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Machine Learning based Fault Prediction in Single Phase Induction Motor

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***Abstract*— Detecting faults in induction motors before they completely stop working, fixing in an induction motor at the right time can prevent losses. A machine learning approach is proposed to detect faults in induction motors. Machine learning and condition monitoring techniques can help in detecting faults early. The approach uses algorithms to analyze vibration signals and learn important features from the frequency distribution of these signals. These features help understand the working status of the motor, including factors like current, voltage, speed, vibration and temperature. The information is then used in an IoT- based application for monitoring and updating. The approach combines feature automatically diagnose faults in motors. This helps in developing a system that can predict faults in a single-phase induction motor using various parameters and machine learning techniques. The system not only detects faults but also provides specific error codes, making it easier for technicians to quickly and accurately diagnose problems for efficient repairs.**

***Index Terms*— Induction Motor, Sensors, Machine Learning, IOT application, Fault Prediction, White Box Algorithm.**

I. INTRODUCTION

This project suggests a practical way to use machine learning to find problems in induction motors us-ing real-world tests. They tested and measured things like current, voltage, temperature, and vibration. Finding faults in these motors is important for keeping motors running smoothly. In the past, there have been three main ways to diagnose faults in these motors:

- Signature extraction: Looking for unique patterns in the data.
- Model-based: Using mathematical models to predict faults.
- Knowledge-based: Using expert knowledge to diagnose issues.

Signature extraction methods use patterns in multiple signals like as current, voltage, power, vibration, temperature, and sound emission to detect problems. One prominent approach is REF[3] Analysis of Motor Current Signature (MCSA), which analyses stator current remotely and is useful for spotting specific defects. However, MCSA can occasionally issue false alerts. Model-based techniques employ mathematical models to forecast how motors will react in the presence of certain defects. While these approaches can offer early warnings, they rely on precise motor models, which may not always be accessible. In contrast, knowledge-based approaches use machine learning techniques without the requirement for explicit models. These techniques are gaining favour because of their ability to manage complicated systems and accurately identify motor defects.

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Single-phase induction machines (SIMs) REF[1] are often used in industries because they are affordable, can handle different types of mechanical loads, and are tough enough for tough environments. However, these machines can break down due to electrical issues, too much load, or wrong operation methods. Even small faults can make the machine work poorly before it completely breaks down, causing financial problems.
Using experimental data, this research suggests a machine learning-based defect diagnostic technique for induction motors REF[5]. It also compares the fault classification accuracy of measured currents and vibration data for the first time.

II. LITERATURE SURVEY

A. In IEEE 2020, Wasim Ahmad et al. submitted "Hybrid Prognostics Technique for Rolling Ele-ment Bearings using Adaptive Predictive Models."

In order to improve the prognostic performance of current bearing health prognosis methods, the paper may introduce and discuss a few critical issues. These issues include figuring out the time to start prediction (TSP), REF[7] handling erratic fluctuations in a bearing's health indicator, and establishing a dynamic failure threshold. The recommended method is assessed using bearing prognostic data from the Centre for Intelligent Maintenance Systems (IMS) that is available to the public. Results from experiments show that the proposed technique can effectively handle random oscillations and calculate an accurate TSP and failure threshold.

B. At IEEE 2019, AYDIN presented the "Artificial Immune Based Support Vector Machine Algo-rithm for Fault Diagnosis of Induction Motors."

The study's primary focus is undoubtedly the artificial immune system, which possesses the ability to learn, remember, and regulate itself. The kernel REF[9] and penalising parameters of the sup-port vector machine are modified using an artificial immune system.
The support vector machine is trained using three-phase motor current.
The new feature vector is made using Park's vector method. The phase space of this feature vector is created by nonlinear time series analysis. Support vector ma-chines are used to identify problems with broken rotor bars and stator short circuits in combined phase space. A three-phase induction motor was utilised to get the experimental results.
It was successfully determined that there were three broken rotor bar issues and a 10% short circuit in the stator.

III. SYSTEM ANALYSIS

We developed the fault prediction induction motor by examining several literature assessments.

IV. EXISTING SYSTEM

The existing system is based on stator currents and motor vibration signals are monitored at the same time and utilized to build a defect diagnostic system. It lacks internal decision-making logic. In this study, three classification algorithms, namely support vector machine (SVM), K-nearest neighbors (KNN),REF[2] and Ensemble, are utilized. Additionally, 17 different classifiers from the MATLAB Classification Learner toolbox are employed. The aim is to evaluate the performance and suitability of these classifiers for diagnosing faults in induction motors. It uses analogue black box inputs and can-not anticipate characteristics. It has been noticed that power loss is a considerable disadvantage, REF[4] and the overall cost is large. Furthermore, there is a significant risk to human life.

V. PROPOSED SYSTEM

In this proposed system, We will forecast the occurrence of a problem in a induction motor, single phase. To measure the current flowing through the induction motor, we utilise a current transformer.
The voltage transformer measures the voltage of an induction motor. Using machine learning to detect faults in a single phase induction motors utilizing data from proximity speed sensor current sensors, voltage sensors, accelerometer and temperature sensors and display specific error codes to facilitate quick and accurate diagnosis for efficient repairs . We use Arduino and a microcontroller (AT-MEGA328) REF[6] to operate and monitor the entire system. If anomalous current runs through the induction motor, the temperature of the single phase induction motor will rise. As a result, any anomalous situation will have an impact on overall efficiency and dependability. Through the use of a relay driver circuit, machine learning is employed to predict malfunctions

and protect our single phase in-duction motor from unusual circumstances by cutting it off from the main power supply.
We will use machine learning to forecast faults in induction motors, single phase. We utilise IoT as well monitor temperature and vibration in single-phase induction motors.

VI. Block Diagram

Fig 1. shown in block diagram of proposed system.

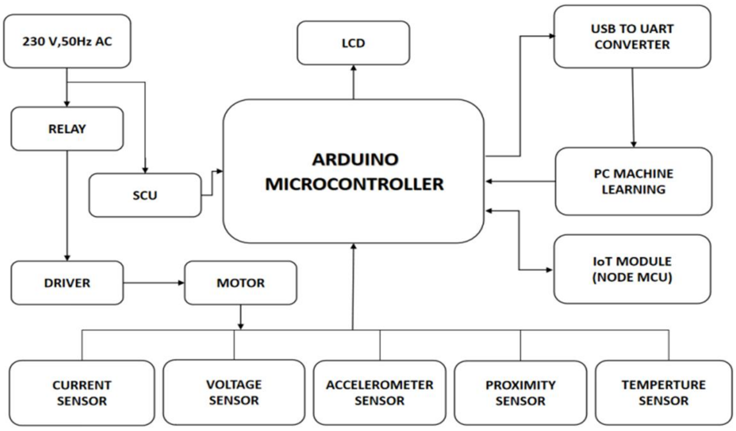

Fig 1. Block Diagram of Recommended System

During this proposed method includes a 230 V 50 Hz AC power supply, Relay, Single phase induction motor, Arduino Microcontroller, LCD, Current Sensor, Voltage Sensor, Current Sensor, Accelerometer sensor, Proimity sensor, Temperature sensor, USB to UART converter for machine learning and Node MCU for IoT.

VII. Hardware Requirement

The components used in this system are Induction motor, Sensors, Relay, ESP32, power supply unit, IoT Module.

A. Stepdown Transformer

A transformer's secondary side steps down the 230V alternating current voltage to 12V from the trans-former's main side.

B. Power Source

Figure 2 illustrates the schematics of power Source Unit.

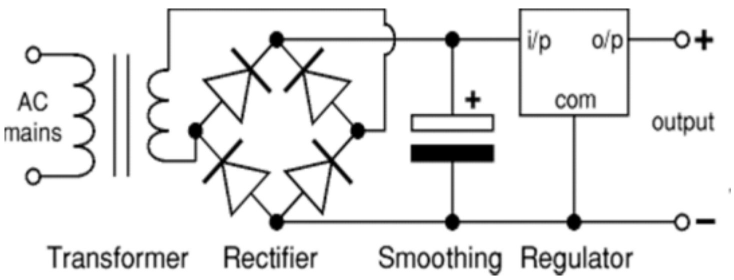

Fig 2. Circuit Block of Power Source

Our signal conditioning device consists of a capacitor, A diode (rectifier) and a voltage regulator are included.

C. Rectifier Unit

In this project, a diode is utilised as a rectifier, converting Alternating Current to Direct Current.

D. Capacitor

The rectifier’s voltage will fluctuate, and a filter will be employed to eliminate the ripples.

E. Temperature Sensor

The purpose of a temperature sensor is to gauge an object's level of heat or cold. Voltage across the diode controls how a temperature meter functions. Direct proportionality exists between temperature change and diode resistance. The LM35 is an integrated circuit sensor that can measure temperature and emit an electrical signal proportional to the temperature (in degrees Celsius). The LM35 produces a greater output voltage than thermocouples and may not require an amplifier.

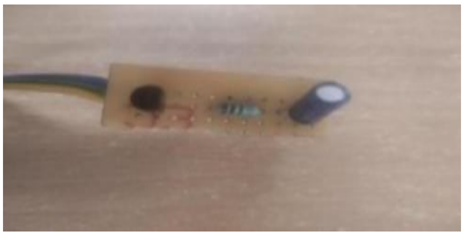

Fig 3. Temperature sensor

F. Current sensor

Any electric current flowing through a conductor can be found and measured using a current sensor. It converts the current into a measurable output that can be used for monitoring, controlling, or protecting purposes in a range of applications. Examples of these outputs include voltage, current, or digital sig-nals. A current sensor, also known as a current transducer or current probe, is a device used to measure the electric current flowing through a circuit. It detects and converts the current into a proportional electrical signal that can be measured and utilized by other devices or systems. current sensors play a crucial role in monitoring and controlling electrical systems by providing accurate measurements of current flow, which is essential for various applications in industries, power distribution, automotive systems, and more.

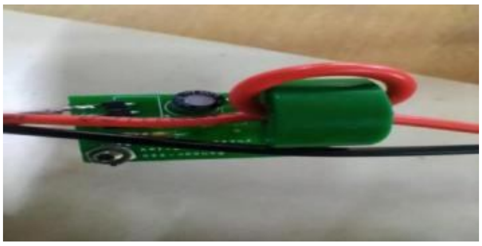

Fig 4. Current sensor

G. Speed Sensor

Rotational speed is measured via a speed sensor, a kind of position sensor. They are found in a variety of commercial and race car models. Similar to several gadgets, a speed sensor is an essential compo-nent of onboard systems.

A speed sensor is a device that measures an object's speed or the rate at which a shaft rotates. One common type of speed sensor is the Hall Effect sensor, which operates based on the Hall Effect princi-ple. In this sensor, a magnetically sensitive semiconductor element detects changes in magnetic field strength caused by the rotation of a gear or other ferrous target passing nearby. As the target moves, it alters the magnetic field sensed by the Hall Effect sensor, resulting in a voltage output proportional to the speed or rate of rotation.

This voltage signal can then be processed to obtain precise speed measurements, making Hall Effect speed sensors widely used in automotive applications such as monitoring vehicle speed, engine RPM, or wheel speed in anti-lock braking systems (ABS).

Fig 5. Speed Sensor

H. Voltage Sensor

A voltage sensor is a voltage-measurement gadget. Voltage sensors are capable of monitoring both low and high current levels. These devices are important for a variety of applications, including power systems and industrial controls. Voltage sensors are devices that measure voltage. Voltage sensors may detect voltage in several ways, including high voltages and low current levels. These devices are re-quired for a variety of applications, including industrial controls and power systems. To measure volt-age, we use a resistor divider and pass the result to an op-amp. The op-amp output is then given to a microcontroller. Synchronous generators provide the foundation for voltage regulation in a conventional electrical system. Automatic voltage regulators modify the excitation field to maintain the de-sired voltage at the generator's terminals.

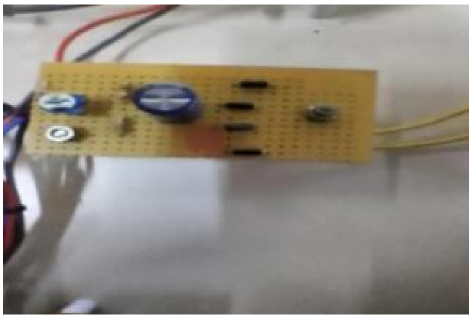

Fig 6. Voltage Sensor

I. Accelerometer

A vibration sensor is a tool used to quantify the amount and frequency of vibration in a machine, sys-tem, or other piece of equipment. These metrics can be used to forecast future breakdowns and identify imbalances or other problems with the asset.

An accelerometer measures appropriate acceleration, which is different from coordinate acceleration (rate of change of velocity). An accelerometer at rest on the Earth's surface will measure g ≈ 9.81 m/s2, which is the acceleration due to gravity. Accelerometer in free fall (at 9.81 m/s) measure zero.

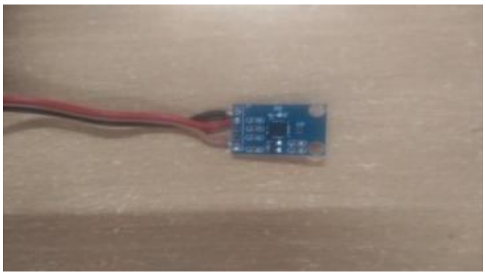

Fig 7. Accelerometer

J. Induction Motor

An AC electric motor that uses the magnetic field of the stator winding to electromagnetically induce an electric current in the rotor and produce torque is called an induction motor, sometimes referred to as an asynchronous motor. For this reason, there is no need to connect an induction motor to the rotor electrically.

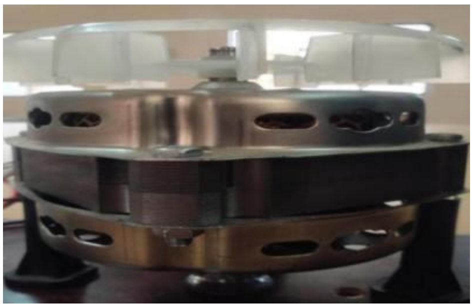

Fig 8. Induction Motor

K. IOT Module

The ESP8266 may be used as an external WiFi module using the standard AT Command set Firmware. Alternatively, it can be utilised to directly function as a WiFi-enabled micro controller by creating a custom firmware using the included SDK. Data from any electrical item may be sent to the Internet of Things with the ESP8266. The Node Micro controller unit is built upon the ESP8266 Wi-Fi module. An image of the NODE MCU can be found in Figure 9.

Fig 9. IOT module

VIII. Simulation Setup

Simulation setup of our project is displayed below at Fig 10 below.
Simulation runs through Proteus Design Suite software tool.

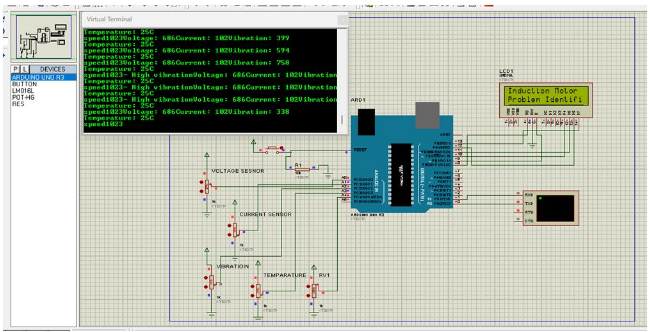

Fig 10. Simulation Setup

The output response of our simulation is shown in below fig 11. The vibration fault is predicted by using accelerometer sensor in the simulation.

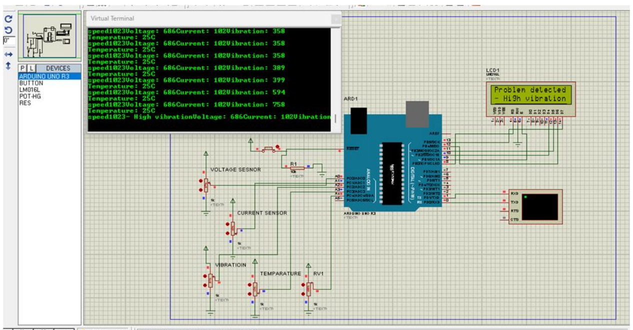

Fig 11. Output Response

IX. Prototype Setup

The hardware arrangement for our research is depicted in Figure 12. The project uses the following components: Power supply, Relay, Single phase induction motor, Arduino Micro controller, LCD, Current Sensor, Voltage Sensor, Current Sensor, Accelerometer sensor, Proximity sensor, Temperature sensor, USB to UART converter for machine learning and Node MCU for IoT.

Induction motor is monitored on different parameters with help of different sensors for real time data. The real time data is run by machine learning algorithm in Arduino (mcu) to predict the up-coming faults. The relay is connected to motor to cut the motor power supply to prevent the failure. Each and every fault have specific error codes which will be displayed in LCD display. Real time data and alerts is send to user in blynk app with help of Node mcu IoT.

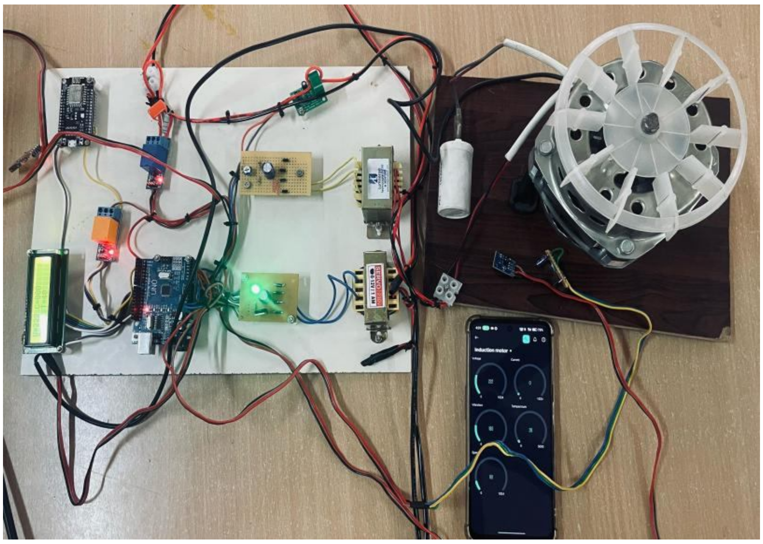

Fig 12. Hardware Setup

X. Result And Discussion

The proposed system successfully predicts faults in single-phase induction motors using machine learning algorithms. By analyzing data from current transformers, voltage transformers, proximity speed sensors, current sensors, voltage sensors, accelerometer, and temperature sensors, the system can identify abnormal conditions that may lead to motor faults. By detecting abnormal current flow or other indicators of potential faults, the system generates specific error codes. These codes facilitate quick and accurate diagnosis, allowing for efficient repairs. The use of machine learning enhances the system's ability to detect faults early, minimizing downtime and reducing maintenance costs. To protect the motor from damage, the system utilizes a relay driver circuit to disconnect it from the main supply when abnormal conditions are detected. This proactive approach helps prevent further damage to the motor, ensuring its overall efficiency and reliability. The system also uses IoT technologies to monitor the temperature and vibration of the single-phase induction motor. This real-time monitoring allows for timely intervention in case of abnormal conditions, further enhancing the motor's protection and performance. By combining machine learning with IoT technology, the proposed system improves the overall efficiency and reliability of single-phase induction motors. Early fault detection, quick diagnosis, and protection mechanisms ensure minimal downtime and reduced maintenance costs, making it a valuable asset in industrial applications.

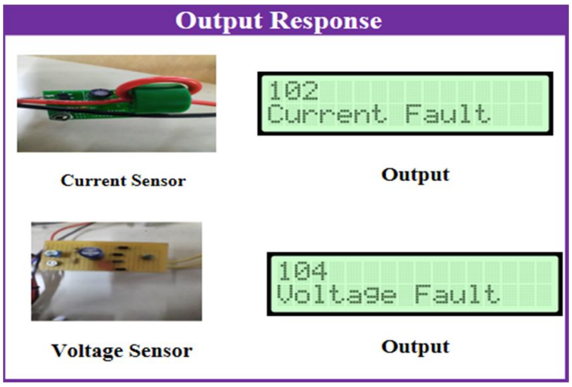

Fig 15. Output response - V&I Sensor

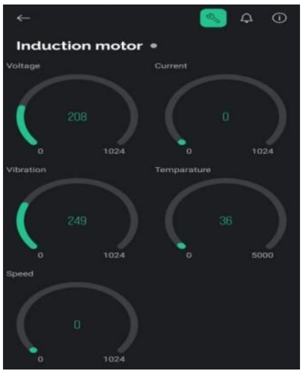

Fig 16. Output response - IoT monitoring in Blynk app

XI. CONCLUSION

Our proposed system aims to enhance the efficiency and reliability of single-phase induction motors by predicting faults using machine learning and IoT technology. By monitoring various parameters such as current, voltage, temperature, and vibration, we can detect abnormalities and protect the motor from damage. This predictive maintenance approach enables quick and accurate diagnosis, leading to efficient repairs, prolonged motor lifespan, and increased operational safety.

FUTURE SCOPE

It promises thorough monitoring of motor health by utilizing a combination of current and voltage transformers coupled with cutting-edge sensors like accelerometer and temperature sensors. Machine learning algorithms can be continuously improved as the system develops to improve the accuracy of defect prediction. In addition, the incorporation of IOT allows for remote control and monitoring, which provides real-time information about motor performance. Potential avenues for future improve-ment could include defect avoidance techniques, predictive maintenance tactics, and sensor technolo-gy optimization.

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