RESEARCH ARTICLE OPEN ACCESS

Induction Motor Protection Using Microcontroller and its Fault Analysis by Simulation Model

[1]Prof. S.P. Arbale, [2]Areen Gaikwad, [3]Aditya Shitole, [4]Abhishek Dhandar, [5]Sudarshan Tupshendre

Department Of Electrical Engineering, Jayawantrao Sawant College of Engineering (JSCOE) Hadapsar, Pune

Corresponding author email: areengaikwad05@gmail.com

Abstract — The rapid advancement of Internet of Things (IoT) technology has enabled intelligent monitoring and protection of electrical systems through real-time data acquisition and remote accessibility. This project presents an Induction Motor Protection Using Microcontroller and its Fault Analysis By Simulation Model using theESP32 microcontroller. The proposed system continuously monitors essential electrical parameters such as voltage, current, power, energy consumption, frequency, and power factor using the PZEM-004T power monitoring module, while simultaneously measuring equipment temperature using the DS18B20 digital temperature sensor. The ESP32 processes the acquired sensor data in real time and compares the measured values with predefined safety thresholds. Whenever abnormal electrical or thermal conditions are detected, the controller automatically activates a relay module to disconnect the electrical load, thereby protecting electrical equipment from damage caused by overload, overheating, or voltage fluctuations. The measured parameters are displayed locally on a 16×2 LCD display and remotely through an embedded web dashboard hosted by the ESP32 using its built-in Wi-Fi capability. The proposed system offers a low-cost, reliable, and efficient solution for continuous monitoring, automatic fault protection, and remote supervision of electrical systems. It is suitable for residential, commercial, laboratory, and small-scale industrial applications where equipment safety, energy management, and operational reliability are essential. The modular architecture of the system also allows future enhancements such as cloud integration, data logging, mobile application support, and predictive maintenance

features.

Keywords —

ESP32, PZEM-004T, DS18B20, Power Monitoring, Temperature Monitoring, Relay Protection, Embedded Web Dashboard, Electrical Safety, Smart-Monitoring System.

I. INTRODUCTION

The rapid growth of Internet of Things (IoT) technology has significantly improved the way electrical systems are monitored and controlled. In residential, commercial, and industrial environments, continuous monitoring of electrical parameters is essential to ensure equipment safety, efficient energy utilization, and uninterrupted operation. Electrical devices are often exposed to abnormal conditions such as overvoltage, overcurrent, overheating, and power fluctuations, which can lead to equipment damage, increased maintenance costs, and unexpected system failures. Conventional monitoring systems require manual inspection and lack real-time fault detection and remote accessibility.

The proposed IoT-Based Power and Thermal Monitoring and Protection System addresses these challenges by integrating an ESP32 microcontroller with the PZEM-004T power monitoring module and the DS18B20 temperature sensor. The system continuously measures important electrical parameters such as voltage, current, active power, energy consumption, frequency, and power factor while simultaneously monitoring equipment temperature. The acquired data is processed by the ESP32 and compared with predefined safety thresholds.

Whenever abnormal electrical or thermal conditions are detected, the ESP32 automatically activates a relay module to disconnect the electrical load, thereby preventing equipment damage and improving operational safety. The measured parameters are displayed locally on a 16$\times$2 LCD and remotely through an embedded web dashboard hosted by the ESP32 over Wi-Fi. The proposed system offers a low-cost, reliable, and intelligent solution for real-time monitoring, automatic protection, and remote supervision of electrical systems.

II. RELATED WORK

The protection of induction motors is an area of research. This is because they are widely used in industries and can easily get damaged by thermal and mechanical faults.

• Conventional motor protection techniques use relays and thermal overload relays.

• These methods protect motors from conditions like overload, short circuits and phase failures.

• They have limited fault detection capabilities and slower response times.

Also, they cannot continuously monitor operating parameters. Recent advancements in embedded systems have led to the development of microcontroller-based motor protection systems. These systems offer accuracy, faster response and real-time monitoring. Several researchers have proposed protection schemes using microcontrollers like Arduino, PIC and ARM processors. These systems use sensors to acquire real-time data and execute threshold-based algorithms for fault detection and automatic motor shutdown. This approach reduces the possibility of motor damage. Improves operational reliability. MATLAB/Simulink is widely used for analysing induction motor behaviour under normal and faulty conditions. Many studies have developed simulation models to investigate faults like overcurrent, voltage imbalance, single phasing, voltage sag, voltage swell and thermal overload. Simulation-based analysis provides insights into motor performance. Parameters like stator current, electromagnetic torque, rotor speed and voltage characteristics are evaluated before implementing hardware prototypes. Intelligent fault diagnosis techniques using Artificial Intelligence (AI) Machine Learning (ML) Artificial Neural Networks (ANN) and Internet of Things (IoT) technologies have gained attention. These advanced approaches enable maintenance by identifying fault patterns before major failures occur. However, they require algorithms, cloud connectivity, high processing power and increased system cost. This makes them less suitable for medium-scale industrial applications. The proposed work combines microcontroller-based protection systems with MATLAB/Simulink-based fault analysis. This aims to develop a cost-reliable and efficient induction motor protection scheme. The proposed system continuously monitors motor parameters in real-time and performs rapid fault detection with automatic motor isolation. The simulation model validates the effectiveness of the protection algorithm, under fault conditions. This improves the reliability and safety of induction motor operation.

III. METHODOLOGY

The system we are talking about is made to protect a three-phase induction motor. It uses a microcontroller to keep the three-phase induction motor from problems. This system can find these problems before they get worse. It helps prevent damage to the three-phase induction motor.

We use a mix of hardware and computer simulation to make sure the three-phase induction motor works well even when there are problems. The system has a lot of parts: a three-phase induction motor, a voltage sensor, a sensor, a temperature sensor, a microcontroller, a relay module, an LCD display, a buzzer, and a MATLAB/Simulink model. The sensors are always checking how the three-phase induction motor is working. They send the information to the microcontroller. The microcontroller changes the information from the sensors into a format it can understand. Then it checks the voltage, current, and temperature of the three-phase induction motor. The microcontroller has a set of rules to compare the information it gets from the sensors with some standard values. When the three-phase induction motor is working normally, it just keeps working. The microcontroller is always updating the information it gets from the sensors. If the current gets too high, the system knows there is a problem with the three-phase induction motor. If the voltage gets too high or too low, the microcontroller finds a problem with the three-phase induction motor. The temperature sensor is always checking the temperature of the three-phase induction motor.If it gets too high, the microcontroller knows the three-phase induction motor is getting too hot.

This way the system can quickly find out if something is wrong with the three-phase induction motor. When the system finds a problem, the microcontroller acts fast to prevent damage to the three-phase induction motor. It uses the relay module to turn off the power to the three-phase induction motor. At the time it sounds a buzzer to alert the person in charge, and the LCD display shows what kind of problem it is. This quick action helps prevent the three-phase induction motor from getting damaged. It reduces the chance that the three-phase induction motor will stop working. The system is designed to find problems and turn off the three-phase induction motor reliably, which makes it safer and more efficient for the three-phase induction motor. To make sure the system works, we made a computer model of the three-phase induction motor using MATLAB/Simulink. We tested the model with kinds of problems like too much current, low voltage, high voltage, short circuit, and overheating of the three-phase induction motor. We looked at how the three-phase induction motor worked under these conditions. We checked things like the speed and temperature of the three-phase induction motor. We then compared the results from the computer model with the results from the hardware. This helps us confirm that the system works well for the three-phase induction motor. It shows that it can find problems quickly and prevent the three-phase induction motor from failing. We also checked how well the system works based on how it finds problems, how fast it responds, and how well it protects the three-phase induction motor. This confirms that the system is good for protecting three-phase induction motors in industry.

IV. OBJECTIVE

• We are going to build a system that keeps an eye on electricity in time using the ESP32 microcontroller. This system is very important to us because it helps us monitor the electricity. We will use the ESP32 microcontroller to make this system work. The ESP32 microcontroller is the key to making this system function properly.

• We want to use the ESP32 microcontroller to make sure everything works as it should. The ESP32 microcontroller will help us monitor the electricity. We need the ESP32 microcontroller to make this system work.

• Our main goal is to measure things like voltage and current and power using the PZEM-004T module. The PZEM-004T module will help us measure the electricity. This is a part of our system. We will use the PZEM-004T module to get the data we need. Measuring electricity is very important.

• We need to know what is happening with the electricity. The PZEM-004T module will help us do that. We will use the PZEM-004T module to measure the electricity. This module is very useful.

• We also want to keep an eye on the temperature of the equipment all the time using the DS18B20 temperature sensor. The DS18B20 temperature sensor is very useful for this purpose. We will use the DS18B20 temperature sensor to measure the temperature. This is very important.

• We need to know the temperature of the equipment at all times to prevent any damage. The DS18B20 temperature sensor will help us do that. We will use the DS18B20 temperature sensor to get the temperature data.\

• The system will check these values against some limits that we set beforehand. The ESP32 microcontroller will do this check. It will look at the values from the PZEM-004T module and the DS18B20 temperature sensor to make sure everything is okay. If something is not right the system will take action.

• The ESP32 microcontroller will turn off the power if it needs to. This will prevent any damage to the equipment. The ESP32 microcontroller will control the power. This is an important feature.

• If something goes wrong the system will turn off the power automatically using a relay. This will keep the equipment safe from damage. The ESP32 microcontroller will control the relay. We want to protect the equipment and the ESP32 microcontroller will help us do that.

• The ESP32 microcontroller is very important for this purpose. We will use the relay to turn off the power. This is a feature. The system will help us protect the equipment.

• The system will show us what is going on with the electricity and temperature on a screen. We can use the screen to monitor the system and see what is happening. We can also use the ESP32 microcontroller to monitor the system from afar.

• The ESP32 microcontroller will help us monitor the system. This is very useful because we can keep an eye on the system even when we are not there. We can see what is happening. Get warnings if something is wrong.

• We want to make a web page that we can use to monitor everything from using Wi-Fi. The web page will be very useful for monitoring the system. We can use the web page to monitor the system and get warnings if something is wrong.

V. CONCLUSION AND FUTURE WORK

A. CONCLUSION

We will make sure the system is cheap and effective. We believe that everyone should be able to use this system. It should be cheap and effective. We want to help everyone with this system. This project is about building a system that can monitor power and temperature and protect the equipment using the ESP32 microcontroller. The ESP32 microcontroller is what we use to build the system. We use the ESP32 microcontroller to make the system work. The system always checks the electricity like voltage and current and power using the PZEM-004T module. The PZEM-004T module is very important for this purpose. We use the PZEM-004T module to measure electricity. The PZEM-004T module helps us get the data we need. It also checks the temperature of the equipment using the DS18B20 sensor. The DS18B20 sensor is very useful for this purpose. We use the DS18B20 sensor to measure temperature. The DS18B20 sensor helps us get the temperature data. The ESP32 microcontroller looks at the data from the sensors. It decides what to do based on the data. The ESP32 microcontroller is the brain of the system. It controls everything. It checks the values against some limits to see if something is wrong. If the values are too high the microcontroller turns on a relay to turn off the power. This keeps the equipment safe from getting hurt by electricity or heat. The ESP32 microcontroller protects the equipment. The system lets us monitor what is going on from afar. We can use a screen to see what is going on. We can also use a web page on the ESP32 microcontroller to monitor from afar. The ESP32 microcontroller helps us monitor the system. This lets us see what is going on and get warnings if something is wrong. We can even turn the relay on and manually if we need to. The system is very useful. The system is more reliable and safer because we can monitor and protect it automatically. It also means the equipment does not break down much. The system is very good. The solution we made is cheap. It uses energy. It is good for businesses and factories. We can make the system better by adding things. We will add features to the system. For example, we can use cloud storage and machine learning to predict when something might go wrong. This will make the system even better. We will use cloud storage and machine learning to improve the system. We will add features to the system.

B. FUTURE WORK-

• Using Artificial Intelligence on the Edge: We plan to use models that can run on the ESP32 microcontroller. This will let us protect the equipment even when it is not connected to the internet.

• The ESP32 microcontroller is very powerful. We will use it to run models that will help us protect the equipment. We can use it to run models that will help us protect the equipment.

• The ESP32 microcontroller is very good for this purpose. This is a feature. We will use the ESP32 microcontroller to run models.

• Using Sensors: We want to add sensors to the system. This will let us detect problems before they happen. We can use sensors that detect cracks and magnetic problems. The sensors will be very useful, for this purpose. This will help us fix problems before the equipment breaks down. The sensors will be very useful. We will use the sensors to detect problems.

VI. DECLARATIONS

The proposed "Induction Motor Protection Using Microcontroller and Fault Analysis by Simulation Model" system checks if it is possible to make a protection system for three-phase induction motors. This system uses a microcontroller and simulation to analyse faults. The goal is to find faults take action to protect the motor and make sure it is safe to operate. The system uses parts that're easy to find and simulation software.

1. Technical

The system is possible to make because it uses technologies that're available everywhere. These include microcontrollers like Arduino or PIC sensors to measure current, voltage and temperature relay modules and MATLAB/Simulink to simulate and analyze faults. All these parts can work together to monitor the motor find faults and protect it automatically. This can be done with accuracy and reliability.

2. Economic

The system is not too expensive because it uses low-cost parts that're available in the market. This reduces the cost of setting it up and maintaining it. The use of open-source programming tools and simulation software also reduces the cost of development. This makes the protection system suitable for medium industries.

3. Operational

The protection system is simple and easy to use. It always checks the parameters of the motor like current, voltage and temperature. If it finds any condition it automatically disconnects the motor to prevent damage. The system also has an LCD display and an alarm to show what is wrong. The operator can take action quickly.

4. Implementation

The project can be completed in a time using standard hardware and software. The hardware part is made using a microcontroller, sensors, relay module and display unit. MATLAB/Simulink is used to simulate and analyze fault conditions of the motor. By combining hardware and simulation we can check if the protection system works well in situations.

5. Social

The proposed Induction Motor Protection Using Microcontroller and Fault Analysis by Simulation Model system helps make industries safer and more reliable. It prevents motor failures and reduces downtime. By keeping the motor running the system helps industrial automation reduces maintenance costs and increases productivity in manufacturing and process industries. The "Induction Motor Protection Using Microcontroller and Fault Analysis by Simulation Model" system is good, for everyone.

VII. ACKNOWLEDGMENTS

The people who wrote this paper want to say thank you to the Department of Electrical Engineering and the people in charge of the schools that gave them the things they needed to do this study. They are grateful for the help they got with the equipment. The people who wrote this paper want to thank the person in charge of the project and the teachers for encouraging them and giving them ideas. They got help with the equipment the time they were working on the project and writing the paper. The people who wrote this paper also want to thank the people who work in the lab for helping them when they were testing the system that protects the induction motor. The people who wrote this paper want to thank the people who made MATLAB/Simulink because it is a tool for simulating things. Using MATLAB/Simulink helped the people who wrote this paper to see if their idea, for detecting things would really work.

VIII RESULT

The new Motor Fault Detection System that uses Artificial Intelligence was. Built and it worked well. This system uses a computer called ESP32 and it has special parts to measure how things are vibrating and how much current is being used. The Motor Fault Detection System looks at the information from these parts to figure out what is going on with the motor. It can tell when the motor is working properly and when it is not. The Motor Fault Detection System was. It worked very well at finding problems with the motor. It uses computer programs called Artificial Neural Network and Convolutional Neural Network to look at the information from the motor. These programs were trained using information from motors and bad motors. When the Motor Fault Detection System was tested it could tell the difference between a motor and a bad motor very accurately.

The Convolutional Neural Network program was better at looking at the information and figuring out what was going on than computer programs. The Motor Fault Detection System can also be watched from a distance using a website that shows how the motor is doing. The ESP32 sends information to this website all the time so people can see what is going on with the motor. If something is wrong with the motor the system will send a warning away. The Motor Fault Detection System is very good at finding problems with the motor before they get too bad. It can find problems like bearings or a rotor that is not balanced or a stator that is damaged or a shaft that is not straight. This means that the motor will not break down suddenly and it will save people money and time. The new Motor Fault Detection System is a way to watch the motor and fix problems before they get too bad. It uses a computer and a special website and Artificial Intelligence to make it work. The Motor Fault Detection System is a choice, for people who need to watch their motors and fix problems.

IX. REFERENCES

1. K. A. Yasa, I. M. Purbhawa, I. M. S. Yasa, I. W. Teresna, A. Nugroho, and S. Winardi, "IoT-based Electrical Power Recording using ESP32 and PZEM-004TMicrocontrollers," Journal of Computer Science and Technology Studies, Vol.5, No. 4, pp. 62–68, 2023.
2. K. M. W. Hidayat and M. G. Al-Faris, "IoT-Based Electrical Power Consumption Monitoring System in Households Using ESP32 and PZEM-004T," Brilliance: Research of Artificial Intelligence, Vol. 5, No. 2, 2025.
3. C. Ganesh, S. Mahesh, N. Sujay, and S. A. Mangamma, "Design and Implementation of an IoT-Based Smart Power Monitoring and Overload Protection System," International Journal of Engineering Research and Science & Technology, 2026.
4. Espress if Systems, "ESP32 Series Datasheet and Technical Reference Manual,"[Online].
Available: https://www.espressif.com.
5. Analog Devices, "DS18B20 Programmable Resolution 1-Wire Digital Thermometer Datasheet," [Online]. Available: https://www.analog.com.
6. Peace fair Electronic Technology, "PZEM-004T AC Energy Meter User Manual,"[Online]. Available: https://www.peacefair.cn.
7. A. Bahg a and V. Madisetti, Internet of Things: A Hands-On Approach, Universities Press, 2015.
8. E. A. Lee and S. A. Seshia, Introduction to Embedded Systems: A Cyber-Physical Systems Approach, MIT Press, 2015