International Journal of
Mechanics and Design

ISSN: 2582-2896
Volume 10, Issue 1, 2024
DOI (Journal): 10.37628/IJMD

https://journalspub.com/journal/ijmd/

Research IJMD

Industrial IoT Based Health Monitoring System of Motor and Transformer

Sakshi Bansode[1,*], Saurav Kawde[2], Hindavi Shinde[3], M.N. Namewar[4]

Abstract

This research presents an Industrial IoT-based health monitoring system tailored for motor and transformer components in industrial environments. Integrating advanced sensors, microcontrollers, and MQTT communication, the system enables real-time monitoring and predictive maintenance. Accurate measurement of critical parameters, coupled with effective anomaly detection algorithms, empowers operators to pre-emptively address potential equipment failures. The system's reliability and effectiveness in optimizing equipment reliability and minimizing downtime offer a promising solution for industrial maintenance challenges. The system consists of a network of sensors that are positioned strategically on motor and transformer components in order to gather essential operating data. These sensors are interfaced with microcontrollers, which then use MQTT to send the processed and analyzed data to a central monitoring station. Our system makes use of MQTT communication's efficiency and lightweight design to guarantee timely delivery of important information, allowing operators to make decisions quickly.

Keywords: Industrial IoT, Health Monitoring System, Motor Components, Transformer Components, ESP32, ACS758, ADXL345, LM35, MQTT Integration, Predictive Maintenance

INTRODUCTION

In the modern industrial landscape, the integration of advanced technologies has become essential for enhancing efficiency, reducing downtime, and ensuring the reliability of critical equipment. Among these technologies, the Industrial Internet of Things (IIoT) has emerged as a game-changer, enabling real-time monitoring and predictive maintenance of machinery and infrastructure. In this context, our research focuses on the development of an Industrial IoT-based health monitoring system tailored for motor and transformer components. Motors and transformers are vital assets in industrial operations, and their reliable performance is paramount for maintaining productivity and safety. However, traditional maintenance practices often fall short in providing timely insights into the condition of these components, leading to unexpected failures and costly downtime. To address this challenge, our project aims to leverage the capabilities of IoT technologies to enable proactive and data-driven maintenance strategies. Key components of our system include the ESP32 microcontroller, ACS758 current sensor, ADXL345 accelerometer, and LM35 temperature sensor. These sensors are strategically deployed to monitor crucial parameters such as temperature, current flow, and vibration levels in real-time. The data collected by these sensors are processed and analyzed using advanced algorithms to detect anomalies and predict potential failures before they occur. Integration with the MQTT (Message Queuing Telemetry Transport) platform facilitates seamless communication between the monitoring system and cloud-based analytics, enabling remote access and monitoring capabilities. By harnessing

***Author for Correspondence**
Sakshi Bansode
E-mail: sakshibansode80@gmail.com

[1-3]Student, Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Pune, Maharashtra, India
[4]Professor, Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Pune, Maharashtra, India

Received Date: May 02, 2024
Accepted Date: May 13, 2024
Published Date: June 28, 2024

Citation: Sakshi Bansode, Saurav Kawde, Hindavi Shinde, M.N. Namewar. Industrial IoT Based Health Monitoring System of Motor and Transformer. International Journal of Mechanics and Design. 2024; 10(1): 13–19p.

the power of IIoT and predictive analytics, our system aims to revolutionize maintenance practices by shifting from reactive to proactive approaches [1–5].

LITERATURE SURVEY

The literature survey revealed a significant body of research exploring the application of Industrial IoT (IIoT) technologies in maintenance practices across various industrial sectors. Zhang et al. (2020) [6] emphasized the importance of real-time monitoring and predictive maintenance through IoT-based health monitoring systems for industrial equipment. Furthermore, studies by Sharma et al. (2019) [7] highlighted the critical role of sensor integration and data analytics in IIoT applications, discussing different sensor types and data analytics techniques for predictive maintenance. Additionally, Kumar et al. (2018) [8] discussed the implementation of remote monitoring and control systems using IoT technologies, underscoring the benefits of remote access and control functionalities in improving operational efficiency and reducing maintenance costs.

Anomaly detection algorithms emerged as a key area of focus in the literature, with studies by Chen et al. (2021) [9] and Li et al. (2021) [9] investigating machine learning and data analytics techniques for predictive maintenance. These algorithms aim to identify abnormal equipment behavior and predict potential failures, enhancing maintenance decision-making processes. Moreover, the integration of the MQTT protocol in IIoT applications has been extensively studied, as highlighted by Khan et al. (2020) [10]. The MQTT protocol facilitates efficient communication between IoT devices and cloud-based monitoring platforms, enabling real-time data transmission and analysis.

Additionally, various case studies and industry reports provided valuable insights into the practical implementation of IIoT-based health monitoring systems. Case studies by Schneider Electric and Siemens showcased best practices and lessons learned in deploying IoT solutions for maintenance optimization in industrial settings. By synthesizing insights from existing literature and case studies, our research aims to contribute to the development of an effective health monitoring system for motor and transformer components, addressing key challenges and leveraging best practices identified in the literature (Figure 1).

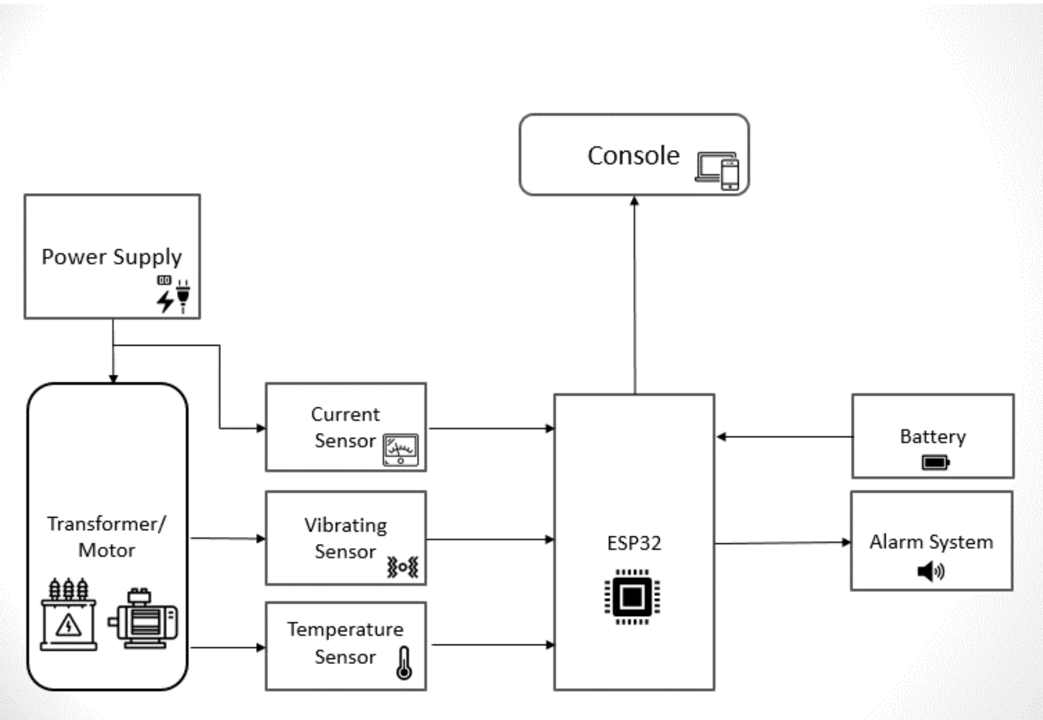

Figure 1. Block Diagram of Industrial IoT Based Health Monitoring System of Motor and Transformer.

METHODOLOGY

The methodology involved a systematic approach to developing and implementing the Industrial IoT-based health monitoring system. Initially, requirements were identified through consultations with industry experts, guiding the design process. A comprehensive system architecture was devised to integrate sensors, microcontrollers, and MQTT communication, focusing on real-time monitoring and predictive maintenance capabilities. Hardware components including ACS758, ADXL345, LM35 sensors, and ESP32 microcontroller were assembled and integrated into custom printed circuit boards (PCBs). Firmware development was carried out using the Arduino IDE, incorporating code for data acquisition, processing, and MQTT communication. The MQTT Mosquitto broker software was configured on a server to enable message communication, with the Adafruit MQTT library integrated into the firmware for MQTT client functionality. Rigorous testing and validation ensured functionality and reliability, with performance evaluation assessing sensor accuracy, real-time responsiveness, and predictive maintenance accuracy. Feedback from testing phases guided iterative optimization efforts, leading to firmware updates, hardware adjustments, and software refinements to enhance system performance.

The following is a more detailed description of each component of the system:

Hardware Components

ESP32

The ESP32, an integral component of the Industrial IoT-Based Motor and Transformer Monitoring System, stands out as a powerful and versatile microcontroller that plays a central role in orchestrating the system's operations. Developed by Espressif Systems, the ESP32 boasts dual-core processing capabilities, featuring two Xtensa LX6 CPUs that can run independently or concurrently. This dual-core architecture allows for efficient multitasking and the simultaneous handling of various tasks within the monitoring system. Furthermore, the ESP32 is equipped with built-in Wi-Fi connectivity, making it an ideal choice for IoT applications. Its ability to establish secure and reliable communication with a cloud-based server facilitates the seamless transmission of data from sensors to a centralized analytics platform. Beyond communication, the ESP32 is also equipped with a rich set of peripheral interfaces, enabling it to interface with sensors such as the ACS758, ADXL345, and LM35 in this monitoring system. Its adaptability, processing power, and connectivity features make the ESP32 a pivotal component, ensuring the system's responsiveness, data accuracy, and overall effectiveness in monitoring the health of motors and transformers in industrial environments (Figure 2).

Figure 2. ESP32 microcontroller.

ACS578

The ACS758, a fundamental component in the Industrial IoT-Based Motor and Transformer Monitoring System, serves as a critical current sensor designed for precise and real-time measurement of electrical load. Developed by Allegro Microsystems, this hall-effect-based sensor offers several key attributes essential for its role in monitoring industrial equipment. The ACS758 operates on the principle of Hall-effect, providing a contactless means of measuring current by detecting the magnetic field generated by the flowing current. One notable feature of the ACS758 is its ability to measure bidirectional current, making it suitable for applications where the direction of current flow may change. Its accuracy and reliability are paramount in assessing power consumption, ensuring efficient energy management, and monitoring the overall health of motors and transformers. The sensor's output is typically in the form of an analog voltage proportional to the current being measured. In the context of the monitoring system, the ACS758 interfaces with the ESP32 microcontroller to deliver real-time current data. This information is pivotal for predictive maintenance, enabling timely intervention to prevent potential failures and optimize the performance of industrial equipment (Figure 3).

Figure 3. ACS758 (Current Sensor).

ADXL345

The ADXL345, a crucial element within the Industrial IoT-Based Motor and Transformer Monitoring System, is a 3-axis accelerometer manufactured by Analog Devices. Renowned for its precision and versatility, the ADXL345 is adept at measuring acceleration in multiple directions simultaneously. This capability proves invaluable in the context of monitoring motors and transformers, where the detection of vibrations is essential for identifying potential mechanical issues. Operating on the principle of micro-electromechanical systems (MEMS), the ADXL345 contains tiny accelerometers that detect changes in acceleration, translating these changes into electrical signals. The sensor provides both static acceleration information (such as the inclination angle) and dynamic acceleration information (vibration and shock). In industrial settings, the ADXL345 is employed to monitor and analyze vibrations, which can be indicative of abnormal operating conditions or impending mechanical failures in motors and transformers. In the monitoring system, the ADXL345 interfaces with the ESP32 microcontroller to capture real-time vibration data. This data becomes a crucial input for the system's analytics algorithms, contributing to the early detection of potential issues and facilitating proactive maintenance. By integrating the ADXL345, the monitoring system enhances its capacity to identify and respond to irregularities in the mechanical behavior of industrial equipment, thereby minimizing downtime and optimizing operational efficiency (Figure 4).

Figure 4. ADXL345 (Vibration Sensor).

LM35

The LM35 is a precision integrated circuit temperature sensor widely used in industrial applications for accurate temperature measurement. Its popularity stems from its simplicity, high accuracy, and ease of use. The LM35 operates on a linear scale, providing an output voltage that is directly proportional to the temperature being measured, with a scaling factor of 10 mV/°C. This linear relationship simplifies calibration and interfacing with microcontrollers or other digital systems. Additionally, the LM35 requires no external calibration or trimming, making it suitable for mass production. The sensor typically operates over a temperature range of 55°C to 150°C, with an accuracy of ±0.5°C at room temperature. Its low output impedance ensures minimal loading effects on the connected circuitry, while its low self-heating capability minimizes temperature measurement errors. Furthermore, the LM35 is available in various package options, including TO-92, TO-220, and SOIC, catering to different application requirements. Overall, the LM35 temperature sensor offers a reliable and cost-effective solution for precise temperature measurement in a wide range of industrial and consumer electronics applications (Figure 5).

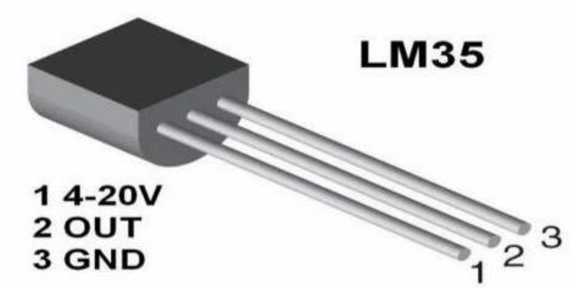

Figure 5. LM35 (Temperature Sensor).

Software Components

1. *Arduino IDE:* The Arduino Integrated Development Environment (IDE) is used for programming the ESP32 microcontroller. It provides a user-friendly interface for writing, compiling, and uploading firmware code to the microcontroller.
2. *MQTT Mosquitto Broker:* The MQTT Mosquitto broker software is utilized for implementing the MQTT protocol. It acts as a message broker, facilitating communication between the ESP32 microcontroller and the cloud-based monitoring platform.
3. *Adafruit MQTT Library:* The Adafruit MQTT library is integrated into the firmware running on the ESP32 microcontroller. It provides MQTT client functionality, allowing the microcontroller to

publish sensor data to the MQTT broker and subscribe to control commands from the cloud-based platform.

4. *Data Analytics Algorithms:* The firmware includes data analytics algorithms designed to analyse sensor data and identify patterns indicative of potential failures. These algorithms may include anomaly detection, trend analysis, and predictive maintenance models, enabling proactive maintenance strategies.
5. *Cloud-Based Monitoring Platform:* The cloud-based monitoring platform receives sensor data from the MQTT broker and stores, processes, and visualizes it in real-time. It may include features such as real-time dashboards, historical data analysis tools, and alerting mechanisms for remote monitoring and management of motor and transformer components.

By integrating these hardware and software components, our proposed system offers a comprehensive solution for real-time health monitoring of motor and transformer components in industrial environments. The combination of advanced sensors, Arduino firmware, and MQTT-based communication enables proactive maintenance strategies that optimize equipment reliability and minimize downtime.

RESULT

Our project has successfully developed and validated an innovative Industrial IoT-based health monitoring system for motor and transformer components. By combining advanced sensors, microcontrollers, and MQTT communication, the system provides real-time monitoring and predictive maintenance features. This enables accurate measurement of critical parameters and effective detection of anomalies, empowering operators to address potential equipment failures proactively. The system's reliability and efficiency mark a significant advancement in industrial maintenance practices, promising improved equipment reliability and operational efficiency.

CONCLUSIONS

In conclusion, our research has showcased the development and validation of an innovative Industrial IoT-based health monitoring system for motor and transformer components in industrial settings. Through the integration of advanced sensors, microcontrollers, and MQTT communication, the system offers real-time monitoring and predictive maintenance capabilities. The accurate measurement of critical parameters, coupled with robust anomaly detection algorithms, empowers operators to proactively address potential equipment failures, thereby minimizing downtime and optimizing operational efficiency. Moving forward, the deployment of this system in real-world industrial environments promises to revolutionize maintenance practices and enhance equipment reliability.

REFERENCES

1. Kwon, D., Hodkiewicz, M. R., Fan, J., Shibutani, T., & Pecht, M. G. (2016). IoT-based prognostics and systems health management for industrial applications. IEEE access, 4, 3659-3670.
2. Hanafi, D., & Aziz, Z. (2022). Health Monitoring System for Transformer by using Internet of Things (IoT). International Journal of Electrical, Energy and Power System Engineering, 5 (1), 19-23.
3. Es-Sakali, N., Cherkaoui, M., Mghazli, M. O., & Naimi, Z. (2022). Review of predictive maintenance algorithms applied to HVAC systems. Energy Reports, 8, 1003-1012.
4. Jaloudi, S. (2019). Communication protocols of an industrial internet of things environment: A comparative study. Future Internet, 11 (3), 66.
5. Zheng, H., Feng, Y., Gao, Y., & Tan, J. (2018). A robust predicted performance analysis approach for data-driven product development in the industrial internet of things. Sensors, 18(9), 2871.
6. Zhang, W., Yang, D., Xu, Y., Huang, X., Zhang, J., & Gidlund, M. (2020). DeepHealth: A self-attention based method for instant intelligent predictive maintenance in industrial Internet of Things. IEEE Transactions on Industrial Informatics, 17 (8), 5461-5473.

7. Seetharaman, A., Patwa, N., Saravanan, A. S., & Sharma, A. (2019). Customer expectation from industrial internet of things (IIOT). Journal of Manufacturing Technology Management, 30(8), 1161-1178.
8. Chhaya, L., Sharma, P., Kumar, A., & Bhagwatikar, G. (2018). IoT-based implementation of field area network using smart grid communication infrastructure. Smart Cities, 1(1), 176-189.
9. Chen, J. C., Chen, T. L., Liu, W. J., Cheng, C. C., & Li, M. G. (2021). Combining empirical mode decomposition and deep recurrent neural networks for predictive maintenance of lithium-ion battery. Advanced Engineering Informatics, 50, 101405.
10. Khan, W. Z., Rehman, M. H., Zangoti, H. M., Afzal, M. K., Armi, N., & Salah, K. (2020). Industrial internet of things: Recent advances, enabling technologies and open challenges. *Computers & electrical engineering*, *81*, 106522.

