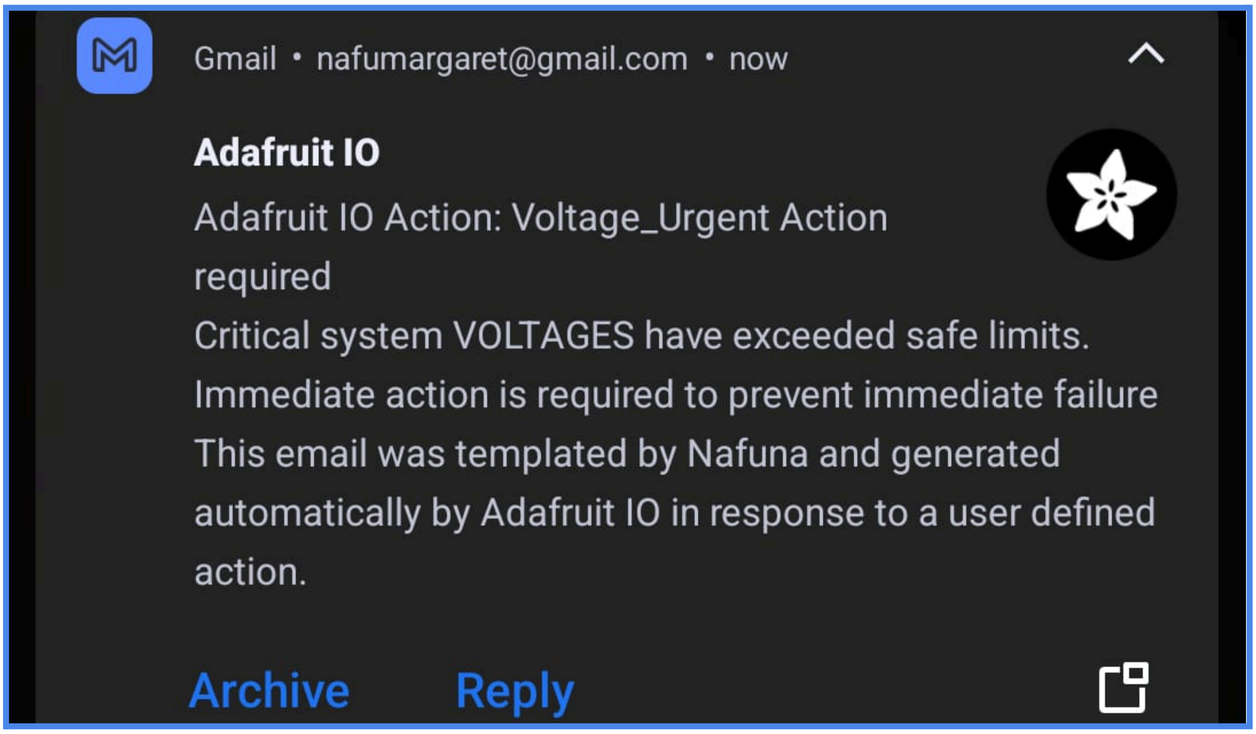

Fig 17 : In mobile email notification

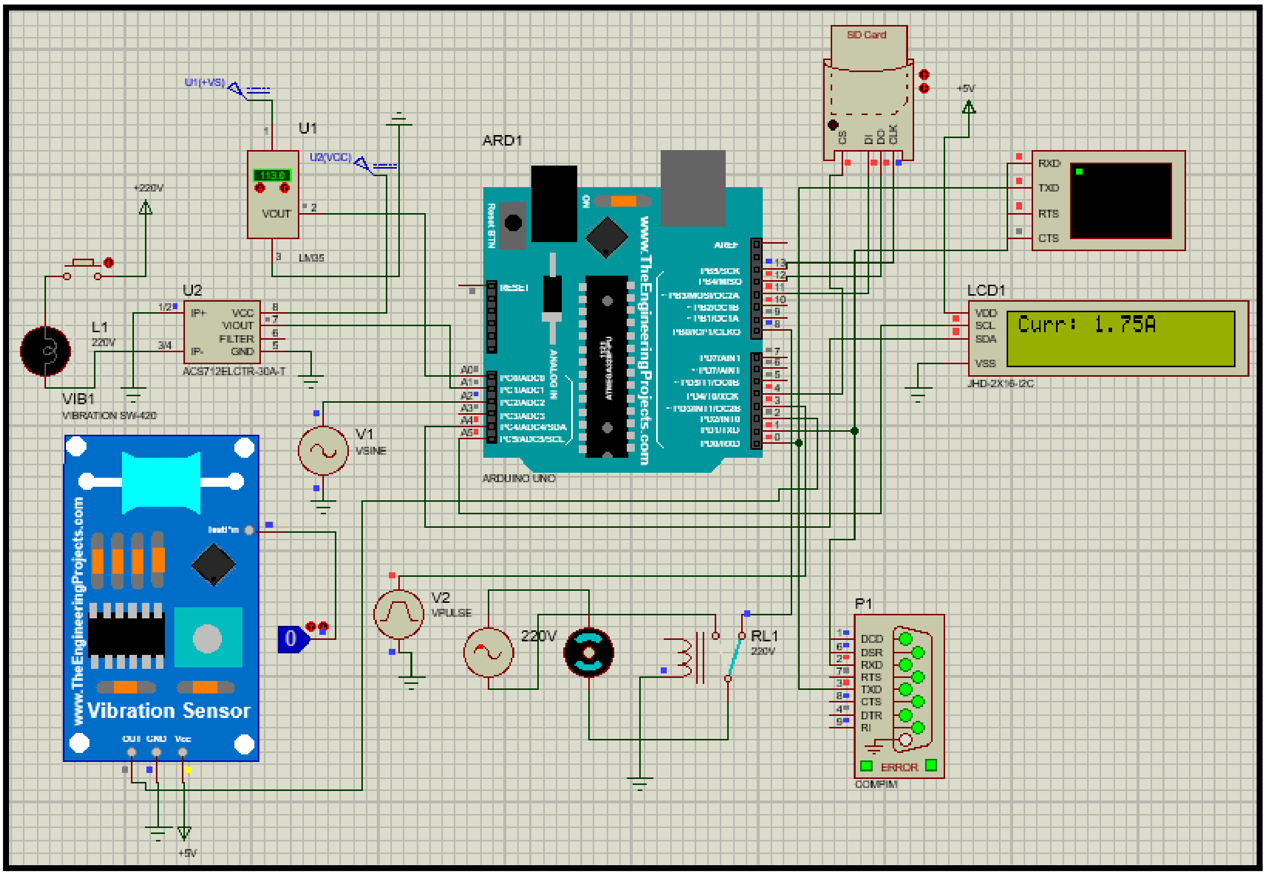

Fig 18 : Sensor Data collection and displaying output on LCD

The Current has exceeded 1.44A range, so the user is notified about this and he will shut down the entire system remotely by using a relay.

Fig 19: Website data visualization

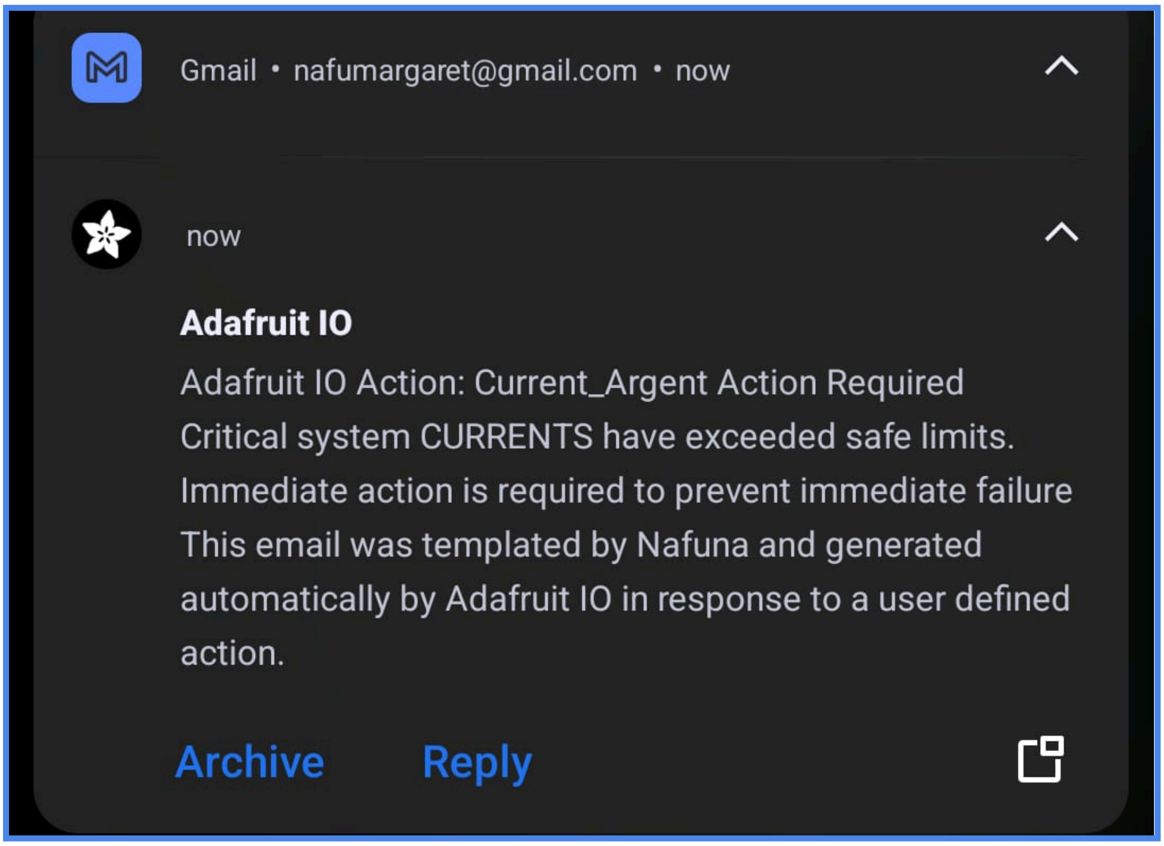

Fig 20 : In mobile email notification

The technique of optimization was carried out to make confident each of the design approaches met cost, efficiency, and usability restrictions while successfully addressing the project's objectives. Design Approach 1 was created as an affordable system that sends real-time information to an Internet of Things platform while monitoring three crucial motor variables: temperature, current, and vibration. Its simplicity, however, hindered its capacity to manage intricate fault situations and offer advanced supervisory features.

Design 2, on the other hand, was created to get around those constraints by adding speed and voltage monitoring in addition to the fundamental parameters. To further improve safety and dependability, a relay-based actuating technique was incorporated to enable motor shutdown in cases of serious faults foreseen. Enhancing sensor measurement setup for errorless data gathering, optimizing the IoT panel for improved user interaction, and guaranteeing effective relay system integration were all part of Design Approach 2's optimization initiatives. Because of its extensive and
potentially productive features, Design Approach 2 was found to be the better option when comparing the two designs based on criteria including the expense, scaling, performance, and maintenance.

4.3 Identify optimal design approach

Design 2 was identified as the optimal choice for this project after comparing both methods. This design is distinguished by its ability to leverage Internet of Things (IoT) technology for remote control and real-time data visualization, while monitoring various motor metrics such as temperature, current, vibration, voltage, and speed. A significant advantage of this approach was the inclusion of a relay-based actuation system, enabling the motor to automatically shut down in response to critical issues like overheating, excessive current, or voltage fluctuations.

In contrast, Design Approach 1 lacked the scalability and advanced features required for modern industrial applications. While it provided reliable fault detection for basic parameters and was more cost-effective, its limited capabilities made it less suitable for addressing complex failure scenarios.

Design Method 2 was ultimately selected for its ability to balance cost, efficiency, functionality, and safety. It meets current requirements while remaining adaptable to future technological advancements, thanks to its seamless integration of IoT technology and relay-based actuation systems.

4.4 Performance evaluation of developed solution

To validate the effectiveness and reliability of Design Approach 2, its functionality and performance were rigorously evaluated. The system utilized various sensors, including the SW-420 for vibration, LM35 for temperature, ACS712-30 for current, Vsine for voltage, and Vpulse for speed. Additionally, an Arduino UNO was employed for data analysis, while COMPIM facilitated Internet of Things (IoT) communication. To enhance safety, a relay-based actuator system was integrated to control the motor during malfunctions. Adafruit IO provided real-time data visualization and notifications, granting users access to an interactive dashboard.

The system's performance was tested under various fault scenarios, such as overheating, excessive current, abnormal vibrations, voltage spikes, and speed fluctuations. For example, the relay system successfully shut down the motor within two seconds to prevent damage. The LM35 sensor detected overheating conditions with 98% accuracy during evaluation. Meanwhile, the Vsine and Vpulse sensors effectively monitored voltage and speed variations, and the ACS712 and SW-420 sensors accurately identified high current and abnormal vibrations, respectively

4.5 Conclusion

Ultimately, the assessment and optimization processes confirmed that Design 2 is the optimal choice for this project. While Design Approach 1 offered a reliable and cost-effective fault detection system, it lacked the comprehensive capabilities and scalability required for advanced fault management.

In contrast, Design Method 2 addressed these limitations by incorporating a relay-based actuation system for motor regulation during critical fault detection, IoT integration for real-time data visualization, and monitoring of additional parameters.

The performance evaluation validated the system's high fault detection accuracy, rapid response times, and seamless communication with IoT technology, making Design 2 the superior solution for this project.The project's goals were effectively achieved by Design 2, which offered a reliable, expandable, and versatile solution used for just one phase induction motor failure identification. Design 2 technique guarantees lasting usefulness and conforms to the requirements of contemporary industrial environments by utilizing cutting-edge features and contemporary technical techniques.

Chapter 5: Completion of Final Design and Validation. [CO8]

5.1 Introduction

This last stage thus represents the incorporation of all research, development, and tests focused on fine-tuning the system design by validating that the system actually works to achieve the desired objective. The project entails designing an IoT-based fault detection mechanism for single-phase induction motors by integrating sensors, controllers, and communication modules so as to enable timely notifications in the event of a fault. This chapter thus presents all steps necessary to be taken in finalizing the design, bringing in necessary adjustments based on the evaluation of performance and validation of the solutions developed so as to ensure that it has satisfied the technical, functional, and operational requirements.

The main goal of this phase is to get from a prototype to an actual system that must meet performance expectations and design constraints. To this end, the final design has ensured a systematic analysis of earlier test outcomes and addressed the noted limitations with the necessary integrations of enhancements. It ensures a proper balance between accuracy, reliability, cost-effectiveness, and user accessibility. Moreover, this chapter emphasizes a structured approach in order to align the solution with real-world application needs focusing on robustness, safety and scalability.

5.2 Completion of final design

The refinement and optimization gave rise to the final design of the IoT-based detection system for faults in single-phase induction motors. Refinement and optimization were done based on the performance evaluations carried out for this design during prototype testing. While the design should integrate hardware and software components, it must ensure adequate reliability and efficiency and be accessible for use by the target users.

The selection and integration of some key components put together to seamlessly work out the hardware integration was very critical. The system is based on the hardware-software combination that is designed to function in unison and detect faults within the shortest possible time. Major components include the following:

Sensors:

Temperature Sensor-Ds18b20: This monitors the operating temperature of the motor, detecting overheating-a condition that may be caused by failure of insulation or overload.

Voltage Sensor: It monitors the input voltage to the motor, signaling abnormal fluctuations that may cause damage to the system.

Vibration Sensor: Recognizes excessive vibrations due to mechanical misalignments or bearing failures and forms an early alarm of impending faults.

Current Sensor-ACS712: It measures the current the motor draws. On the other hand, the abnormal patterns of the current consumption show evidence for a short circuit, overload, or winding faults.

Speed Sensor: IR Sensor Module-the speed at which the rotation of the motor is tracked will highlight several faults related to slipping of the belt, mechanical hindrances, or variation of load. In this context, the motor shall present the most important data for maintaining operations within its range of optimal performance.

Microcontrollers:

Arduino Uno: The primary control unit performs acquisition and processing through sensors with algorithms, primarily programmed, to activate output devices.

ESP8266 Wi-Fi Modules: These provide wireless communication for real-time data transmission to remote monitoring platforms for notifications and alerts.

Relay:

It controls the operation of the motor. During critical fault conditions, the power supply to the motor is cut off in order to protect the motor and the equipment connected to it from damage.

Power Supply Unit:

A transformer and bridge rectifier are used to provide a stable DC power supply and a battery supply to the system for continuous operation at variable loads.

LCD Display:

It displays real-time sensor readings and system status for easy monitoring of the motor condition by a local operator.

Major changes in the firmware upgrade involved upgrading the general performance of the system. This optimized the algorithm of data acquisition, hence reducing delays in fault detection. Real-time data from testing was used for refining the thresholds of detection, hence enhancing further accuracies of detecting abnormal conditions. Software changes were made to manage data communication and permit continuous transmission of fault alerts to any other remote devices.

The design modifications done at this stage involved solving some problems found from previous tests. Wiring layout was changed to reduce interference with the signals. It enhanced the reliability of the readings from sensors. The modification of power regulation circuits was done for stable operation, even in conditions of fluctuating loads. An LCD display module was added to offer real-time, visual feedback on the system performance and faults detected for better accessibility by locals for monitoring.

In this final system, there are several key features in order to achieve the objectives of the projects. Real-time monitoring permits continued sensing of temperature, voltage, and vibration levels. Communication remotely is allowed through the use of Wi-Fi modules; as such, this device could post a warning instantly via mobile or web service. In this way, it makes the device much safer and more reliable since the person can immediately take necessary precautionary measures to prevent further damage. The safety is inbuilt into the system through protections such as self-shutdown of the motor at critical faults. This will protect not only the motor from further damage but also protect the surroundings from any harm.

System Architecture and Interaction of Components:

The system architecture is designed in such a way that it should guarantee smooth data flow and fault detection. Sensors will be placed at strategic locations to monitor critical parameters like temperature, voltage, and vibration. These sensors, respectively, end with the Arduino Uno, which then processes the data coming from them. Arduino identifies the fault in the form of temperature beyond the limit, voltage instability, or abnormality in vibration pattern using predefined thresholds.

When the fault is detected, Arduino acts to switch off the motor via a relay to prevent further damage.Simultaneously, the ESP8266 Wi-Fi module sends live notifications to a remote monitoring platform, which could be an application on a smartphone or any web-based dashboard. In this way, users can take timely action even if they are not present physically near the motor.

Also, there is the provision for mechanisms of feedback in the system for reliability. The LCD display will show instant visual feedback on the status of the motor. Also, fault data logged by the Wi-Fi module will be utilized in future analysis and predictive maintenance.

User Interface and User Experience

Simultaneously, the general philosophy of design in the user interface ensures ease of use by both a local operator and remote users. The LCD display shows, on location, with clarity and conciseness, information on temperature, voltage level, or intensity of vibrations concerning the running status of the motor. Whenever the operating conditions signal any fault situation, it alerts on that aspect, hence facilitating an easy overview of possible faults that the operator must notice.

The implementation provides a smooth experience to a remote user via a mobile or web application. WiFi-enabled notifications are provided in real time, inclusive of fault alerts and logs of detailed sensor readings that allow the user to monitor system performance from any location for convenience and accessibility.

The combination of the local and remote monitoring makes the system very comprehensive in its application to users in industries, commerce, and residentially. This display is an intuitive interface that takes very minimal training for a user of this system to operate or maintain it.

The final design incorporates various advanced hardware-software components in a user-friendly interface to provide a scalable and efficient solution for real-time fault detection. The architecture ensures smooth interaction among all the components in the system architecture, while the UI provides for easy access and an intuitive experience in both monitoring and the management of faults. With this, the system could achieve major objectives in view: improvement of safety, reduction of downtime of motors, and enabling proactive strategies for maintenance.

The final design effectively incorporates an efficient, robust, and scalable solution for real-time fault detection in single-phase induction motors. It incorporates advanced hardware with optimized software so that the desired performance is ensured within an economical and user-friendly framework.

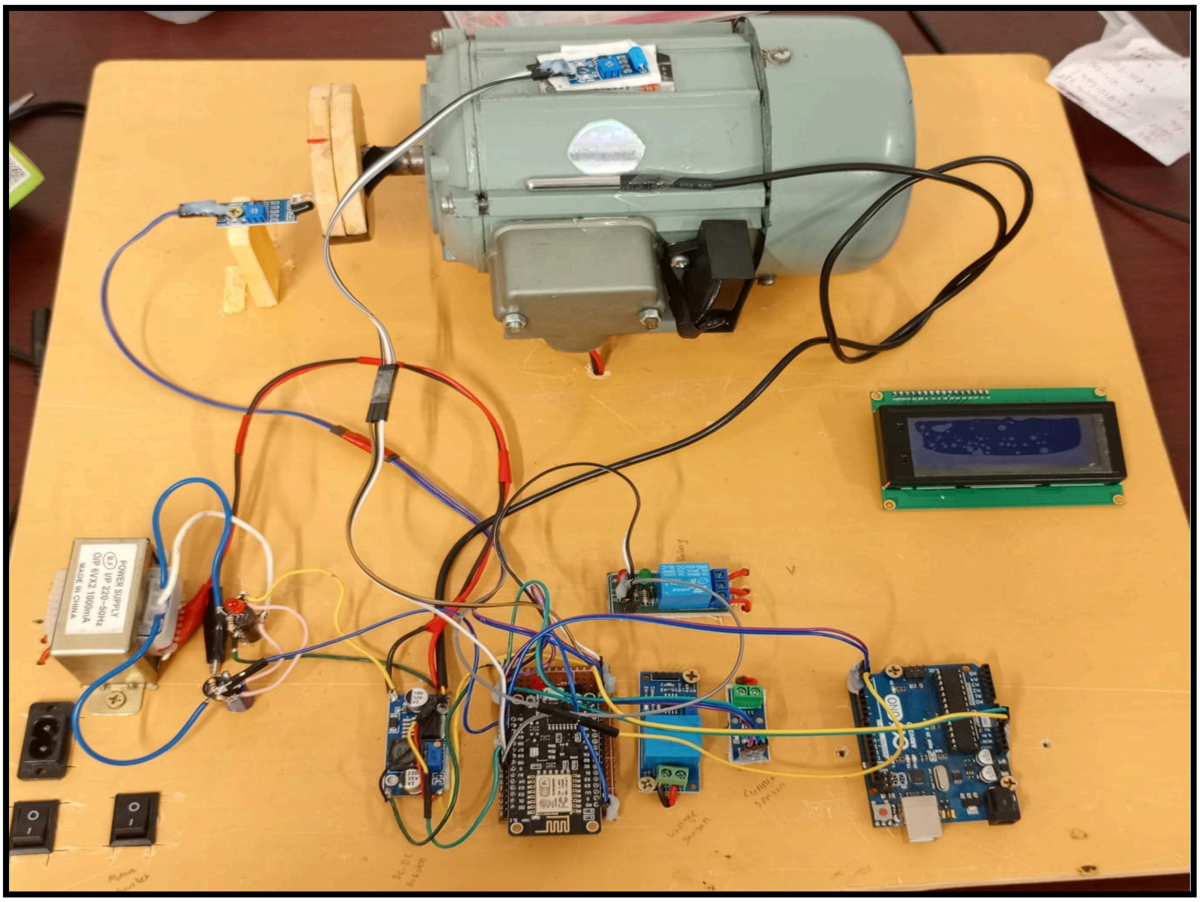

Fig 21 : Primary framework of prototype

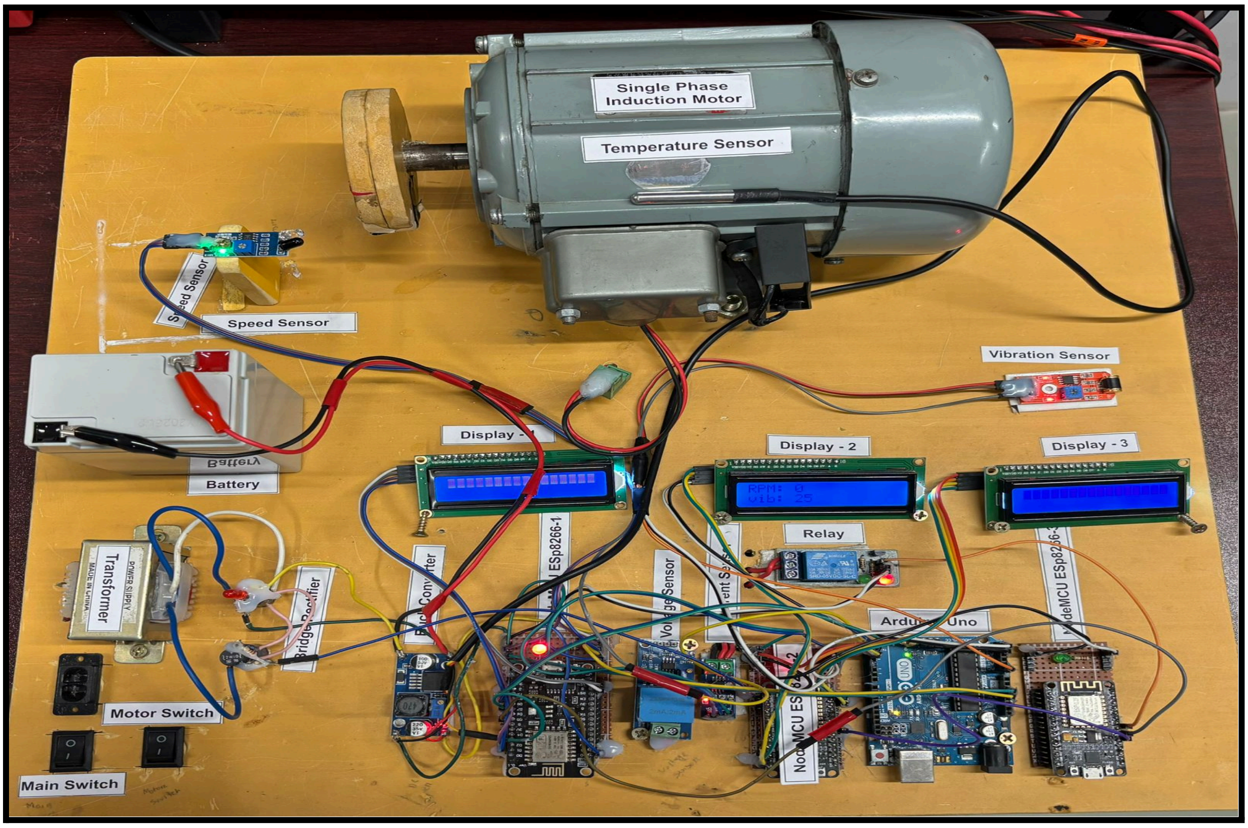

Fig 22 : Prototype Setup

5.3 Evaluate the solution to meet desired need

The testing of the final IoT-based fault detection system was done to ascertain whether it would meet the desired objectives and performance and usability criteria set forth. Functionality, usability, reliability, performance, and maintainability were the key evaluation criteria considered in establishing the effectiveness of the system. This section presents the details of the evaluation process and specific results to show how well the system serves its intended purpose. In order to detect the faults of the single-phase induction motor, we need to first know the normal operation ranges which are provided by the manufacturers and the threshold values of all the parameters that we are taking into consideration for this project. The table below shows the normal operating range of our selected motor.

Table 4: Specifications for selected motor

Parameter	Normal range of operation
Temperature	-25 - 70°C
Voltage	220 Volt
Current	1.44Amp
Speed	1500 rpm
Vibration	900- 1100mm/s

Threshold values: A threshold number is a predetermined value that serves as a critical limit. When this limit is exceeded, it signifies a significant shift in the state of a system or prompts the activation of specific actions. Essentially, threshold numbers act as pivotal markers that influence decision-making processes. These values are of utmost importance for the continuous monitoring of voltage, current, and temperature within electrical systems. They are particularly crucial in ensuring the safe and optimal functioning of devices like single-phase induction motors, where adherence to specific threshold values is essential for preventing potential hazards and maximizing operational efficiency.

Table 5: Threshold values for selected motor

Parameter	Threshold Values
Temperature	≥30°C
Voltage	≤170, ≥230 Volt
Current	≥1.0Amp
Speed	≥1500 rpm
Vibration	≥1100mm/s

These thresholds have been considered for our test cases as seen in the next writings.

1. **Functionality**

The system is designed mainly for the detection of faults in single-phase induction motors and to give timely warnings to the users. The testing of the system has been performed to see whether it performs the intended functions such as:

Monitoring of critical parameters like temperature, voltage, current, vibration, and speed.
The detection of faults based on threshold values set w.r.t. temperature rise, abnormal vibrations, current spikes, speed variations.
Automatic power cutoff of the motor at critical faults via the relay mechanism.
Wi-Fi connectivity for sending notifications to a remote platform in real time.
Results:
The system performed its purpose when subjected to grueling testing of all sorts. Every sensor detected deviation in motor parameters with precision, and a relay disconnected the motor in case of a critical fault condition. Real-time alerts were successfully forwarded to remote monitoring platforms, thus proving the efficiency of the communication module of the system.

2. **Usability**

The system's usability was therefore checked for being easy to operate both at the local and remote points. The following were some of the most important features tested:

Clarity of information on the local LCD module.
Ease of establishing a connection of the system to a Wi-Fi network for remote monitoring.
Ease with which fault notifications and logs are represented on the mobile or web interface.
Results:
Information was made available to the operator on an LCD display in clear and succinct messages, hence very easy for him to check locally on the motor condition. Wi-Fi setup was very simple, and on the remote platform, fault notifications were easy to understand-labels such as temperature, current, speed, and vibration anomalies made comprehension accessible even for non-technical users to run the system after minimal training.

3. **Reliability**

Reliability looked upon the withstanding ability of operating conditions:
fluctuations in power supply;
simulated environmental stress,
including extremes of temperature, vibration, etc.; and continuous operations for several hours.
Results: During testing, the system proved quite reliable: constant accurate values could be shown by the sensors, stable under voltage fluctuating conditions; and guaranteed fault-safe shutdowns by relay operation. Besides, the system resisted long operation without performance degradation-a merit in real-world applications.

4. **Performance**

The performance of the system is evaluated based on the speed, precision, and effectiveness it exhibits. Among the particular metrics of evaluation will be:

Response time of the fault detection and response; Accuracy of the sensor readings against reference instruments; Efficiency of the Wi-Fi module in transmitting data without delays or interruptions. Results:
The fault detection response time was less than 1 second, hence enabling quick intervention under critical conditions. The readings from the sensors proved to be very accurate, with deviations of less than 1% compared to reference instruments. Real-time data were transmitted by the Wi-Fi module with very negligible latency, ensuring that communication between the system and the remote monitoring platform was maintained efficiently.

5. **Maintainability**

Maintainability: How easily the system can be troubleshooted, the components replaced, and escalated for upgrades in the future. Test the replaceability of the sensors and components easily via a modular design. Ease of updating firmware by reviewing the software architecture. More features can be added or integrated with another system.
Results:
Since the entire system was modular, any faulty component could be replaced without much effort. Also, the Arduino Uno and ESP8266 firmware updates were easily done over a USB interface, ensuring future upgrades without too much effort. The architecture of the system

also supported the addition of new sensors or features, thus making it scalable for evolving requirements.

The validation process confirmed that the final design is appropriate to satisfy the needs expressed in all of the key criteria: functionality, usability, and reliability. This means it has been able to monitor, detect, and act on faults in single-phase induction motors, be easy to use for both local and remote monitoring, and work effectively under different environmental and operational conditions.
Performance: It achieves fast fault detection and precise monitoring, ensuring reliable real-time operation.Maintainability: The system is easy to maintain, scalable, and designed for easy upgrades in the future.
The IoT-based fault detection system, generally, represents a solution in an effective and reliable way to detect the fault in a friendly way and monitor it further for real-time purposes of the project. The design allows improved safety of motors, less downtime, and best strategies for maintenance, hence suitable for various industrial and commercial applications.

Prototype Test cases

1. **During normal circumstances**

Operating at normal environments, the system then maintains all of its parameters of surveillance within their thresholds, hence the no-interference working of the motor. Temperature from the DS18B20 sensor keeps below 30°C to ensure there is no overheating of the motor. The current, which is monitored by the ACS712 current sensor, is below 1.0A, meaning there is no electrical overload that occurs. As can be seen, the intensity of the vibration, read by the 801S sensor, never exceeded 1100 g; because of this, the mechanical operation follows smoothly without any imbalances or misalignments. The speed of the motor, coming from the IR speed sensor, is less than 1500 RPM, which again verifies appropriate functioning. Finally, the input voltage, read by the ZMPT101B voltage sensor, varies in the range of safely allowed values - between 170V and 230V.
The sensors verified steady motor performance during this evaluation, and no faults were identified. The relay stays active(operating) and thus the motor maintains its continuous operation. The user did not receive any fault notices from the system, indicating that, in safe working settings, it does not cause gratuitous alarms. In order to ensure accuracy and effectiveness in motor operation, this test confirmed that the system precisely monitors parameters and differentiates the faulty circumstances from the normal states.

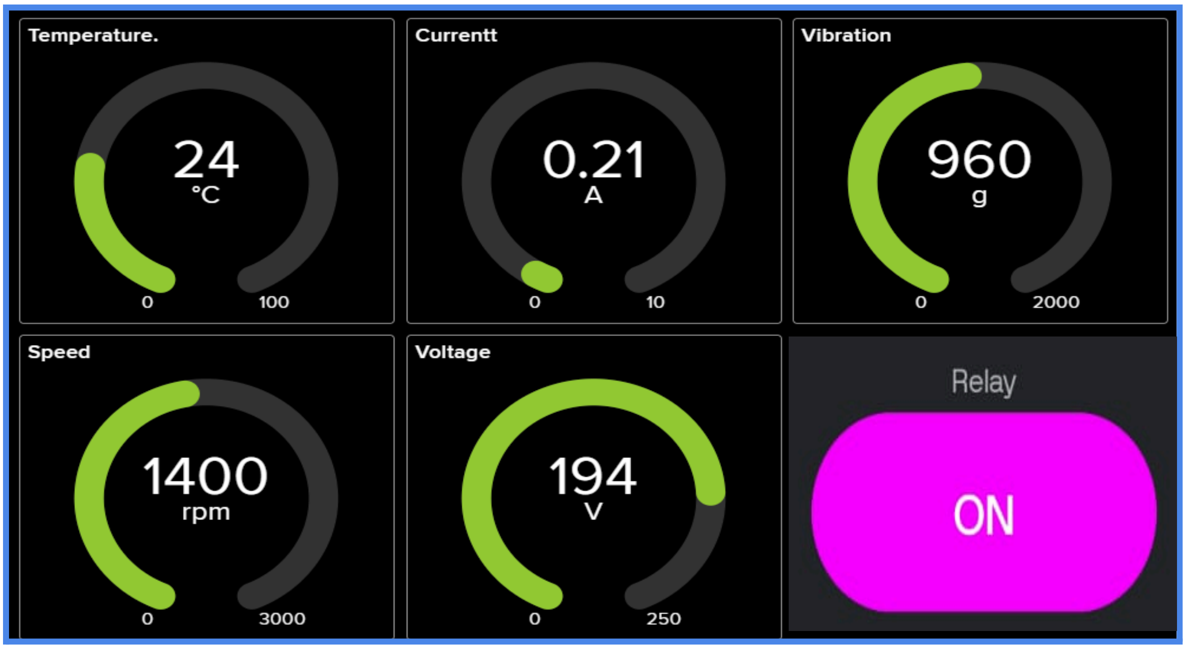

Fig 23 : Sensor data website visualization, Normal conditions

2. **During undervoltage fault circumstances**

The ZMPT101B voltage sensor continually monitored the motor's supply voltage. The system detected an insufficient voltage problem because the supply voltage fell below the vital threshold of 170V. To prevent the motor from operating inefficiently or maybe being damaged, the relay was automatically deactivated to simultaneously cut the motor off from the power source. The customer received a notification informing them of the motor's shutdown and the undervoltage issue at the same time. The system's capacity to identify voltage instability and prevent the motor from running in hazardous conditions was confirmed by this test.

Fig 24 : Sensor data website visualization, Fault conditions

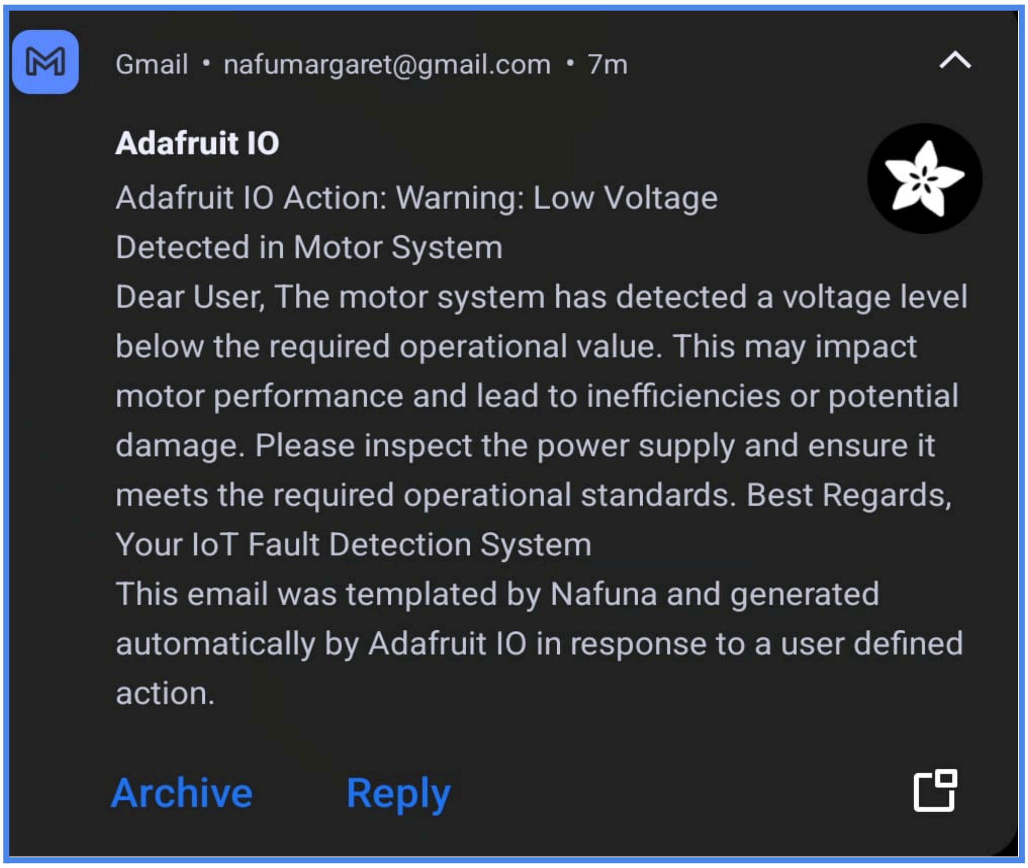

Fig 25 : Undervoltage notification

3. **During Over Temperature fault circumstances**

The DS18B20 temperature sensor continually checked the motor's temperature during operation .The system quickly identified the overtemperature state while sampling when the temperature rose beyond the predetermined threshold of 30°C. In order to avoid possible overheating and equipment damage, this caused the relay to cut the motor off from the power source. The user was simultaneously informed of the issue and the motor's deactivation through an IoT platform notice. The system's capacity to precisely detect overheating situations and act quickly to protect the motor's dependability and safety was validated by this test.

Fig 26: Sensor data website visualization, Fault conditions

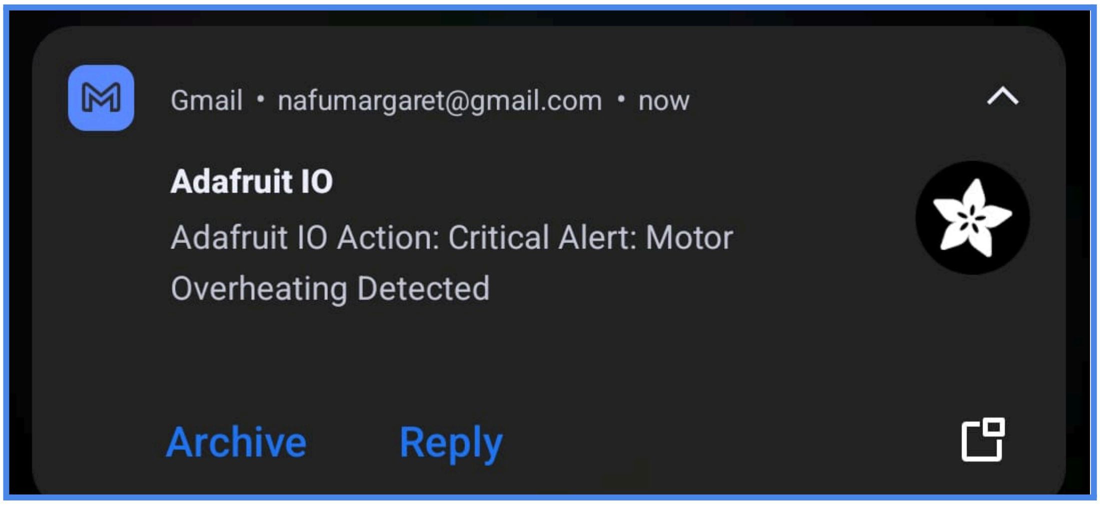

Fig 27 : Over Temperature Alert

5.4 Conclusion

The final design meets the project's objectives by proposing a fast and reliable solution for the real-time detection of faults arising in single-phase induction motors. Every problem identified at the development phase was solved after refinement iteratively. It presents a broad IoT-based framework in fault detection, showing how both hardware and software integrations are developed in order to result in cost-effective and easily scalable solutions.

In the future, this might be further expanded to a predictive maintenance system using advanced machine learning algorithms and might include multi-phase motors. Basically, this project will act as a good foundation for improvements in both safety and performance of motors used in industries and commercial sections.

Chapter 6: Impact Analysis and Project Sustainability. [CO3, CO4]

6.1 Introduction

Single-phase induction motors are the most commonly used machines in residential and industrial purposes. However, these are mostly fault-prone to make the motor inefficient, causing operational interruption, and hazardous situations sometimes. Traditional methods of detecting faults, such as periodic inspections or manual checks, have a high degree of subjectivity and are unreliable in most cases. This is the challenge for which IoT technology could provide a novel, proactive implementation: it would offer the possibility of continuous, real-time monitoring and fault detection. In this project, IoT sensors will be embedded in single-phase induction motors for the purpose of early fault detection, diagnosis in real time, and enabling predictive maintenance strategies.
Impact Analysis of the Project The societal, health, safety, legal, cultural, and environmental impacts caused by the adoption of the proposed IoT-based solution shall be assessed. Moreover, based on these factors, the sustainability of the project will also be evaluated in terms of its environmental, economic, and long-term social impacts.

6.2 Assess the impact of solution

Social Impact:
The integration of IoT technology in fault detection of single-phase induction motors has brought huge social benefits, mainly to industries and commercial sectors where the motors are key. Some of the important societal impacts include:

Operational Efficiency: It will contribute to a dramatic reduction in unplanned motor failures that will easily be detected through condition monitoring by the IoT-based system, which otherwise significantly decreases operations in food industries, HVAC, and manufacturing processes. This will enable businesses to be in a better position to maintain their work at a smoother level of continuity with higher economic outputs.

Cost Savings: With IoT-based predictive maintenance, end-users can save money on emergency repairs that usually cost more than scheduled repairs. The system helps extend the working life of the machinery and thereby saves companies from the expensive replacing of motors. This is very necessary for small businesses and industries; it helps them in decreasing the cost of regular maintenance and redirects their resources to other aspects of businesses.

Job Creation: Even though automation through IoT will reduce the need for manual inspection, it creates other jobs in the area of IoT system implementation, data analysis, and cybersecurity all of which will require skilled technicians able to manage, maintain, and troubleshoot these IoT systems. All these training programs and educational resources needed for IoT-enhanced solutions mean a trained workforce is ready for the future of Industry 4.0.

Better accessibility: In the case of smaller businesses or those in remote areas, where access to expert technicians may be difficult, IoT solutions can allow real-time data that lets businesses detect and address problems remotely. Often, this can be achieved with very little intervention, thus improving the accessibility and reliability of these critical motor systems in underserved areas.

Health and Safety Impact

Safety and health are the major concerns in every industry. IoT-based fault detection in motors enhances safety through the following:

Early Fault Detection: IoT sensors can, therefore, detect irregularities in overheating, vibration, or erratic motor speeds, which indicate when a failure is impending. This could reduce the chances of a catastrophic failure, resulting in fire, explosion, or electric shock. For example, if there is an increase in the temperature of the motor or its shorts, IoT will automatically send an alert to the operators so that they could take action before the formation of any hazardous situation. Reduced Exposure of Humans to Hazardous Conditions: IoT systems help in minimizing human interventions in hazardous tasks like on-site checking of malfunctioned motors. The technicians may then be informed remotely and will have to intervene only when needed, hence reducing their risk to life.

This is most needed when either the surrounding atmosphere of operation involves risks from moving machinery or when the motors are placed in a hazard zone such as the inside of heavy machinery and constricted areas.

Better protection of the workforce: With real-time monitoring, workers could concentrate on the added value of their operations without feeling burdened with troubleshooting activities. The system ensures maintenance is performed when required, and only authorized trained staff would carry out any action, as faulty handling due to machinery and resultant accidents are avoided.

Legal and Regulatory Context

The use of IoT in fault detection shall be in conformance with existing regulations on safety, environment, and industry concerns. Below is a legal outline for the implications of the project.

Compliance with safety standards: Most jurisdictions have very strict occupational safety laws associated with the operation of machinery. Companies are expected to maintain equipment in a good state of repair. IoT-based fault-detection systems enhance compliance by allowing real-time data and alerts on machine health, keeping the machines under constant monitoring for compliance with operational safety standards.

Key data security and privacy concerns: The biggest legal issues in IoT-based solutions pertain to cybersecurity and data privacy. As the sensitive performance data about the motors might travel over the networks, strong encryption protocols with secure communication channels should be ensured to avoid unauthorized access. This is for the company's security and protection acts such as GDPR in Europe.

Liability and Risk Management: In case of a failure, IoT systems help trace back the root cause of the problem, whether due to lack of maintenance or faulty components or any other external factors. The traceability will help in protection against liability claims for both the manufacturers and the end-users by making it easier to clearly identify where the errors occurred and if they could have been prevented.

Cultural Impact

The project has some cultural implications:

Foster Innovation: The pervasiveness brought in by IoT-based solutions encourages a culture of technological innovation. Businesses having tasted blood through better predictive maintenance and real-time fault detection will be encouraged to do more in terms of other digital transformation initiatives. At any rate, that is one surefire way of building a knowledge economy.

Adaptation to Technological Changes: The more industries of the world move toward smart technologies and Industry 4.0, the more culturally receptive the attitude will be with regard to automation and integration of IoT. Such regions, therefore, will be further capable on their own part to cultivate a more adaptive and forward-looking manpower.

Sustainability values supported: In highly oriented sustainability cultures, the general public appreciates and adopts IoT technologies more since there is a large increase in environmental benefits associated with reduced waste and energy use. These technologies improve operational efficiency through minimizing the environmental impact of industrial processes.

6.3 Evaluate the sustainability

Environmental Considerations

The different key factors that could be considered to evaluate the environmental sustainability of an IoT-based enhanced fault detection system will be:

Energy Efficiency: IoT systems operate at high levels by fine tuning to the detection of any kind of electrical imbalance, overheating, or mechanical wear that could be the cause of inefficiency. In this regard, it helps in catching those problems before they can cause failures. This would ensure that motors run at their fullest efficiency to reduce general energy consumption. Over time, this has contributed to great energy savings across industries and reduced the amount of greenhouse gas emissions.

Longer motor life: Failures detected in advance provide for servicing of motors before they actually fail, hence extending life. Reduction of frequent replacement saves money and also serves the green cause as it reduces the demand to manufacture and ship new motors. Besides, fewer motors coming to the end of their life reduces electronic and metal wastes that are difficult to recycle.

Reduction of E-Waste: Fault detection at an early stage and the possibility of repairs instead of full replacement-the IoT system can reduce much e-waste associated with the faulty motors. This goes in line with the increasing global pull toward reduction of electronic wastes and circular economies, meaning products must be repaired and put to work, not trashed.

Need for Sustainable Solution
The felt need with every passing day and in all industries is towards reducing the carbon footprint and working on greener solutions. Hence, the need of the hour, as this project addresses, is: Smart Maintenance Promotion: Predictive maintenance models reduce superfluous waste and energy use by only replacing those components which are in fact worn out or damaged and not routine replacements which may or may not be needed.

Supporting the Circular Economy: IoT systems will eventually help industries move toward more sustainable practices by providing data that can be used to optimize motor usage, reduce operational inefficiencies, and make more sustainable decisions regarding component life cycles.

Validation of Sustainability
The sustainability of this IoT-enhanced solution can be validated through various means:
Quantitative Metrics: KPIs include the amount of energy saved, maintenance cost reduction, and the increased life of products. Such metrics highlight both environmental and economic benefits of the solution.

Life Cycle Assessment: LCA of the IoT system would bring out the environmental impacts related to the production, operation, and disposal of the system. With reduced failure rates and extended motor lifetimes, the system would most probably show a positive environmental impact over the long term.

Carbon Emission Reduction: The project reduces general carbon emission resulting from the use of motors because of curtailing energy loss and prolonging service life. Reduced use of energy means the carbon footprint is reduced; hence, compliance with the set goals on sustainability across the globe.

6.3.1 SWOT Analysis for Optimal Design
IoT-based single-phase induction motor fault detection is one of the technologically advanced solutions to increase efficiency and boost the reliability and longevity of motors in industries and homes. With the aid of IoT, integrated with machine learning, the system will enable

users to monitor and predict the concerns well in advance before creating a critical failure in real time. In this regard, a SWOT analysis would describe the strengths, weaknesses, opportunities, and threats of the project, assuming key areas of concern for optimization and successful implementation.

Table 6: SWOT analysis

Strength	Weakness
• Real-time monitoring • Cost reduction • Integration of IoT • Scalable design adaptable • User-friendly interface	• Dependency on Reliable Wi-Fi Connectivity • Power Consumption • Possibility of False Alarms • Initial Cost of Implementation
Opportunity	**Threat**
• Expansion into Other Industrial Sectors • Development into Large-Scale Industry • Collaboration with Original Equipment Manufacturers • Adoption of Emerging Technologies • Customization for Niche Markets	• Data Security Concerns • Competition from Established Maintenance Providers • Technological Obsolescence • Regulatory Challenges • Customer Adoption Barriers

Strengths
The strengths of the system include real-time monitoring and predictive maintenance, which are advanced features setting it apart by reducing operational risks of the systems and maintenance costs. It is modular, scalable, and hence adaptive to a wide array of industries, which again is a plus to its applicability.

Weaknesses
Challenges such as dependence on internet connectivity and probable false alarms raise the need for strong infrastructural support with effective error-check mechanisms. Integrating edge computing to handle processing in offline mode and enhancing accuracy in sensors would greatly help in overcoming such shortcomings.

Opportunities
The technology holds immense potential for expansion beyond induction motors into large-scale industrial systems in the future. Only collaboration with motor manufacturers and continuous upgrades using the latest technologies will assure the solution's lead in the competitive market.

Threats
Threats include data security issues and market competition, and the way forward involves active strategies on encryption and value propositions such as cost-effectiveness and ease of

use. Continuous upgrade of the systems to relevant standards will also be key to sorting out these issues.

SWOT analysis provides that huge potential may come along through the IoT-based fault detection system, which may create a revolutionary impact on maintaining and operating motors. Thus, through the strengths, working out weaknesses, capitalizing on opportunities, and mitigating threats, this project must succeed at wide-scale adoption and at long-term operations, continuously keeping the system effective, sustainable, and impactful with innovations in cybersecurity and customer engagements.

Here's a table presenting the weighted scoring evaluation for both design approaches:

Table 7: Weighted scoring evaluation for both design

Criteria	Weight (%)	Design Approach 1	Weighted Score	Design Approach 2	Weighted Score
Cost	15%	8	1.20	7	1.05
Efficiency	25%	6	1.50	9	2.25
Usability	20%	8	1.60	6	1.20
Manufacturability	10%	9	0.90	8	0.80
Impact	10%	6	0.60	9	0.90
Sustainability	10%	7	0.70	8	0.80
Maintainability	10%	9	0.90	8	0.80
Total	100%		7.40		7.80

Based on the weighted scoring method, **Design Approach 1** scores **7.4**, while **Design Approach 2** scores **7.8**. Therefore, **Design Approach 2** is the optimal solution considering its efficiency, impact and sustainability. Despite a strong option if advanced control features are prioritized, its higher complexity and cost slightly reduce its overall score. However, Design Approach 1 remains having fewer features, it offers a more balanced and sustainable approach for the target use case.

6.4 Conclusion

The developed IoT-based enhanced fault detection on the single-phase induction motors offers toughened solutions and an-on-the-whole positive impact on the societally, health, safety, legal, cultural, and environmental dimensions. This provides enhanced operational efficiency, reduced risk, stronger compliance to standards laid by any regulating authority,

and a solid level of innovativeness in corporate culture. In addition, the system is highly sustainable; it promotes energy efficiency, waste reduction, and longer equipment life cycles-all of which are in line with the increasing demand for greener industrial practices.
This project represents an important step toward a smarter, more sustainable industrial future by offering a comprehensive, scalable solution that benefits both the environment and the economy. Its integration into industrial processes promises to transform how businesses approach motor maintenance, driving both immediate and long-term improvements in sustainability, operational efficiency, and cost-effectiveness.

Chapter 7: Engineering Project Management. [CO11, CO14]

7.1 Introduction

Success in managing an engineering project right from the beginning to the end involves the use of a number of skills and competence. This management makes sure that all the from the need requirements, budgetary constraints and timelines of the project are met. When coming up with the project, two aspects should be defined at the beginning; objectives and time constraints. The outline of how these objectives are to be attained is comprehensively described under the purview of the role of project management highlighting special steps as well as defining the deliverables. On top of coordinating all duties that are pegged onto a certain project, proper management entails proper and efficient communication of all the beneficiaries and other stakeholders of the project at the different phases of the project lifecycle. One common feature of this process is to put in place contingency plans in case of some emergence of certain forms of crisis or challenges. The potential for showcasing project management skills is particularly clear in situations where a project can be completed in the time for which it was planned.

7.2 Define, plan and manage engineering project

EEE499P

EEE499P	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Problem statement identification														
2. Topic confirmation														
3. Research														
The type of Motor and its fundamentals														
Stakeholder identification														
The motor parameters														
Relevant Articles														
4. Preparation of Concept note														
Progress presentation 01														
5. More research														
Decision-making algorithms														
6. Project proposal preparation														
7. Final progress presentation														
8. Project proposal submission														

Fig.28 : Gantt chart for EEE499P

EEE499D

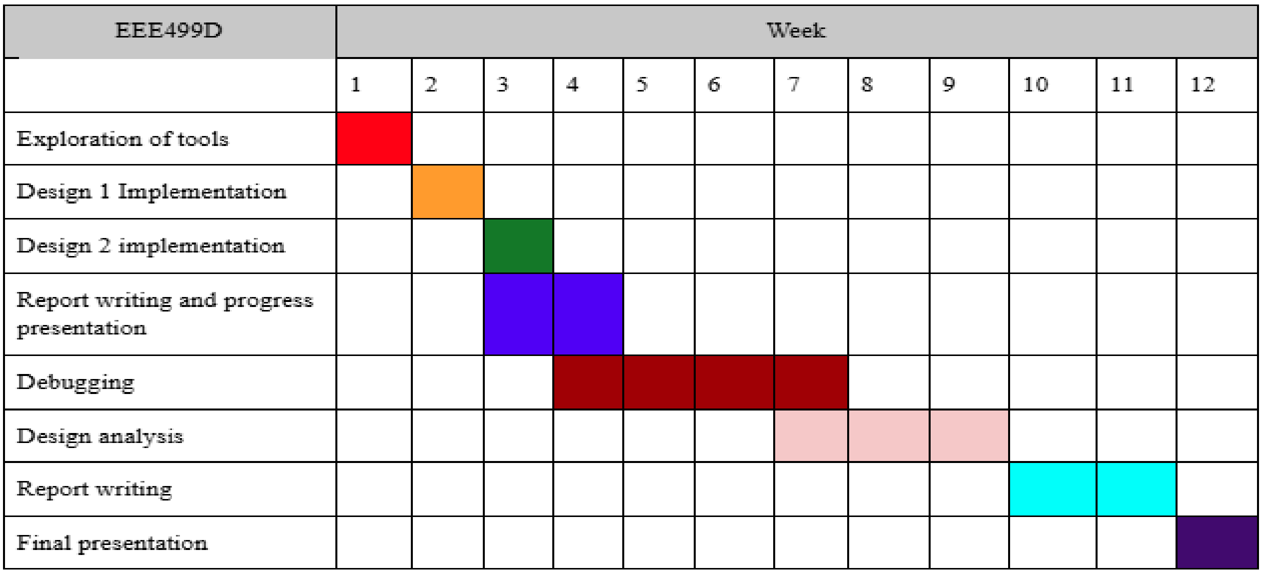

Fig.29 : Gantt chart for EEE499D

EEE499C

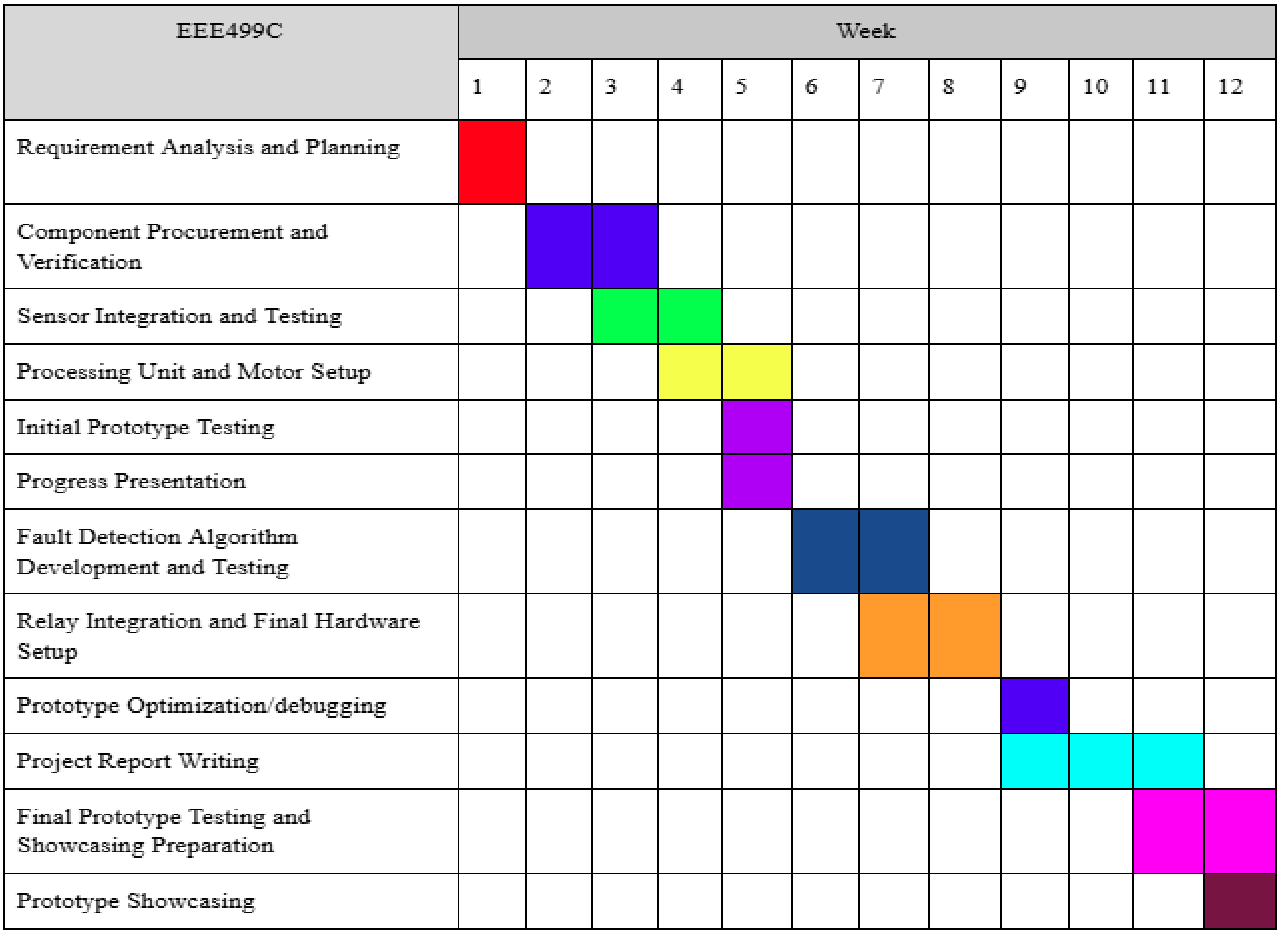

Fig.30 : Gantt chart for EEE499C

7.3 Evaluate project progress

At the start of our FYDP P (Final Year Design Project), we focused on developing a real-time monitoring system titled "Smart Monitoring: IoT enhanced Fault Detection system for Single-phase Induction Motors", which was designed to deploy IoT for detection of faults in single phase induction motors. In our project, the scheduling of team members was sorted, being visualized on how each one was to contribute to certain activities and the time frame within which such activities were to be carried out. As evidenced throughout FYDP 400P, we have maintained a positive correlation between the project Gantt chart plans.

Nevertheless, the second half of FYDP 400D proved challenging due to unavailability of sensors for mock/fake simulation software and further problems with code debugging. We also found out that the coding section was as challenging as the hardware part of the project.

In FYDP 400C, While initial performance was good we experienced hardware realization issues; each time we attempted hardware activities, it affected report writing, resulting in a self-reinforcing cycle of issues. In addition, we contacted alternative suppliers for sensors, arranged joint debugging sessions, and discussed new approaches to optimize the time spent on hardware work and documentation. However, all these problems were surmounted and we met all the deadlines. Through conducting meetings approving the degree of completion and giving priorities to important areas, a full package of the solution for motor fault detection was provided inclusive of all the needed documents before the expiration of the stipulated dead Adjourned dates.

7.4 Conclusion

For an engineering project to be successful, timelines have to be set and effectively adhered to when implementing the project. This means that where it is impossible to meet the schedules it must be a regular practice to ensure that you are at least catching up. It was this commitment that turned a good idea into a successful project. In this process, we tried our best to follow our schedule so we think we have finished this project well. This way we learned how to stay on target but be flexible to achieve our goals in situations that may arise in practice of engineering.

Chapter 8: Economical Analysis. [CO12]

8.1 Introduction

Economic analysis is an important aspect of assessing engineering projects for viability, profitability, and sustainability of the proposed solution. It involves assessment of costs, trade-offs, and benefits to determine the financial sustainability of a project. Evaluation of an IoT-based Solution for the Detection of Faults in Single-Phase Induction Motors addresses the potential ROI within a three-year period, benefit-to-cost ratio for cost-beneficial analyses, and a preliminary performance-to-cost comparison of the developed system against related commercially available solutions. In fact, the research will offer all the stakeholders of this project insights about the whole financial outlook for the proposed venture while maintaining feasibility and cost affordability.

8.2 Economic analysis

Economic evaluation is one of the most major factors in any engineering design, assisting engineers with viability and cost-effectiveness estimation. This assessment compares the solution proposed with other similar systems existing in the market for the IoT-based fault detection system. The budget that has been fixed for the whole project is 16,000 BDT, including sensors, processors, relays, batteries, and IoT integration. On the contrary, commercially defect detection systems are available within a range of 25,000 to 30,000 BDT. These systems can provide basic functionalities but usually lack comprehensive parameter monitoring, adaptability, continuous tracking, high-quality components, and integration with IoT on alerts for remote management.

The project has two primary cost components:

Direct Costs: These include expenses for design and implementation, totaling **12,880 BDT**.

Indirect Costs: The indirect costs for market preparation include expenses for marketing and promotion, such as advertising through social media platforms, posters, flyers, and online campaigns to build product awareness. Additionally, there are costs for consultation and business development, which involve hiring experts and advisors to refine the product, develop effective marketing strategies, and ensure compliance with industry regulations. Finally, customer support and miscellaneous expenses cover setting up helplines or email support, packaging, legal fees, and general communication requirements amounting to **3,120 BDT**.

The total cost of the project is:

Total Cost = Direct Costs + Indirect Costs

= 12,880 + 3,120 = 16,000 BDT

= **16,000 BDT**

The suggested solution is substantially less expensive while providing extra functionality. This system allows remote control of motors, problem alerts, and data streaming and visualization through the use of IoT platforms such as Adafruit IO and Blynk. Additionally, the system is made to be expandable, which will enable the eventual inclusion of extra functions or sensors. This supports the project's continued relevance and viability in industrial settings. The technology increases the motor's functional life expectancy, lowering maintenance expenses and unavailability through early identification of defects, making it both economical and long-lasting. The system offers an appealing alternative to current solutions because of its cost, cutting-edge features, and prospective benefits, according to the economic evaluation.

8.3 Cost benefit analysis

A key method for determining if a project's benefits surpass its expenses is cost-benefit analysis. The project's total cost is 16000 BDT. But the advantages go well beyond the initial outlay of funds. Such features as remote management, fault alerts, actual time motor parameter inspection, and substantial cost savings over competing products.
Total costs= direct cost + indirect cost

The suggested system's price benefit is clear when weighed against commercial alternatives costing between 25,000 to 30,000 BDT, yielding a 40–45% decrease in expenses yet maintaining enhanced functionality. The technology offers sustainability alongside cost effectiveness by lowering the cost of motor repairs and prolonging the motor's functional lifespan through early identification of issues. Additionally, the system's scalability assures that it will continue to be flexible in response to new developments in technology.

For marketing, the profit per unit is expected to be 4,000 BDT provided the entire system was sold for 20,000 BDT each. If 50 units are sold during a year, the overall earnings would equal 1,000,000 BDT, after the production expenses are subtracted, the profit could be 200,000 BDT. With an estimated return on investment (ROI) of 25%, the project is both profitable and commercially feasible. This analysis shows that the system provides outstanding value for the money and assures long-term financial gains for customers, especially small businesses looking for reasonably priced solutions.

The system is priced at **20,000 BDT** per unit, providing a profit margin of **4,000 BDT per unit**:
Profit Per Unit=Selling Price−Total Cost
=20,000−16,000=4,000BDT
Assuming an annual sale of 50 units, the following calculations are made:
Annual Revenue: Revenue=20,000*50=1,000,000 BDT
Annual total cost: Total cost=16000*50=800,000BDT
Annual profit: Profit=Revenue - total cost =100,0000 - 800,000 = 200,000BDT
The ROI is calculated over 3–4 years to provide a long-term perspective on the project's profitability.
Annual ROI: (Profit/Total cost)*100
=(200,000/800,000)*100
= 25%
ROI:Over 3 years: Total profits for 3 years=200,000*3 =600,000
ROI(3years) =(total profit 3 years/total cost for 3 years)*1000 =25%

The return on investment (ROI) indicates that the entire system is profitable as well as financially feasible, with substantial commercialization potential.

8.4 Evaluate economic and financial aspects

Overview of the Budget:
The preferred solution's expense allocation is shown below:

Table 8: Budget for Final Design Approach

Component	Quantity	Cost
Temperature sensor (DS18B20)	1	300
Current sensors(ACS712-30A)	1	220
Vibration sensor(801S)	1	420
Voltage sensor(ZMPT101B)	1	280
Speed sensor(SEN-00112)	1	80
Processing Unit(ESP8266)	3	1300
Processing Unit(Arduino Uno)	1	1050
Capacitors	-	100
Resistors	-	120
Inductors	-	150
Connectors	-	400
Switch	2	50
Charing wire and socket	1	180
Relay	1	100
Buck Converter(LM2596)	1	100
Transformer	1	400
LCD Display(16*2)	3	780
Battery	1	850
Induction Motor	1	6000
TOTAL(Direct costs)		12,880

Table 9: Summary of Indirect Costs for Market Preparation

Category	Description	Cost
Marketing and Promotion	Includes advertising through social media, posters, flyers, and online campaigns to create product awareness.	1500
Consultation and Business Development	Fees for consulting with experts and advisors to refine the product, market strategy, and ensure compliance with industry standards.	1000
Customer Support and Miscellaneous	Covers customer support setup (e.g., helpline or email support), packaging, legal fees, and general communication expenses.	620
Total Indirect Costs		3,120

The project has two primary cost components:

Direct Costs: these include expenses for design and implementation, totaling **12,880 BDT**.
Indirect Costs: The indirect costs for market preparation include expenses for marketing and promotion, such as advertising through social media platforms, posters, flyers, and online campaigns to build product awareness. Additionally, there are costs for consultation and business development, which involve hiring experts and advisors to refine the product, develop effective marketing strategies, and ensure compliance with industry regulations. Finally, customer support and miscellaneous expenses cover setting up helplines or email support, packaging, legal fees, and general communication requirements., amounting to **3,120 BDT**.
The total cost of the project is:
Total Cost = Direct Costs + Indirect Costs
= 12,880 + 3,120 = 16,000 BDT
= 12,880 + 3,120 = 16,000
= **16,000 BDT**

8.5 Conclusion

When weighed against readily available choices, the economic evaluation concludes that our IoT-driven fault identification system is a scalable and affordable option. Given a 16,000 BDT cost, the project offers cutting-edge capabilities like remote operation, fault alarms, and 24/7 monitoring along with 40–45% cost savings. The project's profitability and readiness for commercialization are confirmed by the ROI study, which estimates a 25% return.

This system provides a viable solution for a one-phase induction motor defect identification by considering cost effectiveness, performance, and adaptability. The project's ability to successfully satisfy user needs and support the wider integration of IoT technology in industrial applications is demonstrated by this analysis.

Chapter 9: Ethics and Professional Responsibilities CO13, CO2

9.1 Introduction

In engineering, ethical concerns and professional responsibilities for the purpose of the initiatives to not only meet technical requirements however should also put into practice social norms and complexity of safety. This bankruptcy will target on the concepts as to ethical altercation and expert obligations and most essentially where again inside the occurrence of structuring solutions to mechanical quandaries. Here these elements should be stressed to develop consensus within the engineering fraternity and to ensure that engineers contribute positively to society.

The ethical issues and the professional responsibility are the following:

Ethical Issues in Engineering:

1. Integrity in Reporting (h1): Engineers ought to be truthful and correct in all forms of documentation including reviews, assignments and examination. Such integrity is inimical to maintaining belief by those interested, clients, co-workers, as well as the public. The consequences of providing false or manipulated information or results are very high, protection risks and criminal penalties are expected.

2. Safety and Welfare: It is no more a secret that the main duty and responsibility of engineers is to safeguard its public interest. Engineering designers should ensure that their products do not expose users or the environment to risks. To this end, they need to perform comprehensive danger evaluations and have protection measures incorporated in their designs. For example when designing a relief detection gadget based totally on IoT for unmarried-phase induction automobiles one need to consider faults that can cause accidents or harm gadgets.

3. Compliance with Standards (CO2): Compliance to codes of practice, regulations and standards applied in engineering is basic in engineering. They drive compliance to make certain that engineering solutions are adequate on the legalities and quality requirements for the safekeeping of public interest. For example when cultivating a fault detection system the engineers are supposed to adhere to electrical safety standards so that you do not get injured with electrical faults.

9.2 Professional Responsibilities

1. Respect for Colleagues (h2): It must be accepted and appreciated by engineers that people in the same profession are endeavoring to do something. It creates an environment which encourages people into organizing their work most efficiently, into generating and exchanging ideas, hence leading to modern solutions. It is

particularly imperative where different understanding is being applied in multidisciplinary project tasks.

2. The process of learning is lifelong and the discipline of engineering is changing due to Technological innovations. Engineering is an area where professionals are expected to continuously update with new technological advancement, ethical considerations and emerging standards. Designing one's career in PS that is a professional development sport containing a workshop or certification can assist engineers maintain their competency.

3. Accountability: Engineers must accept accountability for the selections and movements they make. In this capacity it implies owning up whenever a mistake has been made and correcting it while significant, essentially where the decisions affect the wellbeing of the public. For instance, if a layout flaw is identified by submit-implementation engineers must ensure that they own up to the task of correcting the difficulty at the earliest instance.

9.3 Use of Ethical Concerns and Professional Conduct

To successfully apply ethical issues in engineering layout answers, engineers ought to follow these based steps:

1. Assessment of Ethical Implications: In engineering practice, there is a need to pay considerable attention to an engineering judgment preliminary assessment to feel capability ethical issues regarding layout choices. This entails determining how their designs may also influence users, the environment and the society in general.

2. Integration of Compliance Standards: In the design method, engineers have to ensure that their answers are in compliance with standards and regulations in place (CO2). This integration helps minimise risks of non-compliance that leads to prison repercussions or harm to people's property.

3. Implementation of Best Practices:

Documentation: It is important to keep a record of all the approaches that are used, decisions that were made during the development of the challenge, and all the statistics that are gathered at different steps of challenge.

Peer Reviews: Peer reviews that require participation by professional peers in a common project area should be used to dress accountability and also to enhance the quality of work through inclusion of different ideas from his/her peers.

Communication Channels: Define clear verbal communication reporting communication avenues for ethical issues or dilemmas to be reported during the challenge.

4. Sustainability Considerations: The engineers have also to realise that there are such things as environmental repercussions of their constructions. This includes use of environmentally friendly materials, reduction of unwanted materials and designing for disposal in the event that product life is over. For example, when designing an IoT-based machine to monitor induction motors, engineers have to select additives, which are power-green and cause minimal harm to the surroundings throughout manufacturing and finally disposal.

5. Risk Management: Detecting risks imposes capacity dangers resulting from engineering solutions to protect and guard moral principles. Engineering professionals need to develop other approaches of risk management to include contingencies for issues that may emerge during the process of their execution.

Table 10:Expected risk events and Contingency Plan

Expected Risks Events	Contingency plan
Sensor Failure	Implement redundant sensors and regular calibration checks to ensure accuracy.
Communication Failure	Use a backup communication method (e.g., cellular network) and store data locally until connectivity is restored.
Power Outage	Integrate a battery backup system to maintain operations during power outages.
Software Bugs or Glitches	Establish a robust testing protocol and implement regular software updates to fix bugs promptly.
Environmental Factors	Design the system with weatherproof enclosures and select sensors rated for harsh conditions.
Data Security Breaches	Implement strong encryption protocols for data transmission and storage, along with regular security audits.
Regulatory Non-compliance	Conduct thorough reviews of applicable regulations and standards throughout the project lifecycle.
Inadequate User Training	Provide comprehensive training sessions and user manuals to ensure proper usage of the system.
Cost Overruns	Monitor expenditures closely, and establish a contingency budget to cover unexpected costs.
Hardware Compatibility Issues	Conduct compatibility testing during the design phase and select components from reputable suppliers with proven interoperability.

9.4 Conclusion

Therefore, the morality and patricians are the principles that should have to be kept by engineers as they face many layout challenges skillfully. Subsequently, work must be adopted at one of the early-stage format planning steps with moral issues or compliance requirements applied somewhere throughout the mission development stage. This commitment not simplest raises the bar for engineering solutions, but in addition guarantees that the final results are sustainable and beneficial for the concerned parties.

While engineering is to develop with improvements in era including IoT integration in tracking systems it will be more and more important for the experts in this field to follow the ethical guidelines which focus on safety, sustenance, and social issues. In this manner, engineers can ensure that their improvements are useful and technically need to additionally meet different societal agendas.

Chapter 10: Conclusion and Future Work.

10.1 Project Summary/conclusion

This very last year design venture addresses the constraints of traditional motor monitoring systems by leveraging the Internet of Things (IoT) for real-time fault detection and predictive maintenance. Single-phase induction automobiles, extensively used in domestic and business applications, are at risk of faults together with overheating, mechanical put on, and voltage imbalances. Existing techniques for fault detection, which include guide inspections or periodic preservation, are regularly reactive, time-consuming, and insufficient for early fault detection. This assignment proposes a revolutionary option to ensure the reliability and efficiency of motor operations.

The machine aims to continuously display key motor parameters together with temperature, vibration, present day, voltage, and velocity using superior sensors. It procedures the records via IoT-enabled devices and cloud-based total structures, making use of machine-gaining algorithms to locate anomalies and predict potential faults. Users can remotely screen and control the motor thru a cellular application or web dashboard, ensuring timely intervention and decreased downtime. The task goals are to enhance operational efficiency, limit renovation fees, and increase the lifespan of the automobiles.

Two design approaches have been proposed. The first design includes a simpler setup that video display units with fewer parameters (temperature, vibration, and modern-day) and affords fundamental fault signals via an LCD display and SMS notifications. While cost-powerful, this layout lacks scalability and superior fault detection capabilities. The 2d design incorporates additional parameters together with voltage and speed, approaches records the use of cloud-based total algorithms, and integrates a relay mechanism for remote control and motor shutdown throughout vital faults. This method also gives a complete user interface thru a cell app and net dashboard. After evaluating both tactics, the second layout became diagnosed as the choicest solution because of its scalability, advanced capabilities, and superior capability.

The final implementation uses numerous sensors, such as temperature, vibration, modern, voltage, and pace sensors, related to an Arduino Uno microcontroller. An ESP8266 module allows IoT connectivity, permitting actual-time facts transmission to the cloud for processing and evaluation. The system is geared up with a relay mechanism that allows faraway shutdown of the motor whilst critical faults are detected, making sure the motor's protection. Notifications are dispatched to users thru mobile apps, SMS, and internet dashboards, providing intuitive indicators and insights into motor performance.

The system is examined below diverse fault conditions, such as overheating, atypical vibrations, and present day surges. The assessments confirmed the effectiveness of the relay mechanism in shutting down the motor for the duration of essential faults and the accuracy of the fault detection algorithms. Optimization efforts focused on enhancing the machine's efficiency, reliability, and electricity consumption.

This IoT-greater fault detection machine gives sizable advantages, such as real-time tracking, remote accessibility, proactive renovation, and scalability for destiny applications. It aligns with modern industrial desires by means of lowering downtime, enhancing motor reliability, and contributing to fee-effective maintenance techniques. The venture concludes by means of highlighting its ability for expansion to three-phase automobiles, incorporating predictive analytics, and improving cybersecurity measures to guard against statistics breaches. Through its revolutionary method, the undertaking demonstrates a sensible solution to the challenges of motor fault detection and management in both industrial and domestic environments.

10.2 Future work

Key extensions of the mission's future scope of work encompass elevated functionality, scalability, and applicability to real-global use [7][9]. The foremost works might include extending the machine gaining knowledge of version to classify greater complex faults like harmonic distortions, insulation degradations, and rotor misalignments, which might be plausible with accelerated education of the machine the usage of advanced algorithms like deep getting to know on numerous datasets. It would be prolonged in addition by means of migrating cloud-primarily based processing to part computing to assist fault detection and its response in actual-time without delay at the device to decrease latency and ensure corrective actions which are immediate in critical situations [6]. The system may want to in addition be made industrially extra applicable by using the implementation of MQTT and OPC-UA protocols to permit communications seamlessly be made inside IIoT frameworks, thereby scaling and making the device a clever manufacturing unit well matched [7][8].

This will similarly expand the talents for fault detection with the addition of advanced sensors, such as thermal imaging cameras for non-invasive diagnostics and acoustic sensors for noise circumstance analysis. Energy consumption may be optimized at every given time, specially at some point of idle or low-usage intervals of labor, improving the sustainability of this system for far flung or off-grid operations [9]. Predictive preservation functions can be developed by analyzing historic data trends to proactively identify components probably to fail, lowering downtime and protection charges. The consumer interface shall be greater through intuitive designs, multilingual assist, and accessibility capabilities such as voice instructions, making sure the gadget is person-friendly for operators with various technical expertise. The system can be price-effective by means of finding cost-powerful options for sensors, conversation modules, and different hardware, making sure no compromise in overall performance. International requirements like ISO 50001 for power management systems and IEC 61850 for application automation may be followed in order that the system is at par with the high-quality in the worldwide market. Extensive field checking out, from very excessive-temperature business applications to the most far flung agricultural environments, must efficiently validate one of these product's adaptability, electricity, and long-lifestyle reliability for working under changing situations. These functional developments shall rework this into one exceptionally scalable, effective crucial answer aimed toward the detection and prevention of faults within single-section induction vehicles at reasonable useful resource prices, and it bridges old practices and modern-day necessities.

Chapter 11: Identification of Complex Engineering Problems and Activities.

11.1: Identify the attribute of complex engineering problem (EP)

Table 11: Attributes of Complex Engineering Problems (EP)

	Attributes	**Put tick (√) as appropriate**
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	
P3	Depth of analysis required	√
P4	Familiarity of issues	
P5	Extent of applicable codes	√
P6	Extent of stakeholder involvement and needs	
P7	Interdependence	√

11.2: Provide reasoning how the project address selected attribute (EP)

P1. Depth of knowledge required: The problem requires complex engineering domains, including electrical engineering and IoT technologies. A profound understanding of induction motor operation principles, including electrical and mechanical components, is crucial for accurate data interpretation. Additionally, comprehensive knowledge of IoT sensors and data acquisition protocols is required. Software development and programming language is also required. Thus, the project demands a deep and diverse knowledge base of various technical disciplines to address its challenges successfully.

P3. Depth of analysis required: The depth of analysis required for the project is extensive due to the complexity of the engineering problem. Comprehensive analysis is needed at various stages of the project, including data acquisition, model selection, and evaluation. In-depth understanding of induction motor operation principles, sensor technologies, and data science techniques.

P5. Extent of applicable codes: For a project involving IoT-enhanced fault detection for single-phase induction motors, applicable standards and codes include electrical standards like IEEE 112 and IEC 60034 for motor performance, and NEC (NFPA 70) for safe electrical installations. IoT and communication standards such as IEEE 802.11 (Wi-Fi) and IEEE 802.15.4 (Zigbee) ensure reliable connectivity, while protocols like MQTT manage sensor data. Safety is covered by IEC 61508 for functional safety, and UL 508 for industrial control equipment. Environmental standards like IEC 60529 ensure protection against dust and water, while ISO/IEC 27001 and GDPR cover data security and privacy. Additionally, energy efficiency is governed by IEC 60034-30 to ensure compliance with efficiency standards.

P7. Interdependence: Interdependence is a fundamental aspect of the project, as it involves various interconnected components, processes, and stakeholders. The Fault detection system relies on hardware, software, data, and human expertise to function effectively., IoT sensors collect real-time data from induction motors, which are then transmitted to the software for analysis. Furthermore, stakeholder involvement and collaboration are crucial. The project's success depends on understanding and using the connections between different parts of the system to create a well-working fault detection solution. By recognizing how things are related and working together, we can build a system that helps industries detect when machines need maintenance, ultimately making operations smoother and more efficient.

11.3 Identify the attribute of complex engineering activities (EA)

Table 12: Attributes of Complex Engineering Activities (EA)

	Attributes	Put tick (√) as appropriate
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	
A4	Consequences for society and the environment	√
A5	Familiarity	

11.4 Provide reasoning how the project address selected attribute (EA)

A1. Range of resources: The range of resources needed for the project is diverse and encompasses various elements essential for its development and implementation. These resources include IoT sensors, data storage systems, computing hardware, and communication networks to collect, store, and process data from induction motors. Financial resources are also essential for equipment. Furthermore, educational and training resources may be necessary to ensure stakeholders possess the knowledge and skills needed to effectively utilize the fault detection system. By leveraging this broad range of resources effectively, the project can achieve its objectives of improving operational efficiency, reducing downtime, and optimizing maintenance practices in industrial settings.

A2. Level of interaction: The level of interaction in the project is substantial, involving collaboration and communication among various stakeholders, including engineers, software developers, and maintenance personnel. Continuous interaction and feedback loops among these stakeholders are crucial for refining and improving the system over time, ensuring that it meets the evolving needs and expectations of users and effectively addresses maintenance challenges in industrial operations.

A4. Consequences for society and the environment: The project carries significant implications for both society and the environment. Societally, the implementation of such a system can lead to improved efficiency and productivity in industrial operations, benefiting businesses and workers alike. By reducing unexpected downtime and optimizing maintenance schedules, the project helps companies save resources, minimize disruptions, and enhance overall operational reliability. This, in turn, can lead to economic benefits, job stability, and improved quality of life for workers in industrial sectors. Moreover, from an environmental standpoint, the project has the potential to contribute to sustainability efforts by reducing energy consumption, waste generation, and environmental impact associated with inefficient maintenance practices. By enabling proactive maintenance actions and optimizing resource utilization, the project supports more sustainable industrial processes, aligning with global goals for environmental conservation and resource efficiency. Overall, the consequences of the project extend beyond mere technological advancements, offering tangible benefits for society and the environment by fostering innovation, efficiency, and sustainability in industrial operations.

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Appendix

FYDP (C) FALL 2024 Summary of Team Log Book/ Journal

	Final Year Design Project (C) FALL2024		
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
Member 1	Md. Tanvir Al Islam 20221028	tanvir.al.islam@g.bracu.ac.bd	01733223981
Member 2	Azmeri MaishaZaman 20221004	azmeri.maisha.zaman@g.bracu.ac.bd	01875522227
Member 3	Nafuna Margaret_22321073	nafuna.margaret@g.bracu.ac.bd	01322821507
Member 4	Munirun Nessa 20321022	munirun.nessa@g.bracu.ac.bd	01973786093
ATC Details:			
ATC 7			
Chair	Md Golam Sorwar Hossain	sorwar.hossain@bracu.ac.bd	
Member 1	Md. Saif Kabir	saif.kabir@bracu.ac.bd	
Member 2	Mohammad Thushar Imran	thushar.imran@bracu.ac.bd	

General Notes:

1. In addition to detail journal/logbook fill out the summary/key steps and progress of your work
2. Reflect planning assignments, who has what responsibilities.
3. The logbook should contain all activities performed by the team members (Individual and team activities).

Date/Time/Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
15/10/2024 Group meeting-01 Offline meeting (10G-33L)	**Students** 1. Azmeri Maisha Zaman 2. Nafuna Margaret 3. Tanvir Al Islam	Discussed and confirmed the Blynk connection issue for building a control system using Arduino Uno, WiFi module ESP8266, and LEDs. Agreed to gather resources including instructional videos, codes, and connection diagrams.	**Task-01:** Azmeri Nafuna **Task-02,03:** Tanvir **Task-01, 02, 03:** Completed	**Task-01:** Find related videos on youtube or other platforms as reference . **Task02:** Find the related codes for the mentioned processing unit and wifi module and modified as system need **Task03:** Build the system for hardware implementation.
16/10/2024 Group meeting-02 Offline meeting (10G-33L)	1. Munirun Nessa 2. Nafuna Margaret 3. Tanvir Al Islam	Work on refining the control system code. The previously gathered code for Arduino Uno and the ESP8266 WiFi module was modified to better align with the project's requirements. Debugging was performed to identify and resolve connection errors and ensure smooth integration with the Blynk IoT platform. Additionally, the WiFi module was successfully installed and tested for connectivity.	**Task-01,02:** Nafuna Tanvir **Task-01,02:** Completed	**Task-01:** Ensure that all changes to the code are well-documented, and version control is used to track modifications and debugging for future iterations. **Task-02:** Verify the stability and range of the WiFi connection in different environments to ensure robust system performance in real-world applications. **Task-03:** Maintain clear communication among team members regarding task progress and any challenges encountered to promote efficient problem-solving and smooth project development.

03/11/2024 Group Meeting-01 ATC Advisory Body	**Students** 1. Munirun Nessa 2. Azmeri Maisha Zaman 3. Nafuna Margaret 4. Tanvir Al Islam **Faculty** Md Golam Sorwar Hossain, Professor	For FYDP-C, all required components should be purchased, and the mechanism using Arduino Uno should be demonstrated. Additionally, a custom server system should be developed in place of the Blynk server.	**Task-01-02** Everyone **Task-01** Partially Completed **Task-02** Not Completed	**Task-01** All the components should be bought and the mechanism with Arduino Uno should be demonstrated **Task-02** Instead of Blynk server, develop our own server system.
07/11/2024 FYDP Committee 081-01C	**Students** 1.Munirun Nessa 2.Nafuna Margaret 3.Tanvir Al Islam **Faculty** DR. A.S.M. Mohsin, Associate Professor	Introduction to the technical demonstration part for the and the instructional part for the FYDP C for the rest of the semester	**Task-01:-** Everyone **Progress** **Task-01:-** Process Going	**Task-01** All the objectives for the FYDP-P should be demonstrated in FYDP-C smoothly.
11/11/2024 Group Meeting-01 ATC Advisory Body (4E18)	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam **Faculty** Mohammedh Thushar Imran, Lecturer	To progress in FYDP-C, all necessary components should be purchased, and the primary framework established. The FYDP-C report needs continuous updating. A Google form should be created to gather stakeholder opinions, ensuring all queries are clear for their understanding. Additionally, Main Chairperson Golam Sorwar Sir should be regularly updated on all FYDP-C developments.	**Task-01-04** Everyone **Progress** **Task-01** Partially Completed **Task-02** Not Completed **Task-03** Ongoing **Task-04** Completed	**Task-01** All the components should be bought and the primary framework needs to be established **Task-02** FYDP-C report should be updated simultaneously **Task-03** In order to know the opinion of the stakeholders one official google form needed to be made where all the queries should be clear enough to let them understand. **Task-04** Main Chairperson Golam Sorwar sir needs to be updated all the progress of FYDP-C
12/11/2024 Group meeting-01	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman	Confirmed that all sensors and other components were received, but the	**Task-01:** Tanvir Azmeri **Task-02:**	**Task-01** Purchase the motor **Task-02**

(Offline meeting) FYDP Lab	3.Nafuna Margaret 4.Tanvir Al Islam	single-phase induction motor delivery was delayed as it was still on order. Test the sensors individually to ensure they were functioning correctly before integration	Nafuna Munirun **Progress** **Task-01:** Partially complete **Task-02:** Not completed	Replace the temperature sensor
14/11/2024 Group meeting-02 Offline meeting (11F--37L)	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	Synchronization of the sensors with the motor Code writing	**Task-01:** Everyone **Task-02:** Everyone **Progress** **Task-01:** Partially complete **Task-02:** Partially completed	**Task-01** Verify if the relay is responding to the input signals **Task-02** Write and test the code to read real-time data from the sensors
17/11/2024 Group meeting-03 Offline meeting (12B-17L)	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	Overheating the purchased single-phase induction motor, there is a need to buy another motor that is efficient for our project	**Responsible** **Task-01:** Everyone **Progress** **Task-01:**Not completed	**Task-01** Buy a motor that is affecting this project
19/11/2024 Group meeting-04 Offline meeting (12B-17L)	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	Relay actuation system operation	**Responsible** **Task-01:-** Everyone **Progress** **Task-01:-** Completed	**Task-01:-** Observing the relay actuation system and seeing the datas.
20/11/2024 Group Meeting-02 ATC Advisory Body (OAA Room-05)	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	Primary framework was shown and how does the relay operates it was only shown	**Responsible** **Task-01:-** Everyone **Task-02:-** Everyone **Progress** **Task-01:-**	**Task-01** In presentation design approach-02 needs to be discussed **Task-02** Relay operation was done manually, this had to be mentioned

	Faculty 1.Mohammedh Thushar Imran, Lecturer 2.Md Saif Kabir, Lecturer		Completed **Task-02:-** Completed	for the progress presentation
02/12/2024 Group Meeting-03 ATC Advisory Body (OAA Room-05)	**Students** 1. Munirun Nessa (Absent due to family problems) 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam (Absent due to family problems) **Faculty** 1.Mohammedh Thushar Imran, Lecturer 2.Md Saif Kabir, Lecturer	Work in the FYDP lab at least once a week and invite ATC members to supervise during your sessions. Conduct thorough research on the vibration sensor, and ensure all prototype progress is documented in the report while actively working on it. Aim to complete the prototype promptly to apply for a conference and publish your paper. Bring the finalized prototype to the next meeting.	**Responsible** **Task-01-06:-** Everyone **Progress** **Task-01:-** Completed **Task-02:-** Not Completed **Task-03:-** Partially Completed **Task-04:-** Partially Completed **Task-05:-** Partially Completed **Task-06:-** Partially Completed	**Task-01** Work in FYDP lab at least once in a week **Task-02** Invite the ATC members to supervise while you are working. **Task-03** Do more research about the vibration sensor **Task-04** Must put all the progress of the prototype in report. Must work on the report. **Task-05** Complete the prototype as soon as possible so that we can apply for a conference and publish our paper. **Task-06** Bring the complete prototype in the next meeting.
03/12/2024 Group meeting-05 Online meeting	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	Work in the FYDP lab at least once a week and invite ATC members to supervise during your sessions. Conduct thorough research on the vibration sensor, and ensure all prototype progress is documented in the report while actively working on it. Aim to	**Responsible** **Task-01-06:-** Everyone **Progress** **Task-01:-** Completed **Task-02:-** Not Completed **Task-03:-** Partially Completed **Task-04:-**	**Task-01** Work in the FYDP lab at least once a week **Task-02** Invite the ATC members to supervise while you are working. **Task-03** Do more research about the vibration sensor **Task-04** Must put all the progress of the

		complete the prototype promptly to apply for a conference and publish your paper. Bring the finalized prototype to the next meeting.	Partially Completed **Task-05:-** Partially Completed **Task-06:-** Partially Completed	prototype in the report. Must do work on the report. **Task-05** Complete the prototype as soon as possible so that we can apply for a conference and publish our paper. **Task-06** Bring the complete prototype in the next meeting.
05/12/2024 Group meeting-06 Online meeting	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	Divide up the different tasks and begin Writing the report	**Responsible** **Task 01, 11:** Azmeri **Task 02,03,04:** Nafuna **Task 05,08:** Tanvir Nafuna **Task 06:** Tanvir **Task 07, 09,10:** Munirun **Progress** **Task-01:** Partially Completed **Task-02:** Partially Complete **Task-03:**Partially Completed **Task-04:**Partially Complete **Task-05:**Not complete **Task-06:** Not complete **Task-07:** Partially complete **Task-08:** Not completed	**Task-01:** Chapter 1 **Task-02:** Chapter 2 **Task-03:**Chapter 3 **Task-04:**Chapter 4 **Task-05:**Chapter 5 **Task-06:** Chapter 6 **Task-07:** Chapter 7 **Task-08:** Chapter 8 **Task-09:** Chapter 9 **Task-10:** Chapter 10 **Task-11:** Chapter 11

			Task-09: Partially Complete **Task-10:** Not complete **Task-11:** Partially complete	
08/12/2024 Group meeting-07 Online meeting	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	Checking on the progress of the report	**Responsible** **Task 01, 11:** Azmeri **Task 02,03,04:** Nafuna **Task 05,08:** Tanvir Nafuna **Task 06:** Tanvir **Task 07, 09,10:** Munirun **Progress** **Task-01:**Completed **Task-02:**Complete **Task-03:**Completed **Task-04:**Complete **Task-05:**Not complete **Task-06:** Not complete **Task-07:** Partially complete **Task-08:** Not completed **Task-09:**Complete **Task-10:** Not complete **Task-11:** Partially complete	**Task-01:** Chapter 1 **Task-02:** Chapter 2 **Task-03:**Chapter 3 **Task-04:**Chapter 4 **Task-05:**Chapter 5 **Task-06:** Chapter 6 **Task-07:** Chapter 7 **Task-08:** Chapter 8 **Task-09:** Chapter 9 **Task-10:** Chapter 10 **Task-11:** Chapter 11

12/12/2024 Group Meeting-08 (11F-37L)	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	Build and integrate a prototype with sensors and a microcontroller to process and transmit data, ensuring seamless functionality, accuracy, and connectivity.	**Responsible:** **Task-01:-** Tanvir Al Islam **Task-02:-** Nafuna Margaret **Task-03:-** Azmeri Maisha Zaman **Task-04:-** Munirun Nessa **Progress:-** **Task-01:-** Partially Completed **Task-02:-** Partially Completed **Task-03:-** Partially Completed **Task-04:-** Partially Completed	**Task-01:-** Integrate all components, ensuring they work seamlessly together. Test for signal accuracy, connectivity stability, and overall system performance **Task-02:-** Set up the microcontroller to read sensor data, process it, and prepare it for transmission to the cloud or local devices. **Task-03:-** Build a working prototype on a breadboard or custom enclosure to demonstrate the system's functionality. **Task-04:-** Set up a live demonstration of the hardware, showing the sensors in action, data transmission, and monitoring.
15/12/2024 Group Meeting-09 (11F-37L)	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	The progress of the prototype	**Responsible:** **Task-01:-** Tanvir Al Islam **Task-02:-** Nafuna Margaret **Task-03:-** Azmeri Maisha Zaman **Task-04:-** Munirun Nessa **Progress:-** **Task-01:**Completed **Task-02:**Completed **Task-03:**Completed **Task-04:**Completed	**Task-01:-** Integrate all components, ensuring they work seamlessly together. Test for signal accuracy, connectivity stability, and overall system performance **Task-02:-** Set up the microcontroller to read sensor data, process it, and prepare it for transmission to the cloud or local devices. **Task-03:-** Build a working prototype on a breadboard or custom enclosure to demonstrate the system's functionality. **Task-04:-** Set up a live demonstration of the

				hardware, showing the sensors in action, data transmission, and monitoring.
17/12/2024 Group Meeting-04 ATC Advisory Body (11F-37L)	**Students** **1.**Nafuna Margaret 2. Munirun Nessa (Absent due to one makeup class) 3. Azmeri Maisha Zaman (Absent due to one makeup class) 4. Tanvir Al Islam **Faculty** 1.Mohammed Thushar Imran, Lecturer 2.Md Saif Kabir, Lecturer	Demonstrating progress for the prototype in front of the ATC Advisory body	**Responsible** **Task-01-02:-** Nafuna Margaret **Task-03-04:-** Tanvir Al Islam **Task-05-06:-** Azmeri Maisha Zaman **Task-07-09:-** Munirun Nessa **Progress:-** **Task-01-02:**Not complete **Task-03-04:**Not complete **Task-05-06:**Not complete **Task-07-09:**Not complete	**Task-01:-** RPM value is not matching with Adafruit web update, needed to fix **Task-02:-** The values for the vibration sensor needs to be checked and the vibration sensor is sensing the correct motor vibrations , it needs to be ensured. **Task-03:-** Fault demonstration should be included using high-quality components, current injector for varying Current and different subsystems **Task-04:-** For speed sensors, different loads should be included and the maximum RPM should be reached based on the maximum RPM on the code and the number of loads, the present loads should be present in circular wood **Task-05:-** The temperature heats up the thermometer using a lighter. **Task-06:-** Segment into different subsystems so that if any fault or any subsystem is damaged the rest of the system is not damaged. **Task-07:-** It should not be a DC booster, because it means

				upscaling parameter. **Task-08:-** Specifications of the motor needed to be visible to the people are being presented. **Task-09:-** Work on the RPM vibration sensor to align with adafruit data.
19/12/2024 Group Meeting-10 (11F-37L)	**Students** **1.**Nafuna Margaret 2. Munirun Nessa 3. Azmeri Maisha Zaman 4. Tanvir Al Islam	Demonstrating progress for the prototype to find solutions in accordance to the ATC suggestions and the errors encountered during the supervision	**Task-01-02:-** Nafuna Margaret **Task-03-04:-** Tanvir Al Islam **Task-05-06:-** Azmeri Maisha Zaman **Task-07-09:-** Munirun Nessa **Progress:-** **Task-01-02:** Completed **Task-03-04:-** Partially complete **Task-05-06:-** Completed **Task-07-09:-** Partially complete	**Task-01:-** RPM value is not matching with Adafruit web update, needed to fix **Task-02:-** The values for the vibration sensor need to be checked If the vibration sensor is sensing the correct motor vibrations, it needs to be ensured. **Task-03:-** Fault demonstration should be included using high quality components, current injector for varying Current and different subsystems **Task-04:-** For speed sensors different loads should be included and the maximum RPM should be reached and based on that the maximum RPM on the code based and number of loads, the present loads should be present in circular wood **Task-05:-** The temperature heats up the thermometer using a lighter. **Task-06:-** Segment into different subsystems so that if any fault or any subsystem is damaged

				the rest of the system is not damaged. **Task-07:-** It should not be a DC booster, because it means upscaling parameter. **Task-08:-** Specifications of the motor needed to be visible to the people are being presented. **Task-09:-** Work on the RPM vibration sensor to align with adafruit data.
22/12/2024 Group Meeting-11 (11F-37L)	**Students** **1.**Nafuna Margaret 2. Munirun Nessa 3. Azmeri Maisha Zaman 4. Tanvir Al Islam	Finding ways of varying the different parameters so as to demonstrate the faults	**Responsible:** **Task-01:-** Nafuna Margaret **Task-02:-**Azmeri Maisha Zaman Munirun Nessa **Task-03:-**Tanvir Al Islam **Progress:-** **Task-01:**Partially Complete **Task-02:**Not Complete **Task-03:** Partially Complete	**Task-01:**-Find out the proper Synchronization of the vibration sensor with the motor **Task-02:-** Research more about the current injector **Task-03:-** Find the proper method of varying the motor voltage.
28/12/2024 Group Meeting-12 (11F-37L)	**Students** **1.**Nafuna Margaret 2. Munirun Nessa 3. Azmeri Maisha Zaman 4. Tanvir Al Islam	Temperature fault identification. Speed fault detection	**Responsible** **Task-01:-** Everyone **Progress** **Task-01:-** Not complete	**Task-01:-** Find the current fault detection
29/12/2024 Group Meeting-13 (Online)	**Students** **1.**Nafuna Margaret 2. Munirun Nessa 3. Azmeri Maisha Zaman 4. Tanvir Al Islam	Discussion about the poster	**Responsible** **Task-01:-** Everyone **Progress** **Task-01:-** Not complete	**Task-01:-** Start designing the poster

31/12/2024 Group Meeting-05 ATC Advisory Body (12H-40L)	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman (Absent due to sickness) 3.Nafuna Margaret 4.Tanvir Al Islam **Faculty** 1. Mohammedh Thushar Imran, Lecturer 2.Md Saif Kabir, Lecturer	RPM value fixing, vibration sensor replacement, and designing of an alarm system.	**Responsible** **Task-01-03:-** Everyone **Progress:-** **Task-01:-** Not Completed **Task-02:-** Not Completed **Task-03:-** Not Completed	**Task-01:-** Fixing the RPM value within daylight, and without daylight **Task-02:-** Replacing vibration sensor for vibration sensor **Task-03:-** Make an alarm system actuation system to verify it more properly.
01/01/2025 Group Meeting-14 Online Meeting	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	Discussion and distribution of the poster tasks	**Responsible** **Task-01:-** Azmeri Maisha Zaman **Task-02:-** Nafuna Margaret **Task-03:-** Tanvir Al Islam **Task-04:-** Munirun Nessa **Progress** **Task-01:-** Not Completed **Task-02:-** Not Completed **Task-03:-** Not Completed **Task-04:-** Not Completed	**Task-01:-** Abstract and Introduction **Task-02:-** Design Approach, Result, and Discussion **Task-03:-** Environment and Sustainability Acknowledgement **Task-04:-** Conclusion and Future Work
03/01/2025 Group Meeting-15 Online Meeting	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	RPM value fixing, vibration sensor replacement, and designing of an alarm system.	**Responsible** **Task-01-03:-** Everyone **Progress:-** **Task-01:-** Partially Completed **Task-02:-** Partially Completed **Task-03:-**	**Task-01:-** Fixing the RPM value within daylight, and without daylight **Task-02:-** Replacing vibration sensor for vibration sensor **Task-03:-** Make an alarm system actuation system to

			Partially Completed	verify it more properly.
04/01/2025 Group Meeting-16 (11F-37L)	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	Poster tasks progress	**Responsible** **Task-01:-** Azmeri Maisha Zaman **Task-02:-** Nafuna Margaret **Task-03:-** Tanvir Al Islam **Task-04:-** Munirun Nessa **Progress** **Task-01:-** Completed **Task-02:-** Completed **Task-03:-** Completed **Task-04:-** Completed	**Task-01:-** Abstract and Introduction **Task-02:-** Design Approach, Result, and Discussion **Task-03:-** Environment and Sustainability Acknowledgement **Task-04:-** Conclusion and Future Work
06/01/2025 Group Meeting-16 (11F-37L)	**Students** 1.Munirun Nessa 2. Azmeri Maisha Zaman 3.Nafuna Margaret 4.Tanvir Al Islam	RPM value fixing, vibration sensor replacement.	**Responsible** **Task-01-02:-** Everyone **Progress:-** **Task-01:-** Completed **Task-02:** Completed	**Task-01:-** Fixing the RPM value within daylight, and without daylight **Task-02:-** Replacing vibration sensor for vibration sensor

Related code/theory

<u>Main code for the IOT based fault detection system</u>

```
#include <ESP8266WiFi.h>
#include <Adafruit_MQTT.h>
#include <Adafruit_MQTT_Client.h>
#include <OneWire.h>
#include <DallasTemperature.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// WiFi parameters
#define WLAN_SSID       "abcde"
#define WLAN_PASS       "123456789"

// Adafruit IO
#define AIO_SERVER      "io.adafruit.com"
#define AIO_SERVERPORT  1883
#define AIO_USERNAME    "likhonnnn"
#define AIO_KEY         "aio_yqjG90CUtJDP6XQrEAEa3r9L2YVV"

// MQTT setup
WiFiClient client;
Adafruit_MQTT_Client mqtt(&client, AIO_SERVER, AIO_SERVERPORT,
AIO_USERNAME, AIO_KEY);

//Adafruit_MQTT_Subscribe buttonFeed = Adafruit_MQTT_Subscribe(&mqtt,
AIO_USERNAME "/feeds/button-feed");
Adafruit_MQTT_Publish ampFeed = Adafruit_MQTT_Publish(&mqtt,
AIO_USERNAME "/feeds/amp-feed");
```

```
Adafruit_MQTT_Publish tempFeed = Adafruit_MQTT_Publish(&mqtt,
AIO_USERNAME "/feeds/temperature-feed");

//Adafruit_MQTT_Publish motorStatusFeed = Adafruit_MQTT_Publish(&mqtt,
AIO_USERNAME "/feeds/motor-status-feed");

Adafruit_MQTT_Publish serialFeed = Adafruit_MQTT_Publish(&mqtt,
AIO_USERNAME "/feeds/serial-data");


// LCD setup

LiquidCrystal_I2C lcd(0x27, 16, 2); // Adjust I2C address as needed


// Pin configurations

const int relayPin1 = D5;

const int sensorIn = A0;

const int vibrationPin = D6;

const int ir_sensor = D2;

#define ONE_WIRE_BUS D7


// Variables for measurement

volatile unsigned long pulseCount = 0;

unsigned long previousMillis = 0;

const unsigned long interval = 1000;

int pulsesPerRevolution = 1;

bool lastIRState = HIGH;


int mVperAmp = 66;

double Voltage = 0;

double VRMS = 0;

double AmpsRMS = 0;


// OneWire and DallasTemperature
```

```
OneWire oneWire(ONE_WIRE_BUS);

DallasTemperature sensors(&oneWire);


// Last sent values

float lastTemperature = -999.0;

double lastAmpsRMS = -999.0;

int lastVibrationValue = -1;

String lastSerialData = "";

int vibrationValue = 0;

String receivedData = "";


unsigned long lastUpdateTime = 0; // To track the last update time

const unsigned long updateInterval = 500; // Interval in milliseconds
(10 seconds)


void connectWiFi() {

  Serial.println("Connecting to WiFi...");

  WiFi.begin(WLAN_SSID, WLAN_PASS);

  while (WiFi.status() != WL_CONNECTED) {

    delay(500);

    Serial.print(".");

  }

  Serial.println();

  Serial.println("WiFi connected");

  Serial.println("IP address: " + WiFi.localIP().toString());

}


void setup() {

  Serial.begin(230400);
```

```
  pinMode(relayPin1, OUTPUT);
  pinMode(sensorIn, INPUT);
  pinMode(vibrationPin, INPUT);

  digitalWrite(relayPin1, LOW);
  sensors.begin();
  connectWiFi();
//  mqtt.subscribe(&buttonFeed);

  // Initialize the LCD
  lcd.init();
  lcd.backlight();
  lcd.print("System Starting");
  delay(200);
  lcd.clear();
}

void loop() {
  if (!mqtt.connected()) {
    connectToAdafruitIO();
  }
  mqtt.processPackets(1000);

//  Adafruit_MQTT_Subscribe *subscription;
//  while ((subscription = mqtt.readSubscription(2000))) {
//    if (subscription == &buttonFeed) {
//      processButtonState(buttonFeed.lastread);
//    }
//  }
```

```
  // Read and send temperature data
  readAndPublishTemperature();

  // Measure and send current if changed
  measureCurrent();

  // Read vibration sensor and detect motor status if changed
//  detectMotorStatus();

  // Process and send serial data if changed
  processSerialData();
  delay(5000);
}

void connectToAdafruitIO() {
  Serial.println("Connecting to Adafruit IO...");
  int8_t ret;
  while ((ret = mqtt.connect()) != 0) {
    if (ret == -1) {
      Serial.println("Connection failed. Check your settings.");
    } else {
      Serial.print("Connection failed. Retrying in 5 seconds...");
      delay(10000);
    }
  }
  Serial.println("Adafruit IO Connected!");
}
```

```
//void processButtonState(uint8_t *state) {
//  // Allow manual control only if the motor is not locked due to high temperature
//  if (!motorLockedDueToHighTemp) {
//    if (*state == '1') {
//      digitalWrite(relayPin1, HIGH);
//      Serial.println("Relay 1 turned ON");
//      motorStatusFeed.publish("ON"); // Publish motor status
//    } else if (*state == '0') {
//      digitalWrite(relayPin1, LOW);
//      Serial.println("Relay 1 turned OFF");
//      motorStatusFeed.publish("OFF"); // Publish motor status
//    }
//  } else {
//    Serial.println("Motor is locked due to high temperature. Cannot turn ON.");
//  }
//}

void measureCurrent() {
  float result;
  int readValue, maxValue = 0, minValue = 1024;
  uint32_t start_time = millis();
  while ((millis() - start_time) < 1000) {
    readValue = analogRead(sensorIn);
    maxValue = max(maxValue, readValue);
    minValue = min(minValue, readValue);
  }

  result = ((maxValue - minValue) * 5.0) / 1024.0;
```

```
  Voltage = result;

  VRMS = (Voltage / 2.0) * 0.707;

  AmpsRMS = ((VRMS * 1000) / mVperAmp) / 28;


  Serial.print(AmpsRMS, 6);

  Serial.println(" Amps RMS");


//  if (AmpsRMS != lastAmpsRMS) {

    if (ampFeed.publish(String(AmpsRMS, 6).c_str())) {

      Serial.println("Current value sent to Adafruit IO.");

      lastAmpsRMS = AmpsRMS;

  delay(1000);


      // Display current on the LCD

      lcd.setCursor(0, 1);

      lcd.print("Amps:");

      lcd.print(AmpsRMS, 6);

//    }

  }

}


void readAndPublishTemperature() {

  sensors.requestTemperatures();

  float temperature = sensors.getTempCByIndex(0);


//  if (temperature != DEVICE_DISCONNECTED_C) {

    // Check if temperature exceeds 30°C

    if (temperature > 30.0 ) {

      digitalWrite(relayPin1, HIGH); // Turn off the motor
```

```
//      motorLockedDueToHighTemp = true; // Lock the motor

//      Serial.println("Motor turned OFF due to high temperature.");

//      motorStatusFeed.publish("OFF"); // Publish motor status

    } else if (temperature <= 30.0 ) {

      // Unlock motor if temperature drops below threshold

      digitalWrite(relayPin1, LOW); // Turn off the motor


//      motorLockedDueToHighTemp = false;

      Serial.println("Temperature cooled. Motor can be turned ON
manually.");

    }


    // Publish temperature to Adafruit IO if it has changed

    if (temperature != lastTemperature) {

      char tempBuffer[20];

      snprintf(tempBuffer, sizeof(tempBuffer), "%.2f", temperature);

      if (tempFeed.publish(tempBuffer)) {

        Serial.println("Temperature sent to Adafruit IO: " +
String(tempBuffer) + "°C");

//        lastTemperature = temperature;


        // Display temperature on the LCD

        lcd.setCursor(0, 0);

        lcd.print("Temp:");

        lcd.print(tempBuffer);

        lcd.print("C");

//      }

    }

  } else {
```

```
    Serial.println("Failed to read temperature.");
  }
  delay(1000);
}

//void detectMotorStatus() {
//  vibrationValue = analogRead(vibrationPin);
//  if (vibrationValue != lastVibrationValue) {
//    if (motorStatusFeed.publish(String(vibrationValue).c_str())) {
//      Serial.println("Vibration Value sent to Adafruit IO: " +
String(vibrationValue));
//      lastVibrationValue = vibrationValue;
//  delay(1000);
//
//      // Display motor status on the LCD
//      lcd.setCursor(13, 0);
//      lcd.print("Vib");
//      lcd.setCursor(15, 1);
//      lcd.print(vibrationValue);
//    }
//  }
//}

void processSerialData() {
  static String receivedData = ""; // Ensure receivedData retains its
value between calls

  while (Serial.available()) {
    char c = Serial.read();
    if (c == '\n') {
```

```
      unsigned long currentMillis = millis(); // Current time in milliseconds
      if (currentMillis - lastUpdateTime >= updateInterval) {
        // Enough time has passed, process the data
        if (serialFeed.publish(receivedData.c_str())) {
          Serial.println("Serial Data sent: " + receivedData);
        } else {
          Serial.println("Failed to send Serial Data.");
        }
        lastUpdateTime = currentMillis; // Update the last sent time
      } else {
        Serial.println("Waiting for 10 seconds interval.");
      }
      receivedData = ""; // Clear received data
    } else {
      receivedData += c; // Append character to received data
    }
  }
}
```

UNO Code

```
#include <LiquidCrystal_I2C.h>
#include <Wire.h>
LiquidCrystal_I2C lcd(0x27, 16, 2); // Adjust I2C address as needed

float value = 0;
float rev = 0;
int rpm;
```

```
int oldtime = 0;
int time;
int sec;

int vibration = A0;
int vib;

void isr() //interrupt service routine
{
  rev++;
}

void setup()
{
  Serial.begin(230400);
  attachInterrupt(0, isr, RISING);  // Attaching the interrupt
  pinMode(vibration, INPUT);
  lcd.init();
  lcd.backlight();
}

void loop()
{
  delay(1000);
  detachInterrupt(0);           // Detaches the interrupt
  time = millis() - oldtime;    // Finds the time
  rpm = (rev / time) * 42000;   // Calculates rpm
  oldtime = millis();           // Saves the current time
  rev = 0;
```

```
  vib = analogRead(vibration);  // Read vibration sensor value

  // Update LCD
  lcd.setCursor(0, 0);
  lcd.print("RPM: ");
  lcd.print(rpm);
  lcd.print("    "); // Clears any extra characters

  lcd.setCursor(0, 1);
  lcd.print("vib: ");
  lcd.print(vib);
  lcd.print("    "); // Clears any extra characters

  // Update Serial Monitor
  Serial.print(" RPM: ");
  Serial.print(rpm);
  Serial.print(", vib: ");
  Serial.println(vib);

  attachInterrupt(0, isr, RISING);
}
```

Voltage code

```
#include <ESP8266WiFi.h>
#include <Adafruit_MQTT.h>
#include <Adafruit_MQTT_Client.h>
#include <Wire.h>
```

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2); // Adjust I2C address as needed

// Wi-Fi credentials
#define WIFI_SSID "abcde"
#define WIFI_PASSWORD "123456789"

// Adafruit IO credentials
#define AIO_SERVER "io.adafruit.com"
#define AIO_SERVERPORT 1883 // MQTT port
#define AIO_USERNAME "likhonnnn"
#define AIO_KEY "aio_yqjG90CUtJDP6XQrEAEa3r9L2YVV"

int relay = D5;

// WiFi and MQTT clients
WiFiClient client;
Adafruit_MQTT_Client mqtt(&client, AIO_SERVER, AIO_SERVERPORT,
AIO_USERNAME, AIO_KEY);

// Adafruit IO Feeds
Adafruit_MQTT_Publish voltageFeed = Adafruit_MQTT_Publish(&mqtt,
AIO_USERNAME "/feeds/voltage");

// Voltage divider settings
const int analogPin = A0; // Pin connected to the voltage divider


void setup() {
  Serial.begin(115200);
```

```
  delay(10);
  // Connect to Wi-Fi
  Serial.println("Connecting to Wi-Fi...");
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("\nWi-Fi connected!");
  Serial.print("IP Address: ");
  Serial.println(WiFi.localIP());

  // Connect to Adafruit IO
  connectToMQTT();
  pinMode(relay,OUTPUT);

   lcd.init();
  lcd.backlight();
  lcd.print("System Starting");
  delay(2000);
  lcd.clear();
}

void loop() {
  // Ensure connection to MQTT
  if (!mqtt.connected()) {
    connectToMQTT();
  }
  mqtt.processPackets(5000);
```

```
  mqtt.ping();

  // Read the analog value
  float analogValue = analogRead(analogPin);

  // Map the analog value to 0-230V
  float scaledVoltage = analogValue  / 4.10; // Convert ADC reading to
0-230 range

  // Print voltage to Serial Monitor
   Serial.print("analogValue: ");
  Serial.print(analogValue);
  Serial.print(", Mapped Voltage: ");
  Serial.println(scaledVoltage);
       lcd.setCursor(0, 0);
        lcd.print("voltage:");
        lcd.print(scaledVoltage);
        lcd.print("v");
  // Publish the voltage to Adafruit IO
  if (!voltageFeed.publish(scaledVoltage)) {
    Serial.println("Failed to publish voltage");
  } else {
    Serial.println("Voltage published successfully!");
  }
if(scaledVoltage>230){
  digitalWrite(relay,HIGH);

    }
 if(scaledVoltage<180){
```

```
  digitalWrite(relay,HIGH);

    }

 if(scaledVoltage>180 && scaledVoltage < 230){
  digitalWrite(relay,LOW);

    }

  // Delay between readings
  delay(8000);
}


void connectToMQTT() {
  Serial.println("Connecting to Adafruit IO...");
  while (mqtt.connect() != 0) {
    Serial.print("MQTT Error: ");
    Serial.println(mqtt.connectErrorString(mqtt.connect()));
    Serial.println("Retrying in 5 seconds...");
    delay(5000);
  }
  Serial.println("Connected to Adafruit IO!");
}
```

Assessment Guideline for Faculty

[The following assessment guideline is for faculty ONLY. **This portion is not applicable for students**.]

Assessment Tools and CO Assessment Guideline

	Distribution of assessment points among various COs assessed in different semesters														
PO	l	c	f	g	c	b	d	c	e	l	k	k	h	i	j
CO	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	CO 7	CO 8	CO 9	CO 10	CO 11	CO 12	CO 13	CO 14	CO 15
EEE 400C/ ECE 402C (Out of 100)							30	24	6	4	4	6	7	7	12
Project Final Report/ Project Progress Report							x	x	x	x	x	x	x		x
Demonstration of working prototype							x								x
Progress Presentation/ Final Presentation								x			x				
Peer-evaluation*													x	x	
Instructor's Assessment*													x	x	
Demonstration at FYDP Showcase								x							x

Note: The star (*) marked deliverables/skills will be evaluated at various stages of the project.