

IOT-ENABLED SOLUTIONS FOR THREE-PHASE INDUCTION MOTOR OPTIMIZATION AND ENERGY EFFICIENCY

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ABSTRACT

In this study, a highly innovative IoT-based solution for controlling ten three-phase induction motors at the wastewater disposal facility is developed. Instead of conventional, labor-intensive, and error-prone manual operation of these motors, important equipment worth significant amounts may be jeopardized. Contactless motor control, utilization of ultrasonic sensors for real-time monitoring of wastewater levels, preventing motor dry running, and presentation of data through a web-based interface are the salient features of our system. Our results show a high-saving in-energy usage. In addition, we propose an IoT-driven methodology to monitor and evaluate the performance of three-phase induction motors. This approach involves harvesting and processing critical motor parameters through IoT technology, comprising voltage, current, temperature, and vibration sensors. These data are cloud-based and can be accessed from web and smartphone applications, enabling the provision of prompt fault notifications with historical data for predictive purposes. Further, we discuss an intelligent control board of the inductive appliances and focus on the Three-phase Induction motors. Our system integrates conventional protection with IoT-based technology. It works under both automatic and manual control. Finally, we discuss a real-time monitoring system for three-phase motors using wireless networks.

Keywords- Internet of Things (IoT), three-phase induction motor, styling, MIT Application.

1. INTRODUCTION

With the use of IP addresses, intelligent objects may be connected, managed, and monitored in the rapidly expanding field known as the Internet of Things (IoT). This constantly evolving IoT ecosystem has the power to fundamentally alter the way we engage with the real world. Remarkably, the US National Intelligence Council has predicted that IoT devices may eventually be able to pass for everything from food packaging and furnishings to more exotic items like paper documents [1]. In addition to the ease it provides in our daily lives, IoT is ushering in a new era of industrial systems transformation and the rise of "smart industries" [2].

In the pursuit of better connectivity, the deployment of wireless communication networks, such as Wi-Fi, is becoming more and more crucial. This change improves adaptability, lowers costs, and streamlines system complexity [3], [4]. In the industrial sector, where the versatile three-phase induction motor (IM), also known as the asynchronous motor, is an essential part of numerous applications, the effects of this shift are evident [5, 6].

The continuous interest in the control and optimization of IMs has led to the development of a variety of methods for regulating their rotating speed. These techniques include altering the rotor resistance, terminal voltage, pole numbers, and supply frequencies. Altering the electrical frequency is the most effective method of managing instant messages, and it works for all types of IMs [7]. When it comes to controlling frequency power in industrial settings, three-phase inverters are utilized more frequently than single-phase inverters [8].

Instant messaging does provide some challenges, though. Numerous factors, including as lubrication, alignment, electrical variables, ventilation, and load conditions, might lead to failures, vibrations, or overheating [9]. For effective monitoring of electric machinery, a wide range of variables must be evaluated, such as vibration, temperature, current, humidity, insulation resistance, sound, pressure, and capacitance [10], [11]. Previous studies have highlighted the detrimental impacts of vibrations and overheating, which are commonly brought on by issues like corrosion or misalignment. One significant challenge is that whereas IMs frequently need high-voltage AC power given in the form of sinusoidal waves, many typical controllers, such as the Node MCU board, produce square waves at specific frequencies [12]. Combining a variable-frequency driver (VFD) with the Node MCU board offers an appealing way to overcome this technological gap and regulate the IM's rotational speed. The Node MCU board's advantages include low power consumption, affordability, and simplicity of installation. A full Transmission Control Protocol/Internet Protocol (TCP/IP) stack and the required peripheral devices for data processing further support it [12].

The microcontroller (MCU) is an essential component of machine-to-machine communication. The MCU allows the transfer of sensing data over TCP/IP, enabling wireless communication to a cloud server. It can also receive sensor data via input pins and store the information for later use. An easy-to-use Android mobile app makes it possible for end users to easily access this data online. In the event that odd data patterns emerge, users can use the mobile app to remotely switch off the instant messaging gadget or alter its rotational speed. The versatile hypertext preprocessor (PHP), first created for web applications, serves as the foundation for data processing. The transport of sensor data is managed using JavaScript Object Notation (JSON).

2. RESEARCH OBJECTIVE

The purpose of this review paper is to critically examine the various uses and implications of the Internet of Things (IoT) in induction motors. With its quick growth and penetration into nearly every industry, IoT has brought about new potential that have an impact on modern life. This review focuses on the following particular goals: To Create Control Systems Based on the Internet of Things: Provide real-time control and monitoring capabilities for three-phase induction motor systems that are connected to the internet of things. To Increase Motor Efficiency: Examine how internet of things technology may maximize the speed, power consumption, and efficiency of three-phase induction motors. To put in place remote monitoring design systems that enable remote induction motor diagnosis and monitoring in order to promptly carry out maintenance and identify flaws. To Assess Cost-Effectiveness: Assess the benefits and expenses of using Internet of Things-based solutions to support industrial applications for motor optimization and energy efficiency.

3. METHODOLOGY

Induction motors are the most leading component and are used abundantly in industries. Such an induction motor needs to be strictly monitored and controlled. The current flowing through stator coils forms key discriminative features that are necessary for fault detection and classification within induction motors. Conventional wired system techniques pose space-related problems, as well as maintenance complexities, which prompt the industry to look for newer solutions.

Protection of induction motors is of great importance to overcome or avoid any further troubles arising due to high voltage, high current, high temperature, and more. These motors are widely used in cooling processes. These are the main components of systems and can be achieved with the help of 14 three-phase motors for 5.5KW loads, and also, 11 three-phase motors for 12.5 KW loads for Aisha Steel Mills Karachi. The major goal was to monitor the real-time values of current readings for all the three-phase motors in view and the wireless transmission of these data over a Wi-Fi connection. The reason for choosing this wireless mode over the wired version is that it involves a lot of complexity and the cost of maintenance, which significantly happens to be higher as compared with the efficient and cost-effective monitoring system of a wireless sensor-based.

4. SYSTEM DESIGN AND DEVELOPMENT

A. System Overall

Vibration sensors (piezoelectric piece knocking vibration switch), temperature sensors (Digital Temperature Sensor Probe DS18B20 for thermometer waterproof 100CM), voltage sensors (Single Phase Voltage Sensor ZMPT101B), and current sensors (CT Sensor 30A SCT-013-030) were used to enable the display of current, voltage, power, vibration, and temperature values of the Node MCU microcontroller (Node MCU ESP32) running on a three-phase induction motor (Misubishi: SF-JR 1 HP). A program that controls the function as receive-send signal parameters must be created in order to store the data. The outcomes must then be sent to the Thing Speak cloud platform.

Additionally, the website and the MIT smartphone application can be used to verify the electrical parameters and the traceability results as shown in the results.

Figure 1: Multiple users can simultaneously log in. Figure 1: The MIT App Inventor app is available on a mobile device. It can show data in real time, and several users can use a QR code to log in at once simultaneously through a QR code

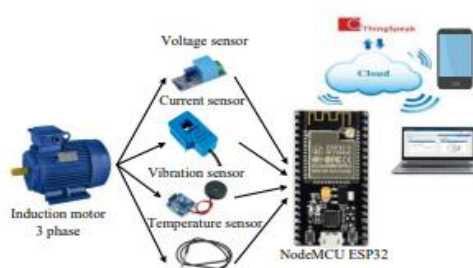


Fig. 1. Diagram model of induction motors three-phase were tested and demonstrated with IoT.

B. Proposed System

Figure 2. System proposal the microcontroller (in Fig. 1) should be set up to familiarize itself with the sensor values first. The sensors transfer the data to the microcontroller for processing. After that, the microcontroller sends data to the Thing Speak cloud platform, which establishes a connection with the MIT software. Data will be sent for smartphone display as a result. The microcontroller will notify the user through their phone's Line app when a parameter is exceeded.

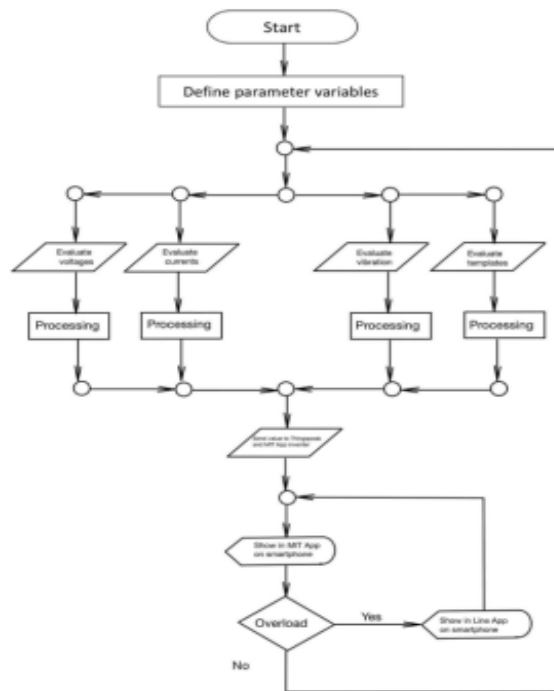


Fig.2. Flowchart model of induction motors three-phase were tested and demonstrated with IoT.

C. System Design of the Proposed IoT-Based Controller

Fig. 1 depicts the system hardware of the proposed IoT-based controller for a three-phase IM. The system hardware monitors the IM's rotation speed and power supply.

The three phase IM's vibration and the surrounding environment are monitored by the SW-420 vibration sensor and the humidity and temperature sensor (DHT22), as seen in Fig. 1. The ESP8266's register stores information on temperature, humidity, motor speed, and vibration.

a Wi-Fi module with an MCU. The web server then uses the data that was stored on the NodeMCU board and looks through it in the web server database. The web server sends an alert to the smart home in the event that the datum value exceeds the cutoff point value.

Therefore, the user can choose to turn the three-phase instantaneous machine on or off or change its spinning speed by using the specifically designed smartphone app. The IM's energy source is controlled by a high-voltage relay module that sits between the NodeMCU board and the VFD inverter. Therefore, if the relay module receives a high (1) signal from the NodeMCU, the three-phase IM is turned on. In contrast, the IM is disabled by setting the output signal. on the NodeMCU, low (0). Through a Wi-Fi connection, an Android device can scan and send or receive sensor data from the NodeMCU board. In addition to being available through a smartphone, the user can retrieve or write the recorded data onto a database.

• Sensors

Sensors are used to detect events or measure changes in their surroundings. The SW-420 sensor is a vibration sensor that measures the vibration of the motor. Both temperature and humidity can be measured via the DHT-22 sensor. the ambient humidity and temperature of the IM. The ESP8266 NodeMCU module receives the sensing data, which is then stored in the database for subsequent use.

• NodeMCU Module ESP8266

The ESP8266 module is a reasonably priced board with robust on-board computing power and complete TCP/IP capability. The open-source NodeMCU module has separate input/output general-purpose pins and a 4 MB storage source for an Internet of Things device. The 3.3 volts that are supplied to the ESPA-2166 module are used to program it. The Arduino IDE software. The ESP8266 module is used in this study. efficiently processed the sensing

data and connected a range of sensors. The pace at which the instant message rotates and the sensor data are modifiable via a smartphone app and stored in a database via a web server-connected Wi-Fi network.

- Module of Relay

The relay module is the high-voltage switch that turns the instant messaging device on and off. If the ESP8266 module's control signal is high (1), the instant messaging device activates. Conversely, the IM is disabled if the control signal is low (0). The relay module, an essential instrument in the digital revolution of sectors and our daily life, allows the three-phase IM's remote control to be controlled with less concern.

- Web Server

The system's software includes a web server for storing web pages and handling HTTP requests, an Arduino IDE for programming the NodeMCU board, and an Android Studio for developing an easy-to-use Android application. The web server's capacity to transport data in real-time from sensors and the three-phase induction motor via an ESP8266 NodeMCU module allows users to retrieve data from their PCs or smartphones. The Arduino IDE is used for programming and control, while the Android app lets users adjust the motor's speed. The web server analyzes data and alerts users to issues when there are irregularities, empowering them to make informed decisions on their vehicle command. Motor control and monitoring are made possible by this software stack over the Internet of Things.

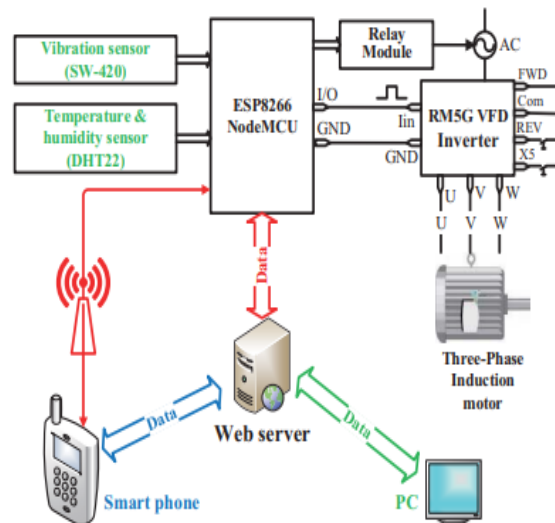


Fig. 3 Proposed topology of the IoT-based controller of the threephase IM

5. REAL-TIME MONITORING SYSTEM FOR THREE PHASE INDUCTION MOTOR

- Architecture of the System

The real-time monitoring solution for three-phase motors ensures consistent and quick monitoring by leveraging the power of wireless networks. Every three-phase induction motor in an industrial setting has sensors installed in strategic positions by the system's architecture. Vibration, temperature, voltage, current, and other crucial information are continuously collected by these sensors. The wirelessly sent data is received by a central microcontroller.

allowing for analysis and aggregation in real time.

- Technology for Wireless Communication

Our real-time monitoring system is based on our advanced wireless connection technology. The microcontroller, sensors, and central monitoring station can all communicate easily thanks to this technology. It is crucial to choose between wireless protocols like Bluetooth and Wi-Fi in order to enable reliable, quick, and two-way data transfer. This methodology ensures real-time motor performance updates and increases the system's adaptability to different industrial conditions.

- Transmission of Data

For real-time monitoring to be successful, data transport must be efficient. The system makes use of sophisticated data transmission protocols to facilitate the safe and efficient transfer of data from the sensors to the central hub. Wireless networks allow for instantaneous communication of collected data, which speeds up analysis and decision-making. Standardized protocols are utilized to ensure interoperability with existing devices and infrastructure, which increases the system's dependability and ease of integration.

- Real-time monitoring's advantages

Real-time three-phase motor monitoring has various benefits for industrial applications.

Fast Fault Detection: The system detects anomalies or irregularities in motor function rapidly, enabling timely corrective action to prevent potential issues.

Proactive Maintenance: Continuous monitoring enables proactive maintenance and minimizes unscheduled downtime by identifying issues early on.

Energy Optimization: Real-time data on motor settings enables dynamic adjustments that maximize energy consumption and raise total energy efficiency.

Enhanced Productivity: Real-time motor monitoring guarantees consistent and reliable performance, lowering unscheduled disruptions and increasing overall productivity.

6. CONCLUSION

Figure 4 illustrates the thorough method this study offers for the continuous monitoring of three-phase induction motors in industrial settings. A range of sensors, including temperature, voltage, current, and vibration sensors, are used by the system. The gathered data is sent to the ThingSpeak cloud platform via the ESP32 NodeMCU. By allowing both manual and Internet of Things (IoT)-based operation, which reduces the requirement for physical presence, this innovative design reduces labor expenses.

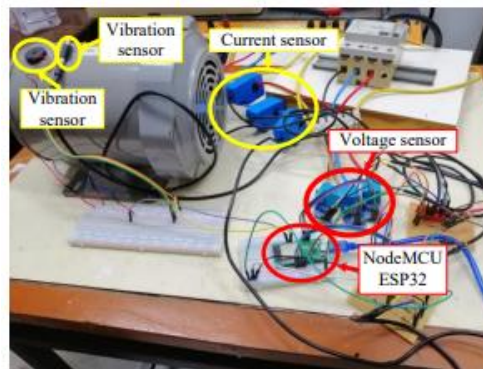


Fig. 4. Hardware control of the three-phase induction motor with IoT.

The use of smart panels for inductive loads in industries allows for effective administration and availability via Wi-Fi, providing a rapid and easy operating system in contrast to human interaction. This smart panel serves as a backup in case of technical issues and permits manual operation if required. Additionally, IoT enables remote management of mechanical and electrical issues, which enhances overall system performance. Industrial energy management is improved when specific motor issues are addressed with MATLAB/SIMULINK and a molded case circuit breaker is employed for maintenance.

The study places a strong emphasis on continuous monitoring, timely notifications, and extensive data archiving. The cloud-based application ensures ongoing motor health inspections by making it simpler to track and evaluate motor performance on-site.

Following successful bench testing, the accuracy for notional loading percentages between 82% and 110% was found to be within $\pm 10\%$. This is a significant advance in gathering information on the energy efficiency of operational electric motors and provides a workable alternative to continuous industrial motor system monitoring.

With the aim of enhancing the sensitivity, precision, and overall efficacy of command controllers, the fundamental work of this research may eventually result in the development of Internet of Things-based motor monitoring systems. Opportunities for additional research and development in the area of industrial energy management are presented by the combination of non-intrusive electronic systems, cloud-based applications, and real-time monitoring. One possible application of IoT systems is the fixing of different types of motor failures.

7. REFERENCE

- [1] "IoT-Based Vibration Analytics of Electrical Machines," by D. Ganga and V. Ramachandran, IEEE Internet of Things Journal, vol. 5, no. 6, pp. 4538-4549, December 2018
- [2] "IoT-based traction motor drive condition monitoring in electric vehicles: Part 1 by J. Kunthong, T. Sapaklom, M. Konghirum, C. Prapanavarat, P. Navaratana, N. Ayudhya, E. Mujjalinvimut, and S. Boonjeed, Digests IEEE 12th International Conference on Power Electronics and Drive Systems (PEDS), Honolulu, HI, 2017, pp. 1,184-1,188. 2018; Education (eLSE),

-
- [3] Assessment of Arduino-based das for-induction motor condition monitoring, Proceedings of the International Conference on Information, Communication, Instrumentation and Control (ICICIC), Indore, 2017, pp. 1–4. P. Sharma and S. R. Kapoor.
- [4] "Induction Motor Parameter Monitoring System using Zig bee Protocol & MATLAB GUI: Automated Monitoring System," by V. C. Khairnar and K. Sandeep, is published in Digests 4th International Conference on Advances in Electrical, Electronics, Information, Communication, and Bio-Informatics (AEEICB), Chennai, 2018, pp. 1-6.
- [5] Shaikh, Shoaib, Ghulam Abid, Safeeullah Soomro, Najeebullah Shaikh, Fahad Razaque, and Nareena Soomro. "Analysis of Illumination Lamp's Performance by Retrofit at University Building." Between 137 and 152 in International Conference for Emerging Technologies in Computing. Cham: Springer, 2018.
- [6] Islam, A.; Rahman, A.; & Al Mamun, A. (2017). Chatbot programming challenges: present and future outlook. Area 10 Humanitarian Technology Conference (R10-HTC), IEEE, 2017, pp. 75–78. IEEE.
- [7] IoT-based condition monitoring of three-phase induction motor," by P. M. Akotkar, V. S. Karale, and A. U. Jawadekar, International "Induction Motor Parameter Monitoring System using Zig bee Protocol & MATLAB GUI: Automated Monitoring System," by V. C. Khairnar and K. Sandeep, is published in Digests 4th International Conference on Advances in Electrical, Electronics, Information, Communication, and Bio-Informatics (AEEICB), Chennai, 2018, pp. 1-6.
- [8] Shaikh, Shoaib, Ghulam Abid, Safeeullah Soomro, Najeebullah Shaikh, Fahad Razaque, and Nareena Soomro. "Analysis of Illumination Lamp's Performance by Retrofit at University Building." Between 137 and 152 in International Conference for Emerging Technologies in Computing. Cham: Springer, 2018.
- [9] Islam, A.; Rahman, A.; & Al Mamun, A. (2017). Chatbot programming challenges: present and future outlook. Area 10 Humanitarian Technology Conference (R10-HTC), IEEE, 2017, pp.75–78,IEEE.
- [10] IoT-based condition monitoring of three-phase induction motor," by P. M. Akotkar, V. S. Karale, and A. U. Jawadekar, International 2018 2nd International Conference on (pp. 329-335). IEEE.