Innovative Journal for Opportunities and Development in Science & Technology,
Volume 6, Issue 7, June. 2026
Paper Id: – IJ2026V6I7 -12 A-E
ISSN 2582-6026

AI BASED MOTOR FAULT DETECTION AND MAINTENANCE PREDICTION SYSTEM FOR SINGLE PHASE INDUCTION MOTOR

[1]Mr. Garud Sumit Sunil, [2]Mr.Dabhade Ashutosh Sahebrao [3]Mr. Deokar Tejas Manjiv, [4]Mr. Daunde Pankaj Babasaheb, [5]Prof. S. T. Kamble

[1]UG Scholar, Electrical Dept., SND College of Engineering and research center,Yeola
[2]UG Scholar, Electrical Dept., SND College of Engineering and research center, Yeola
[3]UG Scholar, Electrical Dept., SND College of Engineering and research center, Yeola
[4]UG Scholar, Electrical Dept., SND College of Engineering and research center, Yeola
[5]Asst. Prof. Electrical Dept. ., SND College of Engineering and research center, Yeola

ABSTRACT-
Electric motors are essential parts that power machines in the manufacturing, energy, transportation, and automation sectors. Single-phase AC induction motors, which are often used in home and light industrial applications, are one type of electric motor. Unexpected motor failures continue to be a significant problem despite their ubiquitous use, resulting in expensive unscheduled downtime, production losses, and considerable worker and equipment safety risks. The intelligent, AI-based system proposed in this project is intended to continually monitor the condition of electric motors in real time and forecast maintenance needs well in advance of any malfunction. Through the analysis of real-time sensor data, such as vibration, temperature, and current signals, the system is able to detect the first indications of fault development that would otherwise go undetected until a catastrophic failure takes place.

The system uses a multi-phase methodology. Continuous collection of raw sensor signals techniques such as Fast Fourier Transform (FFT), and then analyzed by machine learning models including Support Vector Machines (SVM), Random Forest, Convolutional Neural Networks (CNN), and Long Short-Term Memory (LSTM) networks to classify fault types such as bearing defects, rotor bar breakage, stator winding faults, shaft misalignment, and overheating.

A predictive model estimates the Remaining Useful Life (RUL) of the motor, enabling maintenance teams to schedule servicing at the most optimal time — avoiding both unexpected failures and unnecessary early servicing. Results and alerts are presented through a real-time monitoring dashboard that gives operators a clear view of motor health status, active fault conditions, predicted maintenance dates, and historical trends.

I. INTRODUCTION

As the foundation for a variety of applications, including manufacturing machinery, pumps, fans, compressors, and home appliances, electric motors are essential to contemporary industrial and residential systems. Electric motors operate continuously and are vital, so any unplanned failure can result in large production losses, higher maintenance costs, and even safety risks. Therefore, sustaining system stability and productivity depends on electric motors operating dependably and efficiently.

Preventive maintenance methods and routine inspections have historically been used for motor maintenance. In these methods, motors are routinely inspected, regardless of their true state. Although this approach reduces certain failures, it frequently leads to needless maintenance tasks and may still be unable to identify With the advancement of Internet of Things (IoT) technology, it has become possible to develop intelligent monitoring systems that can collect, transmit, and analyze data from physical devices. IoT enables the integration of sensors, microcontrollers, and cloud platforms to create connected systems capable of real-time monitoring and decision-making. In the context of electric motors, IoT-based systems allow continuous observation of important parameters such as temperature, current, and vibration, which are key indicators of motor health.

In this project, an IoT-based motor monitoring system is developed using the ESP8266 microcontroller. The system is designed to collect real-time data from multiple sensors, including a DS18B20 temperature sensor for monitoring thermal conditions, an ACS712 current sensor for measuring electrical load, and an SW-420 vibration sensor for detecting abnormal mechanical behavior. These parameters are crucial in identifying common motor faults such as overheating, overloading, and mechanical imbalance.

The gathered sensor data is sent to ThingSpeak, a cloud platform, where it is saved and made available for remote monitoring. Users may obtain motor data from any location thanks to cloud integration, which improves oversight and speeds up response to unusual circumstances. Additionally, Streamlit is used to create a web-based dashboard that presents the data in an approachable way.

This system's usage of artificial intelligence for anomaly detection is one of its main characteristics. The method uses an unsupervised machine learning technique called Isolation Forest in place of predetermined thresholds. This program looks for anomalous activity that can point to possible problems by analyzing patterns in sensor data. Given that tagged data is not necessary, The integration of IoT and machine learning in this project enables the development of a smart monitoring system capable of early fault detection and predictive maintenance. By identifying anomalies at an early stage, the system helps prevent major failures, reduces downtime, and minimizes maintenance costs. Furthermore, it enhances operational safety by providing timely alerts and insights.

Overall, this project aims to provide a cost-effective, scalable, and efficient solution for monitoring electric motors. By leveraging modern technologies such as IoT, cloud computing, and artificial intelligence, the proposed system contributes to improving the reliability and performance of motor-driven systems in various applications.

II. OBJECTIVES & PROBLEM STATEMENT

2.1 Objectives

The main objective of this project is to develop an IoT-based intelligent system for monitoring and detecting anomalies in electric motors to improve reliability and reduce unexpected failures.
The specific objectives of the proposed system are as follows:

i. Real-Time Motor Monitoring:
To continuously monitor key motor parameters such as temperature, current, and vibration using appropriate sensors to assess the operating condition of the motor.

ii. IoT-Based Data Transmission:
To implement an IoT framework using the ESP8266 microcontroller for transmitting real-time sensor data to a cloud platform for remote access and storage.

iii. Cloud Data Management:
To utilize the ThingSpeak platform for storing, organizing, and analyzing the collected sensor data efficiently.

iv. Data Visualization:
To design a user-friendly web dashboard using Streamlit for real-time visualization and monitoring of motor parameters.

v. Anomaly Detection using Machine Learning:
To apply an unsupervised machine learning algorithm (Isolation Forest) for detecting abnormal motor behavior without requiring labeled datasets.

2.2 Problem Statement

The main objective of this project is to develop an IoT-based intelligent system for monitoring and detecting anomalies in electric motors to improve reliability and reduce unexpected failures. The specific objectives of the proposed system are as follows:

1. **Real-Time Motor Monitoring:**
   To continuously monitor key motor parameters such as temperature, current, and vibration using appropriate sensors to assess the operating condition of the motor.
2. **IoT-Based Data Transmission:**
   To implement an IoT framework using the ESP8266 microcontroller for transmitting real-time sensor data to a cloud platform for remote access and storage.
3. **Cloud Data Management:**
   To utilize the ThingSpeak platform for storing, organizing, and analyzing the collected sensor data efficiently.
4. **Data Visualization:**
   To design a user-friendly web dashboard using Streamlit for real-time visualization and monitoring of motor parameters.
5. **Anomaly Detection using Machine Learning:**
   To apply an unsupervised machine learning algorithm (Isolation Forest) for detecting abnormal

Improved Maintenance Strategy:
To support predictive maintenance by providing timely alerts and insights, reducing downtime and maintenance costs.

III. LITERATURE REVIEW

In recent years, the integration of Internet of Things (IoT) and machine learning techniques in electrical systems has significantly improved the monitoring and maintenance of electric motors. Various researchers have proposed different approaches for real-time monitoring, fault detection, and predictive maintenance of motors using sensor-based data acquisition and intelligent analysis methods. The following literature provides an overview of important contributions in this domain.

1. **Ridho Syawali and Selamat Meliala (2023)** presented an IoT-based three-phase induction motor monitoring system that focuses on real-time data acquisition and remote accessibility. In their work, multiple sensors are used to monitor essential parameters such as voltage, current, and temperature of the motor. The collected data is transmitted using a microcontroller to an IoT platform, allowing users to monitor motor conditions remotely through web interfaces. The system also includes alert mechanisms that notify users when abnormal conditions occur. Their study highlights the importance of continuous monitoring in preventing unexpected motor failures and improving operational efficiency. However, the system primarily relies on threshold-based detection methods, which may not be effective in identifying complex or unseen fault patterns.
2. **N. A. Mohammed et al. (2023)** proposed an advanced predictive maintenance system that combines IoT with machine learning techniques for electrical motor monitoring. In this system, sensor data such as temperature, current, and vibration is continuously collected and transmitted to a cloud environment. Machine learning algorithms are then applied to analyze the data and detect anomalies that may indicate potential faults. The study emphasizes the use of data-driven models to improve maintenance strategies by predicting failures before they occur. The authors demonstrate that integrating machine learning with IoT enhances the accuracy of fault detection compared to traditional methods. However, their approach requires labeled datasets for training, which may not always be available in real-world scenarios.
3. **S. F. Chevtchenko et al. (2023)** developed a predictive maintenance framework based on anomaly detection using real-time IoT data from induction motors. Their approach focuses on analyzing sensor signals such as vibration and temperature using signal processing and machine learning techniques. The system uses data-driven models to identify deviations from normal operating.

Conditions, enabling early detection of faults. The results show that anomaly detection methods can effectively identify subtle changes in motor behavior that may not be detected by conventional techniques. This work demonstrates the effectiveness of unsupervised learning approaches in industrial environments where labeled fault data is limited. However, the complexity of the model and computational requirements may pose challenges for implementation on low-cost embedded systems.

4. **Stalin Arciniegas et al. (2025)** introduced an IoT-based motor fault detection system using TinyML techniques for real-time anomaly detection. The system is designed to run lightweight machine learning models directly on edge devices, enabling faster processing and reduced dependency on cloud resources. The authors focus on detecting abnormal vibration patterns associated with bearing faults in motors. Their results indicate that edge-based intelligence can achieve high accuracy while maintaining low power consumption and latency. This approach is particularly useful for real-time applications where immediate response is required. However, the system may be limited by the computational constraints of embedded devices and may require optimization for handling multiple parameters simultaneously.
5. **Recent research on IoT-based health monitoring systems for AC induction motors (2024)** emphasizes the integration of sensors, communication technologies, and cloud platforms for continuous condition monitoring. These systems typically involve collecting real-time data from various sensors and transmitting it to cloud-based platforms for storage and analysis. The studies highlight the role of IoT in enabling remote monitoring, data logging, and visualization of motor parameters. Additionally, the incorporation of intelligent algorithms allows for early fault detection and improved decision-making. While these systems provide a comprehensive monitoring solution, many of them still depend on predefined thresholds or semi-automated analysis, which may limit their ability to detect complex anomalies.

Innovative Journal for Opportunities and Development in Science & Technology,
Volume 6, Issue 7, June. 2026
Paper Id: – IJ2026V6I7 -12 A-E
ISSN 2582-6026

IV. POWER SYSTEM STABILITY

Power system stability is defined as the capability of a system to maintain an operating equilibrium point after being subjected to a disturbance for given initial operating conditions Power system stability is categorized based on the following considerations:

i. The nature of the resulting instability mode indicated by the observed instability on certain system variables.

ii. The size of the disturbance which consequently influences the tool used to assess the system stability.

iii. The time margin needed to assess system stability

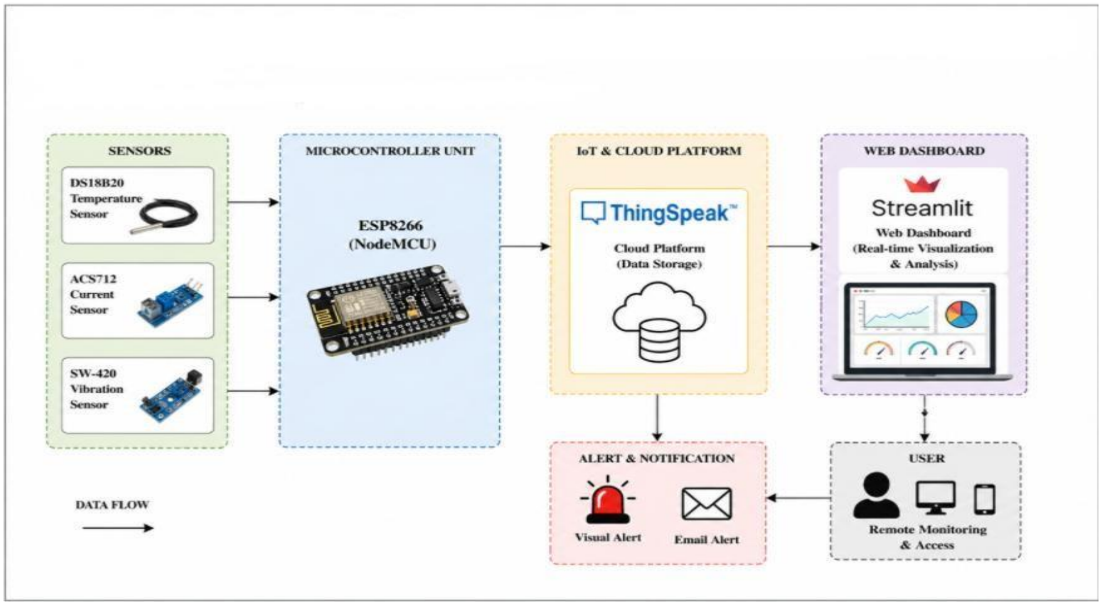

Fig.1: Classification of Power System

A. Rotor Angle Stability:

The proposed IoT-based intelligent motor monitoring and anomaly detection system is designed to continuously observe the operating condition of an electric motor using sensor data, process this data using a microcontroller, and transmit it to a cloud platform for storage, analysis, and visualization. The system integrates hardware components, communication modules, cloud services, and machine learning techniques to achieve real-time monitoring and early fault detection.

The architecture mainly consists of five major sections: sensor layer, microcontroller unit, IoT cloud platform, web dashboard, and alert/notification system, along with the end user. Each component plays a specific role in ensuring proper data flow and system functionality.

1. Sensor Layer

The sensor layer is the first and most important part of the system, responsible for collecting real-time data from the motor. In this project, three types of sensors are used: temperature sensor (DS18B20), current sensor (ACS712), and vibration sensor (SW-420). These sensors are directly connected to the motor setup and continuously monitor different physical parameters.

The **DS18B20 temperature sensor** is used to measure the temperature of the motor. Temperature is a critical parameter because overheating is one of the most common causes of motor failure. Continuous monitoring helps in identifying abnormal temperature rise, which may occur due to overloading, poor ventilation, or insulation failure.

The **ACS712 current sensor** measures the current flowing through the motor. Current consumption provides insight into the electrical load on the motor. Any sudden increase or decrease in current can indicate abnormal conditions such as overload, short circuits, or mechanical issues. Monitoring current helps in understanding the electrical behavior of the motor during operation.

The **SW-420 vibration sensor** is used to detect vibrations in the motor. Mechanical faults such as bearing wear, misalignment, or imbalance often produce unusual vibrations. By monitoring vibration patterns, the system can detect early signs of mechanical failure.

All these sensors generate analog or digital signals corresponding to the motor’s operating condition. These signals are then sent to the microcontroller for further processing.

2. Microcontroller Unit (ESP8266)

The microcontroller unit acts as the central processing component of the system. In this project, the ESP8266 (NodeMCU) is used because of its built-in Wi-Fi capability and cost-effectiveness.

The ESP8266 receives input signals from all the connected sensors. It processes this data by converting analog signals into digital values (if required), performing basic filtering, and preparing the data for transmission. The microcontroller ensures that the data is collected at regular intervals for continuous monitoring.

One of the key functions of the ESP8266 is communication. It connects to a Wi-Fi network and transmits the processed sensor data to the cloud platform. This eliminates the need for complex wired communication systems and enables remote monitoring.

The microcontroller also acts as a control unit that can be programmed to handle basic decision-making tasks, such as triggering alerts when certain conditions are met. However, in this system, advanced analysis is mainly performed on the cloud side.

V. METHODOLOGY

The IoT-based intelligent motor monitoring and anomaly detection system's methodology outlines the sequential steps involved in its design, development, and implementation. This part provides a methodical explanation of system modeling, data collecting, data transfer, analysis, and assessment, much like the reference report's organized methodology.

1. Modeling systems

The suggested system is represented as a combination of software and hardware elements that cooperate to keep an eye on an electric motor's condition. Sensors, a microcontroller (ESP8266), a cloud platform (ThingSpeak), and a web dashboard (Streamlit) make up the system. The motor is considered as the primary system under observation. Key parameters such as temperature, current, and vibration are selected because they directly indicate the health and performance of the motor. These parameters are monitored using appropriate sensors connected to the ESP8266 microcontroller.

The ESP8266 acts as the central unit that collects data from sensors, processes it, and transmits it to the cloud. The cloud platform stores and organizes the data, while the dashboard provides visualization and analysis. Additionally, a machine learning model is integrated into the system to detect anomalies in motor behavior.

The overall system is designed to operate continuously, ensuring real-time monitoring and analysis.

1. Hardware Implementation

The hardware setup includes sensors and a microcontroller connected to the motor. Each component plays a specific role in the data acquisition process.

1.1 Temperature Measurement (DS18B20)

The DS18B20 digital temperature sensor is used to measure the motor's surface temperature. It provides accurate readings and communicates using a one-wire protocol, which simplifies wiring and reduces complexity. The sensor is placed in contact with the motor body to capture real-time temperature variations.

1.2 Current Measurement (ACS712)

The ACS712 current sensor is used to measure the current flowing through the motor. It works on the Hall-effect principle and provides an analog output proportional to the current. This helps in identifying overload conditions or abnormal power consumption.

1.3 Vibration Detection (SW-420)

The SW-420 vibration sensor detects mechanical vibrations in the motor. It provides a digital output indicating the presence of vibration. This is useful for identifying issues such as imbalance, misalignment, or bearing faults.

1.4 Microcontroller (ESP8266)

The ESP8266 (NodeMCU) is used as the main processing unit. It reads data from all sensors, processes the signals, and sends the data to the cloud platform using Wi-Fi connectivity. The microcontroller is programmed using embedded C or Arduino IDE.

The ESP8266 continuously reads these values using its input pins. Analog signals from the ACS712 are converted into digital values using the built-in ADC of the microcontroller. Digital sensors like DS18B20 directly provide processed data.

To ensure accuracy, the data is sampled periodically and may be averaged or filtered to reduce noise. This step is important to avoid false readings and improve reliability.

2. Data Transmission (IoT Communication)

After collecting the data, the ESP8266 transmits it to the ThingSpeak cloud platform using Wi-Fi. The communication is established through HTTP protocol.

Each sensor parameter is mapped to a specific field in the ThingSpeak channel. The microcontroller sends data packets at fixed intervals (e.g., every 15–20 seconds). This ensures continuous updating of sensor values on the cloud.

The data transmission process involves:

1. Connecting ESP8266 to Wi-Fi network
2. Preparing data in required format
3. Sending HTTP request to ThingSpeak API

VI. EXPECTED RESULT

Using sensors, the system will continually monitor critical motor characteristics including temperature, current, and vibration. Real-time data collection and frequent updates will provide ongoing motor status monitoring without the need for human intervention.

Using Wi-Fi connectivity, the ESP8266 microcontroller will effectively send the gathered sensor data to the ThingSpeak cloud platform. In order to facilitate systematic monitoring and future analysis, the data will be appropriately kept in several areas.Temperature, current, and vibration graphs and data in real time will be shown on the Streamlit dashboard. In an easy-to-understand manner, users will be able to see patterns, variances, and overall motor function.

The incoming sensor data will be examined by the Isolation Forest algorithm, which will look for unusual patterns without requiring labeled datasets. The system will be able to differentiate between normal and abnormal operating conditions effectively.

The system will generate alerts whenever abnormal conditions such as high temperature, excessive current, or unusual vibration are detected. These alerts will help users take immediate action and prevent further damage.

Case 1: Normal Operating Condition

In this case, the motor operates under standard conditions with no faults. The temperature remains within safe limits, the current is stable according to load conditions, and vibration levels are minimal.

The sensors continuously send stable data to the ESP8266, which transmits it to the cloud. The dashboard displays smooth and consistent graphs with no sudden spikes or fluctuations.

The anomaly detection model identifies the data as normal and does not generate any alerts. This indicates that the motor is functioning properly and does not require any maintenance.

Case 2: Temperature Rise Condition

In this case, the temperature of the motor gradually increases due to factors such as overloading, poor cooling, or continuous operation for a long duration.

The DS18B20 sensor detects this rise and sends increasing temperature values to the system. The dashboard shows a rising trend in temperature over time.

If the temperature exceeds the normal operating range or shows abnormal deviation, the anomaly detection algorithm classifies it as an anomaly. The system generates an alert indicating a possible overheating condition.

This helps in taking corrective actions such as reducing load or stopping the motor to prevent damage.

Case 3: Overcurrent Condition

In this case, the motor draws higher current than normal due to excessive load or electrical faults such as short circuits.

The ACS712 current sensor detects the increase in current and sends updated values to the ESP8266. The dashboard shows a sudden or gradual increase in current levels.

The anomaly detection model identifies this deviation from normal behavior and marks it as abnormal. An alert is generated indicating an overload condition.

This allows users to take necessary action before the motor is damaged due to excessive current.

VII. CONCLUSION

The anticipated outcomes show that the suggested system would efficiently track motor parameters, identify anomalous circumstances, and send out prompt alarms. Through ongoing monitoring and intelligence analysis, the system will contribute to increased dependability, less downtime, and safe operation of electric motors.

REFERENCES

[1] R. Syawali and S. Meliala, "IoT-Based Three-Phase Induction Motor Monitoring System," IEEE Access, 2023.

[2] N. A. Mohammed, M. A. Hannan, and A. Mohamed, "IoT and Machine Learning-Based Predictive Maintenance for Electrical Motors," IEEE Access, vol. 11, pp. 45231–45242, 2023.

[3] S. F. Chevtchenko, A. Valeev, and D. Kaplun, "Anomaly Detection for Predictive Maintenance of Induction Motors Using IoT Data," IEEE Sensors Journal, vol. 23, no. 18, pp. 20567–20575, 2023.

[4] S. Arciniegas, J. Gomez, and L. Rodriguez, "TinyML-Based IoT System for Motor Fault Detection Using Vibration Analysis," IEEE Internet of Things Journal, 2025.

[5] M. K. Sharma and P. Singh, "IoT-Based Health Monitoring System for AC Induction Motors," IEEE Access, vol. 12, pp. 11345–11358, 2024.

[6] A. Kumar and R. Gupta, "Smart Motor Monitoring and Fault Detection Using IoT and Cloud Computing," IEEE Transactions on Industrial Informatics, vol. 18, no. 6, pp. 3890–3898, 2022.

[7] J. Lee, H. Kim, and S. Park, "Real-Time Condition Monitoring of Electric Motors Using IoT and Edge Computing," IEEE Internet of Things Journal, vol. 9, no. 14, pp. 12045–12054, 2022.

[8] Y. Zhang and X. Wang, "Machine Learning-Based Fault Diagnosis in Electric Motors Using Sensor Data," IEEE Transactions on Industrial Electronics, vol. 69, no. 5, pp. 4567–4576, 2022.

[9] P. Verma and S. K. Jain, "Cloud-Based IoT Framework for Industrial Motor Monitoring and Analysis," IEEE Access, vol. 10, pp. 78521–78530, 2021.

[10] K. R. Rao and V. R. Kumar, "Vibration-Based Fault Detection in Induction Motors Using IoT Techniques," IEEE Sensors Journal, vol. 21, no. 9, pp. 10234–10242, 2021.