Erudite Journal of Engineering Technology and Management Sciences

Vol. 2, No. 1, March 2022, pp. 05-07

Journal homepage: http://www.ejetms.com

E-ISSN: 2583-2131

IOT-BASED THREE-PHASE INDUCTION MOTOR SPEED CONTROL AND MONITORING

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Received: 02 January 2022
Accepted: 01 March 2022

Keywords:
Induction Motor,
IoT,
Speed Control,
Remote Monitoring,
Embedded System,
Smart Maintenance

ABSTRACT

This paper presents the design and implementation of an IoT-based system for the speed control and real-time monitoring of a three-phase induction motor. The system integrates a microcontroller, sensors, and Wi-Fi communication to enable remote access and control through a web interface or mobile application. The proposed method not only improves operational efficiency but also enables predictive maintenance by logging critical parameters such as speed, voltage, and current. The system is tested in real-time conditions and demonstrates reliable control and effective monitoring capabilities.

1. INTRODUCTION

In modern manufacturing industries, electric motors play a crucial role in driving mechanical and electromechanical systems. Historically, DC motors were predominantly used to meet industrial demands. However, with the advent of AC induction motors, their superior performance characteristics have made them the preferred choice for industrial automation. The key advantages of induction motors include their simple rotor construction, which contributes to lower cost, increased durability, and minimal maintenance requirements. A study of induction motor construction and operation highlights three major categories of faults: electrical, mechanical, and environmental. Electrical faults arise from issues such as unbalanced supply voltage or current, single phasing, under or over voltage, and overload conditions. Mechanical faults include problems like broken rotor bars, mass imbalance, air gap eccentricity, bearing damage, and failures in both rotor and stator windings. Environmental faults are typically caused by ambient temperature fluctuations, external moisture, and machine vibrations. The performance of an AC induction motor is highly dependent on these electrical, mechanical, and environmental parameters. Consequently, control methods for such motors must be finely tuned to these parameters, emphasizing the necessity for continuous monitoring to ensure uninterrupted operation and to predict faults before they lead to breakdowns.

In this context, the rise of the Internet of Things (IoT) has emerged as a transformative force in industrial automation, driven by rapid advancements in wireless telecommunications [3]. IoT enables remote access and control by allowing individual devices or entire systems to communicate over a shared platform [1], [8]. This concept of a “System of Systems” fosters enhanced communication and data exchange among devices, including performance metrics, logs, and statistical data. As a result, industries can leverage this interconnected environment to boost productivity, optimize management, and enhance overall throughput [9]

2. LITERATURE REVIEW

Over the past two decades, significant efforts have been made in the field of induction machine monitoring, leading to the development of numerous techniques with varying advantages and limitations. One notable method introduced in 2008 involves a non-intrusive and in-service motor efficiency estimation approach using the Air Gap torque method [4]. This technique requires only motor terminal quantities and nameplate details, along with pre-installed potential and current transformers, commonly used for protection purposes. However, it necessitates continuous on-site monitoring of motor parameters. Another technique proposes a low-cost wireless sensor network designed for monitoring high-range induction motors in the field [5]. This system features a smart switch equipped with a data logger to track operating conditions and manage winding connection modes automatically. Despite its cost-effectiveness, its application is limited to small areas due to the lack of long-range communication capabilities. Supervisory Control and Data Acquisition (SCADA) systems are also employed to develop user interfaces for motor monitoring. However, these systems offer limited adaptability due to the high cost of their software libraries. Wireless communication technologies such as RF, ZigBee, and Bluetooth are commonly used for short-range, simple applications owing to their ease of use and low data volume requirements [5], [6]. Nonetheless, these technologies are constrained by slow communication speeds, limited range, and data security concerns. Additionally, more advanced systems such as PLC-SCADA-based fault detection and protection systems offer web-based remote control and monitoring functionalities. While effective, their main drawback is their high cost. Lastly, the combination of the bacterial foraging algorithm with non-intrusive efficiency estimation methods has been explored [7]. Though potentially effective, this approach tends to be computationally intensive and complex in practice.

3. METHODOLOGY

The system comprises a NodeMCU microcontroller for Wi-Fi communication, a tachometer for speed sensing, and a TRIAC-based voltage controller interfaced with a web server. The NodeMCU reads speed data from the tachometer and uploads it to a cloud database. Users can monitor this data through a web or mobile interface. Speed commands sent from the interface are interpreted by the NodeMCU, which adjusts the firing angle of the TRIAC accordingly to control the motor's voltage and speed. The entire setup was prototyped on a lab-scale three-phase motor.

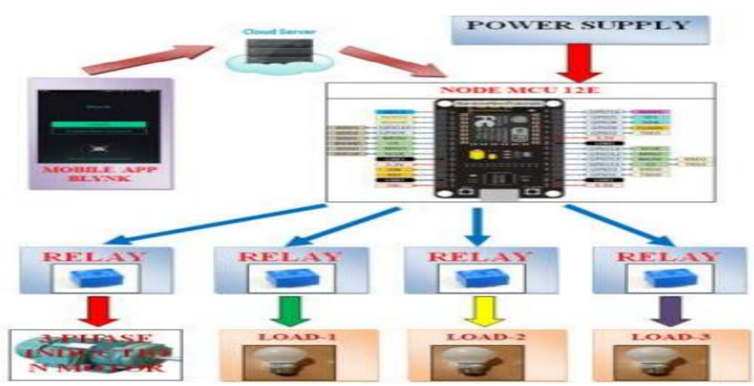

Figure. 1. Schematic diagram of IoT-based Control and Monitoring Architecture for Induction Motor.

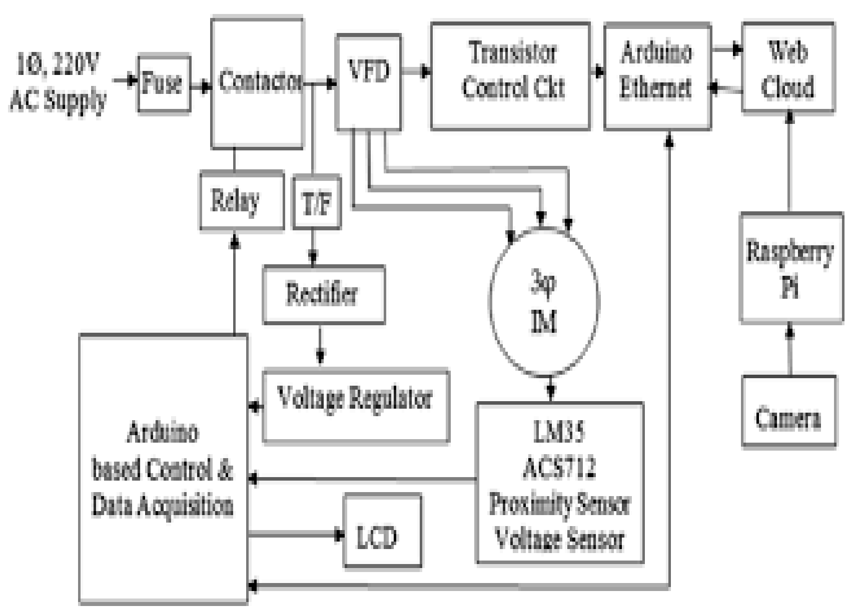

Figure 2 Block Diagram

4. RESULTS

The developed IoT-based system for monitoring and controlling a three-phase induction motor proved to be highly effective during implementation and testing. These sensors were connected to an ATmega328 microcontroller, with the ESP8266 Wi-Fi module facilitating wireless data transmission to online platforms like ThingSpeak and the Blynk mobile applicationThe voltage and current readings obtained via potential and current transformers were accurate, while the LM35 sensor provided reliable temperature measurements. An infrared sensor tracked motor speed effectively. Furthermore, the system enabled remote operation of the motor, such as turning it on or off through the interface app. Overall, the integration of hardware and IoT components allowed for continuous and accurate monitoring, providing early warnings in case of abnormal conditions and enhancing overall motor safety and efficiency.

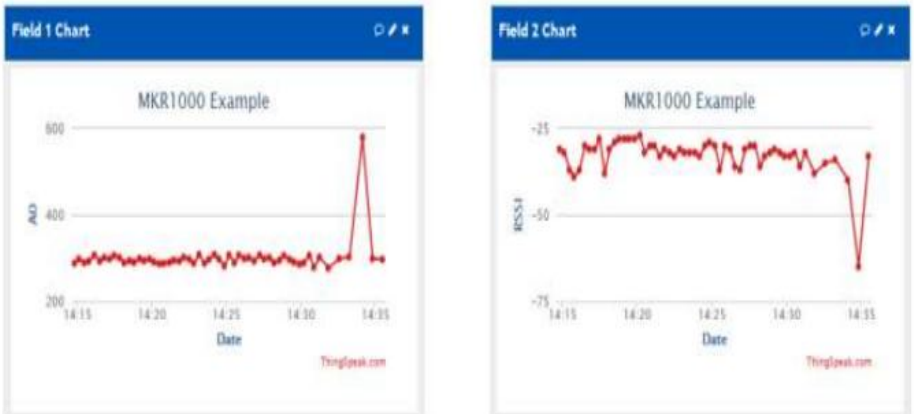

Figure 3. Reference Thing Speak Graph of current vs Time

5. CONCLUSION

The research presents a comprehensive IoT-based solution for the monitoring and control of three-phase induction motors. By integrating various sensors with microcontroller and Wi-Fi technologies, the system enables real-time data acquisition and remote accessibility. This approach facilitates early detection of potential faults, thereby enhancing preventive maintenance strategies and reducing the likelihood of unexpected motor failures. The ability to monitor critical parameters such as voltage, current, temperature, and speed remotely contributes to improved operational efficiency and reliability of industrial motor systems. The successful implementation and testing of this system underscore its potential applicability in various industrial settings, offering a cost-effective and efficient solution for motor parameter monitoring and control.

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