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Intelligent Motor Health Monitoring and Predictive Maintenance using IoT & Machine Learning

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Abstract: *In modern industrial environments, the continuous operation of electric motors is essential for maintaining productivity and efficiency. Unexpected motor failures can lead to significant downtime, increased maintenance costs, and reduced system reliability. To address this issue, an Intelligent Motor Health Monitoring and Predictive Maintenance System using IoT and Machine Learning is proposed. The system utilizes an ESP32 microcontroller as the central processing unit to collect and analyze real-time data from multiple sensors. An ADXL345 accelerometer is used to monitor vibration levels, a DS18B20 temperature sensor measures motor temperature, and voltage and current sensors track electrical parameters of the motor. These sensors continuously gather operational data, which is processed by the ESP32 and displayed on an LCD for local monitoring.*
The collected data is also transmitted to a laptop or cloud platform through IoT communication, enabling remote monitoring and data analysis. Machine learning techniques can be applied to analyze the historical and real-time data to identify abnormal patterns and predict potential motor failures before they occur. A relay module is integrated into the system to automatically disconnect the motor during abnormal conditions, thereby protecting the equipment from severe damage. The proposed system enhances reliability, reduces unplanned downtime, and supports predictive maintenance strategies in industrial motor applications..

Keywords*:* IoT, Predictive Maintenance, Motor Health Monitoring, Machine Learning, ESP32, Vibration Analysis, Temperature Monitoring, Industrial Automation

I. INTRODUCTION

Electric motors play a vital role in modern industrial systems, as they are widely used in manufacturing plants, transportation systems, and automated machinery. Among different types of motors, induction motors are the most commonly used due to their high efficiency, simple construction, and low maintenance requirements. Despite their advantages, motors are still vulnerable to various types of faults such as overheating, excessive vibration, electrical overload, and mechanical wear. These faults can lead to sudden equipment failure, which may result in production loss, increased maintenance costs, and safety risks in industrial environments. Therefore, continuous monitoring of motor health has become an important requirement for ensuring reliability and operational efficiency in industrial systems [1].
Traditional maintenance methods are generally based on scheduled or reactive maintenance strategies. In scheduled maintenance, equipment is inspected or serviced at regular intervals regardless of its actual condition, which may lead to unnecessary maintenance activities. On the other hand, reactive maintenance occurs only after a fault or failure has occurred, which can result in unexpected downtime and costly repairs. These limitations have encouraged industries to adopt predictive maintenance approaches, where the condition of equipment is continuously monitored and

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maintenance actions are performed only when necessary. Predictive maintenance helps detect early signs of faults and prevents catastrophic failures in critical systems [2].

In recent years, the integration of Internet of Things (IoT) technology has significantly improved the efficiency of condition monitoring systems. IoT enables devices, sensors, and machines to communicate with each other and share real-time data through the internet. By integrating sensors with microcontrollers and cloud platforms, industries can remotely monitor machine conditions and analyze operational data continuously. This connectivity allows engineers and maintenance teams to observe equipment performance in real time and take corrective actions before failures occur, thereby improving system reliability and reducing maintenance costs [3].

Another key technology supporting predictive maintenance is machine learning (ML). Machine learning algorithms can analyze large volumes of sensor data and identify hidden patterns that may indicate potential faults or abnormal operating conditions. By using historical and real-time data, ML models can predict future failures and provide early warnings to maintenance teams. This intelligent analysis helps industries shift from traditional maintenance practices to data-driven maintenance strategies that enhance operational efficiency and equipment lifespan [4].

Various physical parameters are used to monitor the health condition of motors, including vibration, temperature, current, and voltage. Vibration analysis is widely used for detecting mechanical faults such as imbalance, bearing defects, and misalignment. Temperature monitoring is important because excessive heat can damage motor insulation and reduce the lifespan of electrical components. Similarly, abnormal voltage and current levels can indicate electrical issues such as overload conditions or short circuits. Monitoring these parameters simultaneously provides a comprehensive understanding of the motor's operating condition [5].

Recent advancements in microcontroller technology have made it possible to implement compact and low-cost monitoring systems. Microcontrollers such as the ESP32 offer integrated Wi-Fi and Bluetooth communication, making them ideal for IoT-based monitoring applications. These devices can collect data from multiple sensors, process the information locally, and transmit it to remote monitoring platforms. The ESP32 also supports real-time data processing, which enables quick detection of abnormal conditions and faster response to potential faults [6].

In addition to monitoring, automated control mechanisms can also be integrated into smart maintenance systems. For example, relay modules can be used to automatically shut down equipment when abnormal conditions are detected. This automatic protection mechanism helps prevent severe damage to machinery and improves the safety of industrial systems. Furthermore, the collected sensor data can be stored and analyzed over time to improve fault prediction accuracy and support machine learning models used for predictive maintenance [7].

Several research studies have explored the use of IoT and machine learning for monitoring industrial equipment. Researchers have proposed systems that use vibration sensors, temperature sensors, and electrical monitoring techniques to identify motor faults and predict failures. These systems demonstrate that real-time monitoring combined with intelligent data analysis can significantly improve the efficiency of maintenance processes and reduce operational downtime. However, there is still a need for cost-effective and easy-to-implement monitoring solutions that can be adopted by small and medium-scale industries [8].

Considering these challenges, this study proposes an Intelligent Motor Health Monitoring and Predictive Maintenance System using IoT and Machine Learning. The system uses an ESP32 microcontroller to collect real-time data from multiple sensors such as an ADXL345 vibration sensor, DS18B20 temperature sensor, and voltage and current sensors. The collected data is analyzed and displayed locally while also being transmitted to a monitoring platform for further analysis. By combining sensor-based monitoring, IoT connectivity, and intelligent data analysis, the proposed system aims to improve fault detection, enhance predictive maintenance capabilities, and increase the overall reliability of industrial motor systems [9].

II. PROBLEM STATEMENT

Electric motors are widely used in industrial environments for operating machinery, pumps, conveyors, and various automated systems. The continuous operation of these motors is critical for maintaining production efficiency and

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minimizing operational downtime. However, many industries still rely on traditional maintenance methods such as periodic inspections or reactive maintenance, where faults are addressed only after a failure occurs. These approaches often fail to detect early signs of motor degradation such as abnormal vibration, overheating, or irregular current consumption. As a result, unexpected motor failures can occur, leading to production interruptions, increased repair costs, equipment damage, and safety risks for workers. Furthermore, the lack of real-time monitoring and intelligent analysis makes it difficult to accurately predict motor health and schedule maintenance at the appropriate time. Therefore, there is a need for an intelligent and cost-effective system that can continuously monitor key motor parameters such as vibration, temperature, voltage, and current, analyze the collected data, and predict potential faults in advance. Implementing an IoT-based monitoring system combined with machine learning techniques can help detect abnormal patterns in motor operation, provide early fault warnings, and support predictive maintenance strategies to improve reliability, reduce downtime, and enhance the overall efficiency of industrial motor systems.

OBJECTIVE

1. To develop an IoT and AI-based system for real-time monitoring and predictive maintenance of induction motors.
2. To continuously measure key motor parameters such as temperature, current, voltage, and vibration using appropriate sensors.
3. To detect abnormal operating conditions and automatically cut off motor power using a relay for protection.
4. To transmit sensor data from the ESP32 microcontroller to the Laptop through the MQTT protocol for centralized monitoring.
5. To store all collected sensor data in CSV format for historical analysis and machine learning training.

III. LITERATURE SURVEY

1. Paper Name: IoT-Based Smart Monitoring System for Industrial Motors
Year: 2019
Author: A. Kumar, S. Singh, and R. Patel
Publication: IEEE
Journal Name: IEEE Internet of Things Journal

This study presents an IoT-based system designed to monitor the operational parameters of industrial motors in real time. The system integrates sensors to measure temperature, vibration, and electrical parameters such as voltage and current. A microcontroller collects sensor data and transmits it to a cloud platform where it can be accessed remotely through a monitoring dashboard. The proposed system aims to improve the reliability of industrial equipment by allowing maintenance teams to track motor performance continuously and identify abnormal conditions at an early stage.

The research demonstrates that real-time data monitoring significantly reduces the risk of unexpected motor failures. By analyzing the collected data patterns, the system can detect anomalies related to overheating or excessive vibration, which are common indicators of motor faults. The implementation of IoT technology enables remote monitoring and provides timely alerts, helping industries minimize downtime and improve maintenance efficiency.

2. Paper Name: Machine Learning-Based Predictive Maintenance for Industrial Equipment
Year: 2020
Author: J. Lee, H. Davari, J. Singh, and V. Pandhare
Publication: Elsevier
Journal Name: Mechanical Systems and Signal Processing

This paper focuses on the application of machine learning techniques for predictive maintenance in industrial equipment. The authors explore the use of sensor data such as vibration, temperature, and operational load to develop predictive models capable of identifying early signs of equipment degradation. The study uses machine learning

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algorithms including support vector machines and decision trees to analyze historical operational data.
The results show that machine learning models can effectively predict potential failures before they occur. By identifying abnormal trends in sensor data, the system can provide early warnings that allow maintenance teams to perform preventive actions. The research highlights the importance of integrating intelligent data analysis with sensor-based monitoring systems to improve equipment reliability and reduce maintenance costs.

3. Paper Name: Real-Time Motor Condition Monitoring Using IoT Sensors
Year: 2018
Author:M. Patel, K. Shah, and D. Mehta
Publication: Springer
Journal Name: Journal of Industrial Information Integration
This research proposes a real-time motor condition monitoring system using IoT technology and sensor networks. The system incorporates sensors to measure motor vibration, temperature, and electrical parameters, which are transmitted to a cloud-based monitoring platform. The primary objective of the system is to provide continuous monitoring and early fault detection for industrial motors.
The authors emphasize that continuous monitoring of operational parameters can significantly improve fault detection accuracy. By analyzing sensor data trends, maintenance personnel can identify mechanical issues such as bearing wear or rotor imbalance before they lead to complete motor failure. The system demonstrates the effectiveness of IoT-based monitoring in improving operational efficiency and reducing maintenance delays.

4. Paper Name: Smart Predictive Maintenance of Electric Motors Using Artificial Intelligence
Year: 2021
Author: L. Zhang, Y. Wang, and T. Li
Publication: IEEE
Journal Name: IEEE Access
This paper discusses the use of artificial intelligence techniques for predictive maintenance of electric motors. The proposed system collects sensor data related to vibration, temperature, and electrical characteristics and applies artificial intelligence algorithms to analyze the collected data. The objective of the system is to detect early fault symptoms and provide predictive insights for maintenance planning.
The study highlights that AI-based analysis can significantly improve the accuracy of fault detection compared to traditional monitoring systems. By training machine learning models with historical motor data, the system can identify abnormal patterns that indicate potential mechanical or electrical faults. The results demonstrate that AI-driven predictive maintenance helps improve equipment reliability and reduce unexpected operational failures.

5. Paper Name: Vibration-Based Fault Diagnosis of Induction Motors
Year: 2017
Author: P. Vas and R. Perera
Publication: IEEE
Journal Name: IEEE Transactions on Industry Applications
This paper focuses on vibration analysis techniques for diagnosing faults in induction motors. The authors analyze vibration signals generated by motors under different operating conditions to detect faults such as rotor imbalance, bearing defects, and shaft misalignment. Advanced signal processing techniques are used to extract meaningful features from vibration data.
The study demonstrates that vibration analysis is an effective method for detecting mechanical faults in motors. By monitoring vibration patterns continuously, the system can identify abnormal operating conditions and provide early

warnings before severe damage occurs. The research emphasizes the importance of vibration monitoring as a key parameter in motor health monitoring systems.

6. Paper Name: IoT and Cloud-Based Monitoring System for Industrial Machines
Year: 2022
Author: R. Sharma, A. Gupta, and S. Verma
Publication: Springer
Journal Name: Journal of Cloud Computing
This research presents an IoT and cloud-based monitoring framework for industrial machines. The system integrates multiple sensors to collect data related to machine performance and sends the data to a cloud platform for storage and analysis. The objective of the system is to enable remote monitoring and predictive maintenance of industrial equipment.
The results indicate that the integration of IoT with cloud computing improves data accessibility and analysis capabilities. Maintenance teams can monitor machine conditions from remote locations and receive alerts when abnormal parameters are detected. The study highlights that combining IoT, cloud platforms, and intelligent data analysis can significantly enhance predictive maintenance strategies in industrial environments.

IV. PROPOSED SYSTEM

The proposed system aims to develop an Intelligent Motor Health Monitoring and Predictive Maintenance System using IoT and Machine Learning to continuously monitor the operational condition of an induction motor. The system integrates multiple sensors, a microcontroller, and communication technologies to detect abnormal motor conditions and prevent unexpected failures. By monitoring key parameters such as vibration, temperature, voltage, and current, the system can identify early signs of motor faults and provide timely alerts. The collected data is processed locally using the ESP32 microcontroller and transmitted through IoT connectivity for further analysis and predictive maintenance. The proposed architecture is divided into several functional sections that work together to ensure reliable monitoring and efficient motor protection.

A. Sensor-Based Motor Condition Monitoring

The proposed system uses multiple sensors to collect real-time data related to the motor's operating condition. An ADXL345 accelerometer sensor is used to measure vibration levels of the motor in three axes. Vibration monitoring is essential because abnormal vibration patterns often indicate mechanical faults such as bearing wear, misalignment, or rotor imbalance. Continuous monitoring of vibration data allows the system to detect mechanical issues before they lead to severe damage.
In addition to vibration monitoring, a DS18B20 temperature sensor is used to measure the temperature of the motor. Overheating is a common cause of motor failure and can occur due to excessive load, insulation degradation, or poor ventilation. The temperature sensor continuously records the motor temperature and sends the readings to the ESP32 microcontroller. By analyzing temperature variations, the system can detect abnormal thermal conditions and generate warnings when temperature levels exceed safe operating limits.

B. Electrical Parameter Monitoring

Electrical parameters play a crucial role in determining the health condition of an electric motor. In the proposed system, voltage and current sensors are integrated to measure the electrical behavior of the motor during operation. The voltage sensor continuously measures the supply voltage provided to the motor, ensuring that the motor operates within the required voltage range. Voltage fluctuations or drops can negatively affect motor performance and may indicate issues in the power supply system.
Similarly, the current sensor measures the current drawn by the motor. An abnormal increase in current consumption may indicate overload conditions, short circuits, or internal motor faults. By monitoring voltage and current simultaneously, the system can analyze electrical performance and detect irregular patterns. This electrical monitoring

helps identify both mechanical and electrical faults, providing a comprehensive motor health assessment.

C. Microcontroller-Based Data Processing

The ESP32 microcontroller acts as the central processing unit of the proposed system. It collects sensor data from the vibration sensor, temperature sensor, voltage sensor, and current sensor. The ESP32 processes the incoming data and compares it with predefined threshold values to determine whether the motor is operating under normal or abnormal conditions.

The ESP32 is particularly suitable for this application because it supports high processing capability and built-in Wi-Fi communication. The microcontroller can perform basic data analysis and manage communication between sensors and the monitoring platform. If abnormal conditions are detected, the ESP32 immediately generates alerts and triggers protective actions to prevent further damage to the motor.

D. IoT-Based Data Communication and Monitoring

To enable remote monitoring, the proposed system uses IoT communication through the ESP32's Wi-Fi capability. The sensor data collected by the ESP32 is transmitted to a laptop or cloud-based monitoring system. This allows maintenance engineers and system operators to monitor motor performance in real time from remote locations.

The IoT platform can store historical sensor data, which can be analyzed to observe long-term performance trends of the motor. This data storage and accessibility improve maintenance planning and enable continuous monitoring without the need for physical inspection. Remote monitoring also helps industries reduce maintenance effort and respond quickly to abnormal motor conditions.

E. Machine Learning-Based Predictive Maintenance

Machine learning techniques can be applied to the collected sensor data to improve fault detection and prediction capabilities. Historical data related to vibration, temperature, voltage, and current can be used to train machine learning models. These models learn patterns associated with normal motor operation and identify deviations that may indicate potential faults.

By analyzing real-time sensor data along with historical patterns, machine learning algorithms can predict the probability of motor failure in advance. This predictive capability allows maintenance teams to schedule repairs before a major breakdown occurs. As a result, industries can reduce unexpected downtime, improve equipment lifespan, and optimize maintenance strategies through data-driven decision-making.

F. Automated Motor Protection and User Interface

The proposed system also includes an automatic protection mechanism using a relay module connected to the ESP32 microcontroller. When abnormal conditions such as excessive vibration, high temperature, or abnormal current are detected, the ESP32 can activate the relay to disconnect the motor from the power supply. This protective action prevents severe damage to the motor and enhances system safety.

Additionally, the system includes an LCD display that provides real-time information about motor parameters such as temperature, voltage, current, and vibration levels. The LCD interface allows users to easily monitor the motor status locally without requiring additional devices. Combined with IoT monitoring and machine learning analysis, the system provides a complete solution for intelligent motor health monitoring and predictive maintenance in industrial applications.

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V. SYSTEM DESIGN

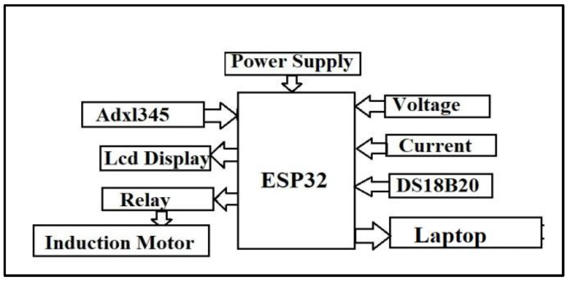

Fig 1: System architecture

The system design of the Intelligent Motor Health Monitoring and Predictive Maintenance using IoT and Machine Learning is developed to monitor the operational parameters of an induction motor and detect abnormal conditions in real time. The system integrates multiple sensors, a microcontroller, communication modules, and control components to ensure effective monitoring and protection of the motor. The architecture is designed to collect sensor data continuously, process it using the ESP32 microcontroller, and transmit the information through IoT communication for monitoring and predictive analysis. Each component in the system plays an important role in maintaining the reliability and efficiency of the motor monitoring system.

A. Power Supply Unit

Fig 2: Power supply unit

The power supply unit provides the necessary electrical power to operate all the components in the system. It converts the available AC supply into a regulated DC voltage required by the microcontroller and sensors. The ESP32 and other electronic components typically require a stable 5V or 3.3V DC supply for proper functioning.

A regulated power supply ensures that the system operates without fluctuations that may affect sensor readings or microcontroller performance. Stable power is essential for maintaining reliable data acquisition and communication within the system. The power supply unit also ensures electrical safety by protecting sensitive electronic components from voltage spikes or irregular power conditions.

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B. ESP32 Microcontroller Unit

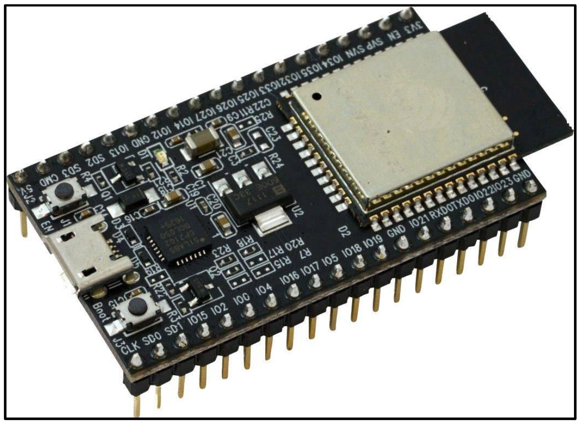

Fig 3: ESP 32

The ESP32 microcontroller acts as the central processing unit of the entire system. It collects data from various sensors connected to it and processes the information in real time. The ESP32 is widely used in IoT applications because it offers high processing capability, low power consumption, and built-in Wi-Fi and Bluetooth communication features.

In the proposed system, the ESP32 receives signals from the vibration sensor, temperature sensor, voltage sensor, and current sensor. It analyzes the data and compares the values with predefined threshold limits. If the sensor readings exceed the acceptable range, the ESP32 generates alerts and activates the protection mechanism. The ESP32 also transmits the collected data to a laptop or cloud platform for remote monitoring and predictive analysis.

C. ADXL345 Vibration Sensor

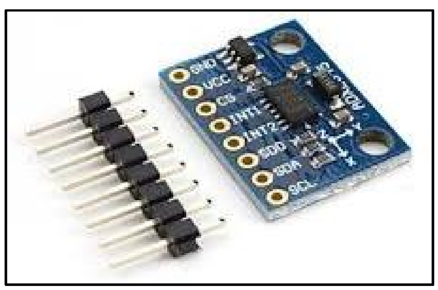

Fig 4: Vibration Sensor

The ADXL345 accelerometer sensor is used to measure the vibration of the induction motor. This sensor can detect vibration along three axes (X, Y, and Z), which helps identify mechanical faults such as imbalance, shaft misalignment, or bearing damage. Excessive vibration is one of the earliest indicators of mechanical problems in motors.

The ADXL345 provides high-resolution digital output and communicates with the ESP32 through communication protocols such as I2C or SPI. By continuously monitoring vibration patterns, the system can detect abnormal mechanical conditions at an early stage. The vibration data collected from the sensor is analyzed to determine whether the motor is operating under normal or faulty conditions.

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D. DS18B20 Temperature Sensor

Fig 5: Temperature sensor

The DS18B20 temperature sensor is used to measure the operating temperature of the motor. Temperature monitoring is critical because excessive heat can damage motor insulation and significantly reduce the lifespan of electrical components. The DS18B20 sensor provides accurate digital temperature readings and can operate reliably in industrial environments.

This sensor communicates with the ESP32 through a single-wire digital communication protocol, which simplifies wiring and reduces hardware complexity. The temperature readings are continuously monitored, and if the motor temperature exceeds the safe operating limit, the system generates an alert and may activate the protective mechanism to prevent overheating damage.

E. Voltage Sensor and Current Sensor

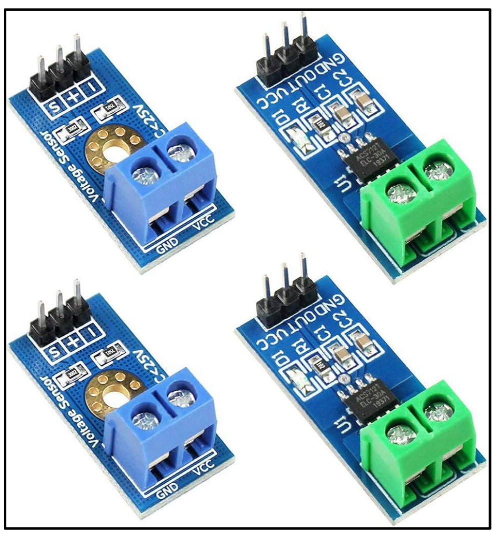

Fig 6: Voltage and current sensors

The voltage and current sensors are used to monitor the electrical performance of the induction motor. The voltage sensor measures the supply voltage provided to the motor and ensures that it remains within the acceptable operating range. Voltage fluctuations may indicate issues in the power supply system or electrical disturbances that can affect motor performance.

The current sensor measures the current drawn by the motor during operation. Excessive current consumption may occur due to overload conditions, internal faults, or mechanical resistance within the motor. By analyzing voltage and current together, the system can detect electrical abnormalities and identify potential motor faults. Continuous electrical monitoring helps maintain stable motor operation and prevents damage caused by electrical stress.

F. Relay Module and Motor Control

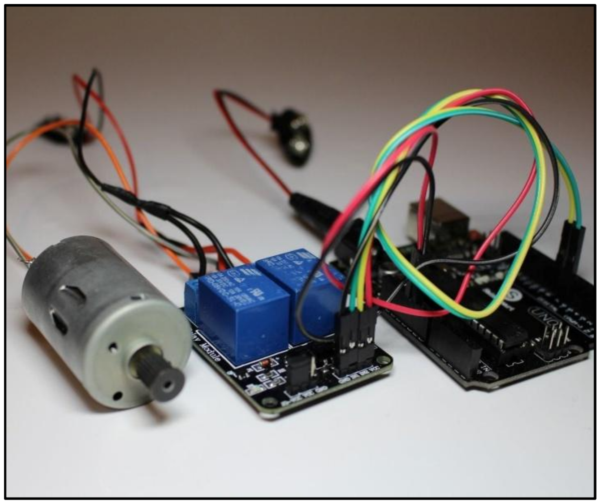

Fig 7: Relay module

The relay module is used as a switching device to control the operation of the induction motor. It acts as an interface between the low-power control signals from the ESP32 and the high-power motor circuit. When the ESP32 detects abnormal conditions such as excessive temperature, abnormal vibration, or high current levels, it sends a signal to the relay module.

The relay then disconnects the motor from the power supply, preventing further damage. This automatic shutdown mechanism provides an additional layer of protection for the motor and ensures system safety. The relay module therefore plays a critical role in implementing automated fault protection within the proposed system.

G. LCD Display Unit

Fig 8: LCD Display

The LCD display is used to provide real-time information about the motor's operating parameters. It displays important sensor readings such as vibration levels, motor temperature, voltage, and current. The display allows users to monitor the system locally without requiring additional monitoring devices.

The LCD interface improves user interaction by providing clear and immediate feedback about the motor's condition. It helps operators quickly identify abnormal conditions and observe system performance directly from the monitoring unit.

H. IoT Communication and Monitoring System

The ESP32 microcontroller enables IoT connectivity through Wi-Fi communication, allowing the system to transmit sensor data to a remote monitoring platform or laptop. This connectivity enables real-time monitoring of motor performance from remote locations. The collected data can be stored and analyzed for long-term performance evaluation and predictive maintenance analysis.

Through IoT connectivity, maintenance engineers can track motor health continuously and receive alerts whenever abnormal conditions occur. The integration of IoT communication with sensor-based monitoring provides an efficient and intelligent solution for industrial motor health monitoring and predictive maintenance.

VI. RESULT

The developed prototype of the Intelligent Motor Health Monitoring and Predictive Maintenance System using IoT and Machine Learning was successfully implemented and tested using an induction motor integrated with multiple sensors and an ESP32 microcontroller. The experimental setup consists of an induction motor, ESP32 controller board, relay module, LCD display, temperature sensor (DS18B20), vibration sensor (ADXL345), voltage sensor, and current sensor. The system was assembled on a hardware board where all components were interconnected to monitor the operational parameters of the motor in real time. The ESP32 microcontroller collected data from the connected sensors and displayed the real-time values on the LCD screen while also transmitting the data to the monitoring system through IoT communication.

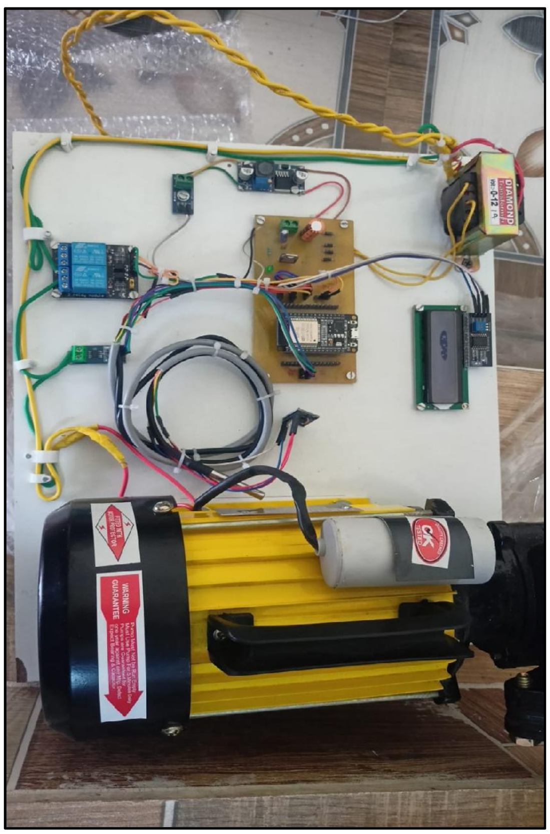

Fig 9: Model view

During system testing, the sensors successfully measured important parameters such as motor vibration, temperature, voltage, and current. The LCD display provided continuous real-time information about the motor status, enabling easy monitoring of system performance. When the motor operated under normal conditions, the sensor readings remained within the predefined threshold limits, and the system maintained stable operation. When abnormal conditions such as increased temperature or vibration were simulated, the ESP32 microcontroller detected the abnormal values and triggered the relay module to disconnect the motor, thereby preventing potential damage. The results demonstrate that the proposed system can effectively monitor motor health parameters, detect abnormal operating conditions, and provide an automated protection mechanism. The integration of IoT communication also enables remote monitoring and supports predictive maintenance by allowing long-term analysis of sensor data patterns.

VII. CONCLUSION

The proposed Intelligent Motor Health Monitoring and Predictive Maintenance System using IoT and Machine Learning provides an effective solution for continuously monitoring the operational condition of induction motors in industrial environments. The system integrates multiple sensors such as vibration, temperature, voltage, and current sensors with an ESP32 microcontroller to collect real-time data related to motor performance. By monitoring these parameters simultaneously, the system can detect abnormal operating conditions at an early stage and prevent unexpected motor failures. The ESP32 microcontroller processes the sensor data and displays the information on an LCD screen while also transmitting the data through IoT communication for remote monitoring and analysis.

The experimental implementation of the prototype demonstrates that the system can successfully monitor motor health parameters and identify faults such as overheating, excessive vibration, and abnormal electrical conditions. The integration of a relay module enables automatic shutdown of the motor when unsafe operating conditions are detected, which helps protect the equipment from severe damage. Furthermore, the use of IoT connectivity allows maintenance personnel to monitor the motor remotely and analyze collected data for predictive maintenance. Overall, the proposed system improves reliability, reduces unexpected downtime, enhances equipment safety, and provides a cost-effective solution for intelligent motor condition monitoring in modern industrial applications.

VIII. FUTURE SCOPE

The proposed Intelligent Motor Health Monitoring and Predictive Maintenance System using IoT and Machine Learning provides an effective solution for continuously monitoring the operational condition of induction motors in industrial environments. The system integrates multiple sensors such as vibration, temperature, voltage, and current sensors with an ESP32 microcontroller to collect real-time data related to motor performance. By monitoring these parameters simultaneously, the system can detect abnormal operating conditions at an early stage and prevent unexpected motor failures. The ESP32 microcontroller processes the sensor data and displays the information on an LCD screen while also transmitting the data through IoT communication for remote monitoring and analysis.

The experimental implementation of the prototype demonstrates that the system can successfully monitor motor health parameters and identify faults such as overheating, excessive vibration, and abnormal electrical conditions. The integration of a relay module enables automatic shutdown of the motor when unsafe operating conditions are detected, which helps protect the equipment from severe damage. Furthermore, the use of IoT connectivity allows maintenance personnel to monitor the motor remotely and analyze collected data for predictive maintenance. Overall, the proposed system improves reliability, reduces unexpected downtime, enhances equipment safety, and provides a cost-effective solution for intelligent motor condition monitoring in modern industrial applications.

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