



IoT Based Motor Vibration and Temperature Detector For Real-Time Monitoring

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KEYWORDS

Motor Vibration
Real-Time Data Processing
Temperature Detection

ABSTRACT

The motor vibration and temperature detector utilizing IoT technology represents a sophisticated system for real-time monitoring of motor health. This device incorporates advanced sensors to measure both vibration levels and temperature variations, offering a thorough assessment of the motor's condition. Leveraging Internet of Things (IoT) connectivity, the detector transmits data to a centralized platform, enabling remote monitoring and immediate access to essential information. When positioned near the motor, the sensor collects data and uploads it to the ESP32, which functions as an interface between the programmer and the user, effectively serving as the project's core component. The temperature and vibration data are displayed on an LCD screen and through THINGER.IO. This setup allows for comprehensive analysis of the data, including the correlation between vibration and temperature measurements. Additionally, all data collected from the motor is recorded, facilitating in-depth analysis of vibration and temperature trends over time.

Received 14 August 2024; Revised 05 September 2024; Accepted 30 September 2024; Published 01 October 2024.

1.0 INTRODUCTION

In recent years, the integration of Internet of Things (IoT) technologies has revolutionized industrial monitoring systems, particularly in the context of motor performance. Motors are critical components in various industrial applications, and their efficient operation is vital for overall system reliability. However, motor failures often result from unmonitored vibrations and temperature fluctuations, which can lead to significant downtime and costly repairs [1]. This paper addresses the need for a proactive monitoring solution by proposing a Motor Vibration and Temperature Detector using IoT. The primary problem is the lack of real-time monitoring and early warning systems that can prevent motor failures. The objectives of this study are to develop a cost-effective IoT-based system capable of real-time detection and analysis of motor vibrations and temperature, to provide early warnings of potential failures, and to enhance maintenance protocols through timely data-driven insights [2]. The proposed IoT-based Motor Vibration and Temperature Detector is designed to bridge the gap between traditional motor monitoring methods and modern, proactive maintenance strategies. By leveraging IoT technology, this system enables real-time data collection and analysis, allowing for continuous monitoring of critical motor parameters such as vibration and temperature.

The integration of sensors within the motor system allows for the detection of even slight deviations from normal operating conditions [3]. These sensors transmit data wirelessly to a centralized platform, where it is analyzed to identify potential issues before they escalate into critical failures. The system's ability to provide real-time alerts enables maintenance teams to respond promptly, reducing the risk of unexpected downtime and costly repairs [4].

In addition to its real-time monitoring capabilities, the IoT-based system offers several other advantages. The data collected by the sensors is not only used for immediate fault detection but is also stored for long-term analysis. This historical data allows for trend analysis and predictive maintenance, where patterns of motor behavior can be identified, and potential issues can be addressed before they lead to failure. Moreover, the system's modular design ensures scalability, making it suitable for various industrial environments, regardless of the size or complexity of the motor systems in use. By providing a comprehensive view of motor health, the IoT-based detector supports a shift from reactive to proactive maintenance practices, ultimately enhancing overall system efficiency [5]. The implementation of the Motor Vibration and Temperature Detector is expected to bring significant benefits to industries that rely heavily on motor-driven systems [6]. By enabling continuous monitoring and early fault detection, this IoT-based solution reduces the likelihood of unexpected motor failures, thus minimizing downtime and associated costs. Furthermore, the insights gained from the system's data-driven analysis can lead to more informed maintenance decisions, extending the lifespan of motors and improving operational reliability. As industries continue to embrace digital transformation, the adoption of IoT-based monitoring systems like this one will play a crucial role in optimizing performance and ensuring the long-term sustainability of industrial operations [5], [6].

2.0 LITERATURE REVIEW

2.1 Microcontroller

The Internet of Things (IoT) has significantly transformed industrial monitoring practices by enabling real-time data collection and analysis. [7] provide a comprehensive overview of IoT-based industrial monitoring systems, highlighting their ability to enhance operational efficiency and predictive maintenance. Their study emphasizes the integration of IoT technologies in industrial settings, showcasing how these systems facilitate remote monitoring and management through real-time data acquisition [8]. [9] further elaborate on smart monitoring systems that leverage IoT for various industrial applications. They discuss the implementation of IoT frameworks to monitor parameters such as temperature, humidity, and vibration, and demonstrate how these systems contribute to proactive maintenance strategies [4], [10]

2.2 Temperature Sensor

Vibration analysis is a critical technique for diagnosing faults in rotating machinery, including motors. [11] review various vibration analysis techniques used for fault diagnosis, including Fast Fourier Transform (FFT) and time-domain analysis. They provide insights into the effectiveness of these methods in detecting anomalies and diagnosing motor issues [12]. [13] focus specifically on electrical motors, discussing how vibration analysis can identify different types of motor faults. Their study underscores the practical application of vibration analysis in motor health assessment and maintenance [14].

2.3 Integration of IoT with Vibration and Temperature Sensors

Integrating IoT with vibration and temperature sensors has revolutionized the monitoring of industrial equipment by enabling advanced data analytics and real-time tracking. [18] delve into the intricacies of this integration, emphasizing the architecture of the IoT framework designed for motor monitoring. Their research outlines how IoT technologies facilitate comprehensive data collection through various sensors and enable sophisticated real-time analytics. The study demonstrates that

incorporating IoT into motor monitoring systems not only enhances the accuracy of detecting anomalies but also optimizes maintenance schedules, thereby reducing downtime and operational costs [19], [20]. Expanding on this, [21] focus on the practical implementation of IoT-based sensor systems tailored for monitoring motor vibrations and temperatures. Their work underscores the critical design considerations required to effectively deploy IoT solutions in industrial settings. They discuss the system's capacity for continuous monitoring, which plays a crucial role in early issue detection and predictive maintenance. By integrating real-time data with advanced analytics, their system significantly improves the reliability of motors, contributing to more efficient and proactive maintenance strategies [22]. The integration of IoT with vibration and temperature sensors offers substantial benefits, including enhanced monitoring capabilities and improved operational efficiency. The combined efforts of [23], [24] illustrate the transformative impact of IoT technologies on industrial motor monitoring. Their research highlights how these advanced systems facilitate timely interventions and data-driven decisions, paving the way for more resilient and cost-effective industrial operations.

2.4 Data Processing and Analytics in IoT System

Effective data processing and analytics are essential for deriving actionable insights from IoT systems. [25], [26] discuss the role of big data analytics in IoT-based industrial monitoring, covering data storage, analysis, and visualization methods. Their study highlights how big data analytics can enhance the insights gained from IoT systems, leading to better decision-making and operational efficiency [27], [28]. [7], [29] provide an overview of data processing techniques for IoT applications, including filtering, anomaly detection, and predictive analytics. They emphasize the importance of these techniques in processing sensor data and deriving valuable insights for industrial applications [30], [31].

3.0 METHODOLOGY

The methodological approach of this research involves a structured process to achieve the project's objectives, divided into three key phases. In Phase 1, a preliminary study is conducted to identify relevant literature and journals, as well as to assess the suitability and limitations of various sensors for the project. Phase 2 entails a comprehensive literature review, focusing on analyzing previous research to understand methodologies and findings that inform the current study. The final phase involves conducting experiments to test hypotheses and achieve project goals, followed by a detailed analysis of the experimental data. This systematic approach ensures a thorough investigation, integrating theoretical insights with practical experimentation to effectively address the project's aims. Below is general block diagram of motor vibration and temperature detector using IoT.

3.1 General Block Diagram

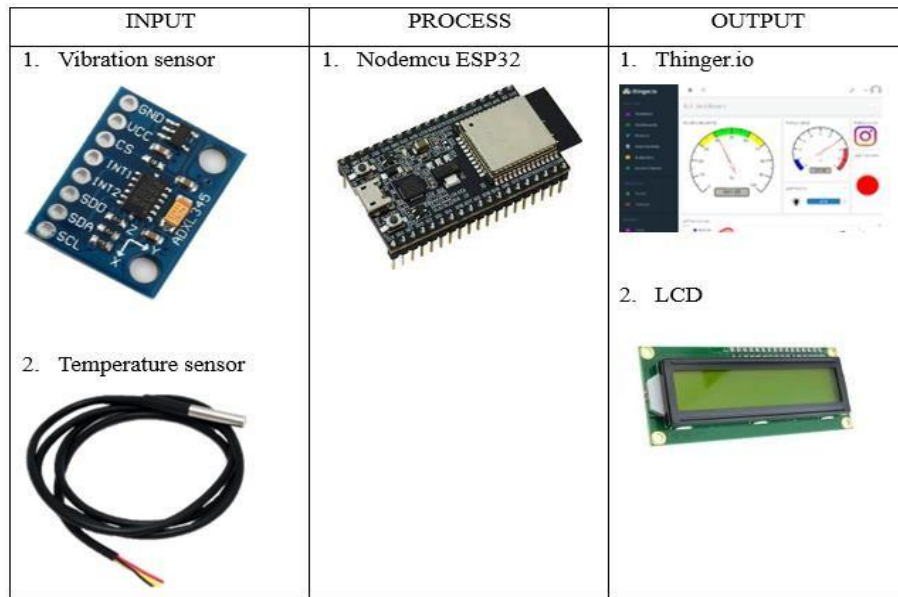


Figure 1: Block diagram of motor vibration and temperature detector using IoT

3.2 Flowchart

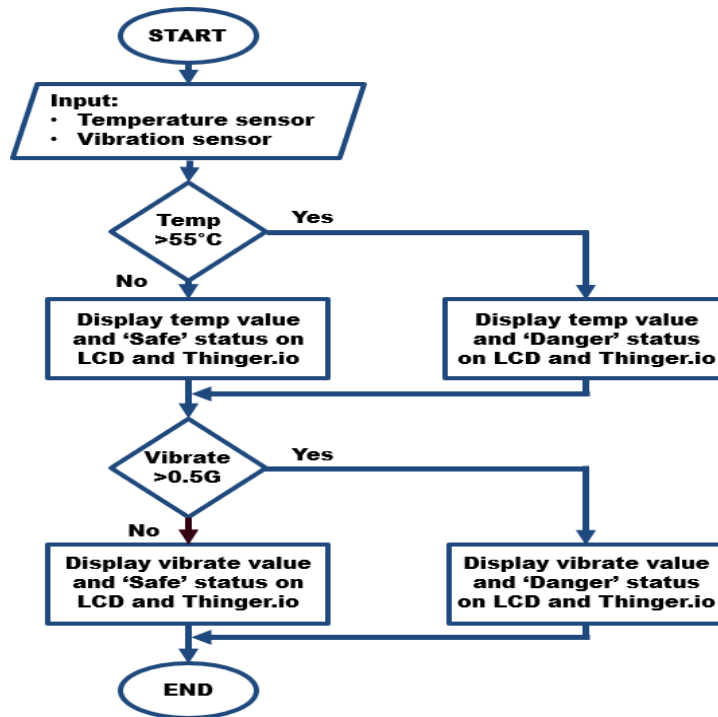


Figure 2: Flowchart for Motor Vibration and Temperature Detector using IoT

The system begins by receiving inputs from two sensors: a temperature sensor and a vibration sensor. It first evaluates the temperature reading. If the temperature exceeds 55°C, the system categorizes this as a "Danger" status, displaying both the temperature value and the "Danger" status on the LCD and Thingier.io. If the temperature is 55°C or lower, it is considered "Safe," and the system presents the temperature value along with the "Safe" status on these platforms. Subsequently, the system assesses the vibration level. If the vibration measurement is 0.5G or higher, it is classified as a "Danger" status, with the vibration value and "Danger" status displayed on the LCD and Thingier.io. Conversely, if the vibration is below 0.5G, it is deemed "Safe," and the system shows the vibration value and "Safe" status on both platforms. This process ensures that temperature and vibration levels are continuously monitored and reported accurately for real-time motor condition analysis.

3.3 System Design

The system design involves the development of an IoT-based architecture that integrates vibration and temperature sensors with a central monitoring system. The design emphasizes modularity to allow easy expansion and adaptability to different motor types [32]. Sensors are connected to a microcontroller or gateway that transmits data to a cloud-based platform for further analysis. The system also incorporates a user interface for real-time monitoring and alerts.

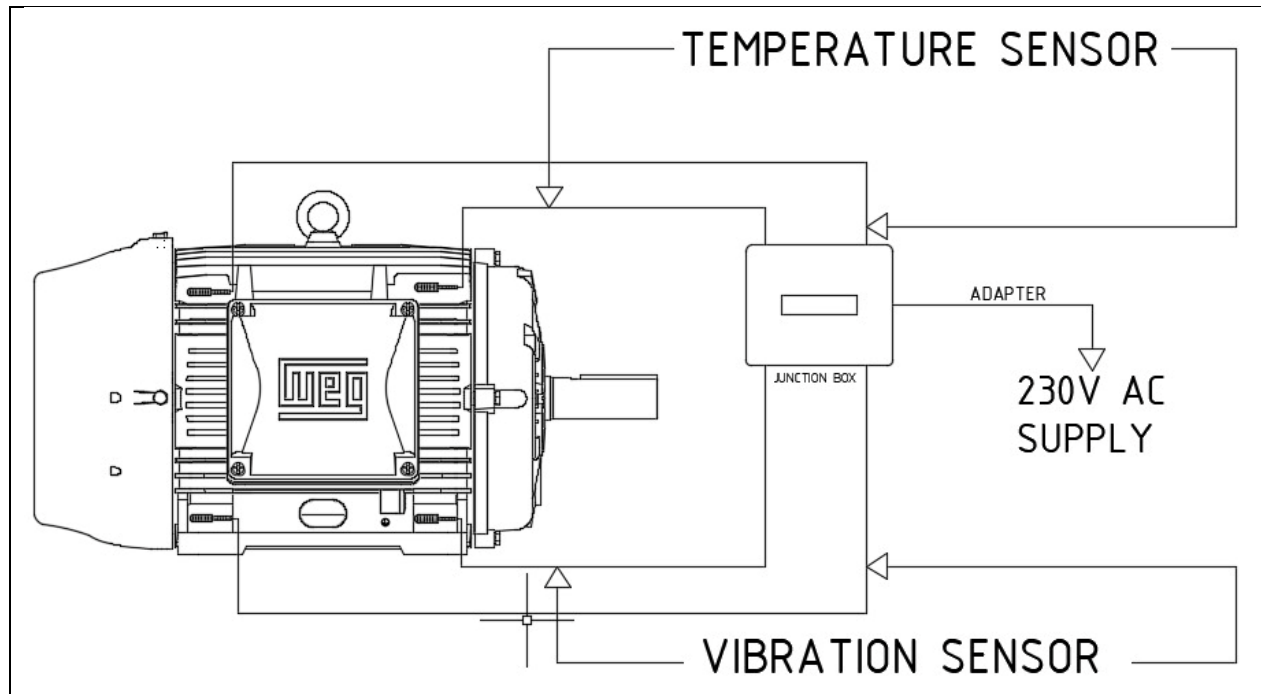


Figure 3: System design sensors position

3.4 Hardware Design

This project employs the ADXL335 vibration sensor to measure both static acceleration due to gravity in tilt-sensing applications and dynamic acceleration resulting from motion, shock, or vibration. Additionally, the project utilizes the DS18B20 temperature sensor to interface with the vibration sensor. The Nodemcu ESP32 microcontroller is incorporated to ensure Wi-Fi or Bluetooth connectivity for transmitting meter readings to the user. An LCD is used to establish communication between integrated circuits (ICs) through Inter-Integrated Circuit (I2C) communication. The ADC

ADS1115 analog-to-digital converter is implemented for applications requiring high-resolution analog-to-digital conversion. The Arduino IDE is employed to write, compile, and upload code to Arduino microcontrollers and compatible boards. Furthermore, Thinker.io is utilized for data management and visualization, device management, security and access control, user interface, scalability and flexibility, and API integration. Below is example of collection hard design for this project. Below is an examples of hardware design.

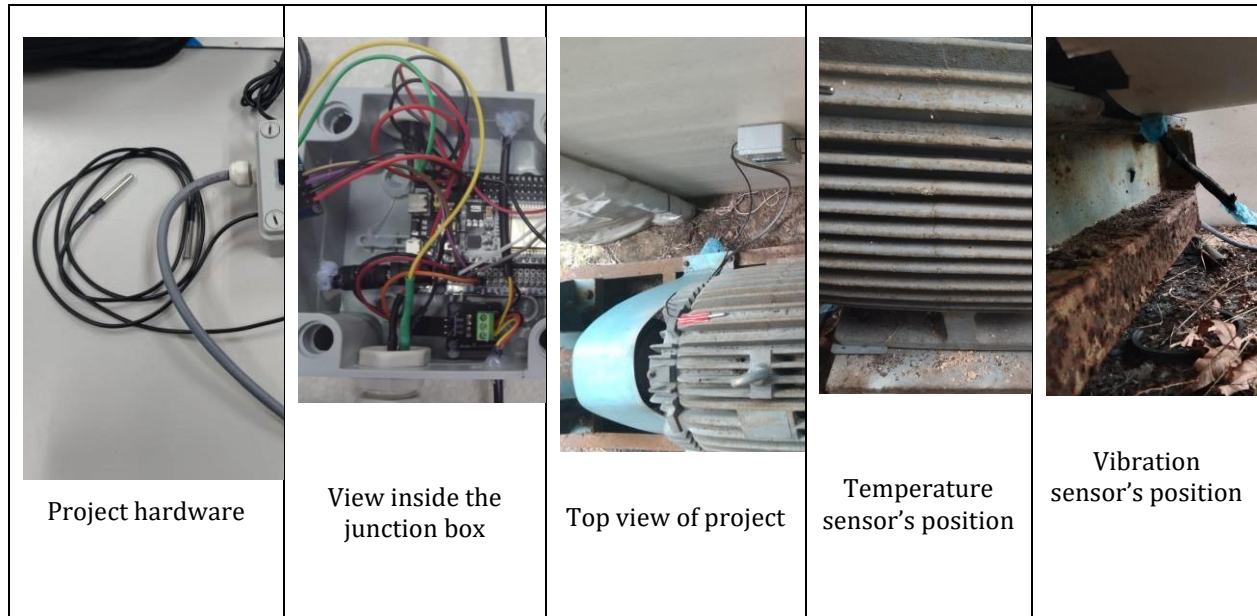


Figure 4: Hardware design

4.0 RESULTS

The table presents the temperature and vibration readings of motor water pump chiller A over a nine-hour period, from 8:00 am to 5:00 pm. Temperature 1 (back of the motor) and Temperature 2 (front of the motor) are distinct readings from the same sensors within the chiller, while Vibration 1 (back of the motor) and Vibration 2 (front of the motor) indicate the measured vibration levels at two different points. The data includes temperature readings in degrees Celsius ($^{\circ}\text{C}$) and vibration measurements in G (Gravitational Force). The temperature readings generally show an upward trend throughout the morning, peaking around 2:00 pm, with both sensors recording temperatures exceeding 65°C . This indicates that the chiller is experiencing overload, with external temperature factors also affecting its performance. The temperatures range from 30.75 to 70.81°C for Temperature 1 and from 29.88 to 67.75°C for Temperature 2. The vibration readings display a more variable pattern, with fluctuations between positive and negative values. The general trend suggests higher vibration levels in the morning and evening, with lower readings during the midday. However, there are notable exceptions, indicating that factors beyond the overall system load may influence the vibration changes. The vibration readings range from -0.477 to 0.415 G for Vibration 1 and from -0.398 to 0.085 G for Vibration 2. Further analysis of the correlations between temperature and vibration readings could provide valuable insights into potential operational or maintenance issues with the chiller.

Table 1: The data motor waterpump chiller A

Time	Temperature1 (°C)	Temperature2 (°C)	Vibration1 (G)	Vibration2 (G)
8.00 am	30.75	29.88	0.075	0.085
9.00 am	42.0	40/69	0.019	-0.222
10.00 am	46.56	44.69	0.235	-0.177
11.00 am	48.81	47.19	0.415	-0.268
12.00 pm	49.25	49.25	0.379	0.082
1.00 pm	49.25	49.25	0.379	0.082
2.00 pm	70.81	66.06	0.228	-0.264
3.00 pm	67.25	67.75	0.253	-0.435
4.00 pm	55.44	56.81	0.244	-0.447
5.00 pm	50.75	51.56	0.088	-0.398

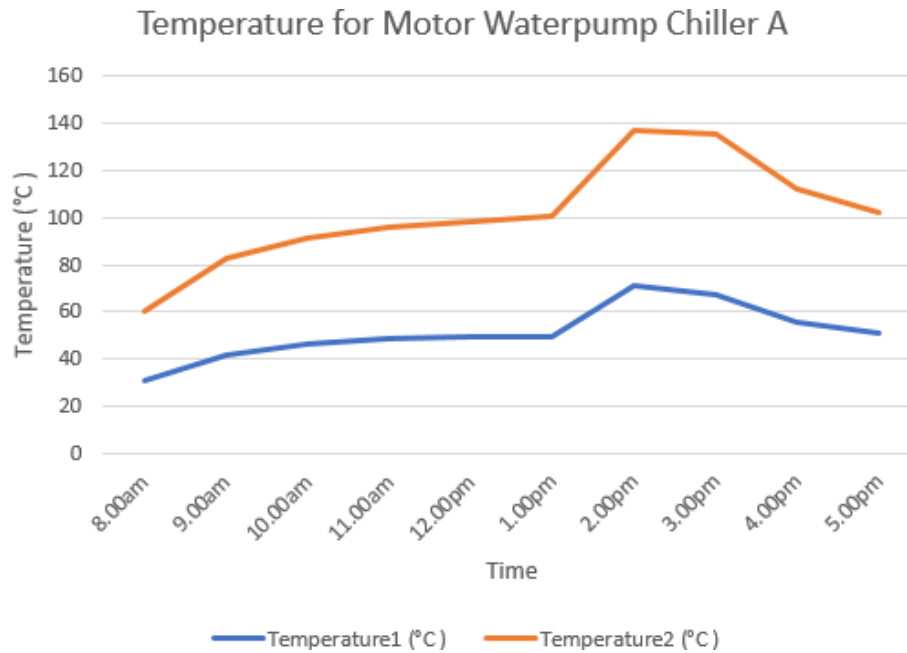


Figure 5: Graph temperature for motor water pump chiller A

Figure 5 above shown the variation in temperature and vibration data over time for two monitored devices. Temperature1 begins at 30.75°C at 8:00 am, gradually rising to its peak of 70.81°C at 2:00 pm, before slightly decreasing by 5:00 pm. Similarly, Temperature2 starts at 29.88°C at 8:00 am, reaches its highest point at 66.06°C at 2:00 pm, and then decreases slightly towards 5:00 pm. Regarding vibration, Vibration1 starts at a low value of 0.075 G at 8:00 am, peaks at 0.415 G at 11:00 am, and then gradually declines by 5:00 pm. In contrast, Vibration2 fluctuates, beginning at 0.085 G at 8:00 am, turning negative, and reaching its peak negative value of -0.447 G at 4:00 pm. These trends highlight significant changes in both temperature and vibration throughout the day, emphasizing the importance of continuous monitoring to prevent potential motor issues. The graph illustrates the temperature variations labeled "Temperature1 (°C)" and "Temperature2 (°C)" recorded from 8:00 AM to 5:00 PM. Temperature 1 begins around 30°C, gradually rises to approximately 50°C, remains relatively stable, and peaks at about 70°C by 2:00 PM. It then gradually decreases to around 50°C by 5:00 PM. In contrast, Temperature 2 starts at approximately 60°C, steadily increases to 90°C by 1:00

PM, then surges to 140°C by 2:00 PM. It remains at this high level until 3:00 PM, then drops to around 110°C by 4:00 PM, and finally settles at about 100°C by 5:00 PM. The graph reveals distinct trends for each temperature measurement. Temperature 1 exhibits a gradual increase followed by a decrease, while Temperature 2 shows a more pronounced rise, a plateau, and then a decline. These differing patterns suggest that the two temperatures may be monitoring different aspects of the Motor Water Pump Chiller A, each reflecting different heating and cooling dynamics within the system.

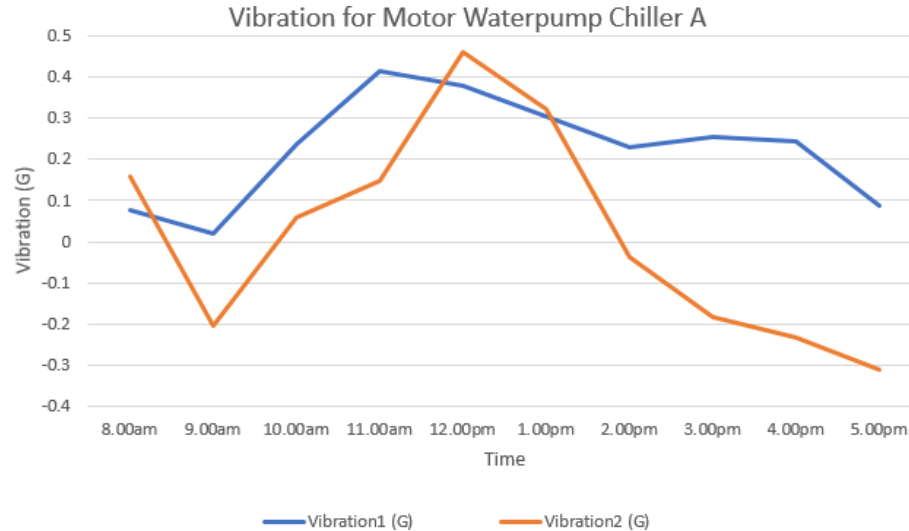


Figure 6: Graph vibration for motor water pump chiller A

The graph depicts the vibration levels of a motor water pump chiller over time. The blue line represents Vibration 1, measured at the back of the chiller, while the orange line represents Vibration 2, measured at the front. Both vibrations are recorded in G (gravitational force). The data shows that Vibration 1 increased from 8:00 AM to 11:00 AM, then decreased from 11:00 AM to 5:00 PM. In contrast, Vibration 2 consistently exhibited higher levels than Vibration 1, reaching its peak at 12:00 PM. The measurements were likely obtained using an ADXL 335 accelerometer coupled with an ADC ADS1115 analog-to-digital converter.

Table 2: Motor water pump chiller B data

Time	Temperature1 (°C)	Temperature2 (°C)	Vibration1 (G)	Vibration2 (G)
8.00 am	27.63	29.56	0.147	0.191
9.00 am	31.63	38.19	-0.282	0.125
10.00 am	32.81	40.5	0.325	-0.053
11.00 am	34.13	41.56	-0.349	0.333
12.00 pm	34.63	45.44	-0.326	-0.042
1.00 pm	35.81	41.06	0.009	0.405
2.00 pm	35.44	40.88	0.302	0.109
3.00 pm	36.13	33.63	0.322	0.007
4.00 pm	35.81	34.25	0.214	0.029
5.00 pm	35.19	33.63	-0.371	0.713

The table shows the temperature and vibration readings of a motor water pump chiller B over a period of time. The data is recorded from 8:00 am to 5:00 pm. The first two columns show the time of the reading and the corresponding temperature readings of two sensors, labeled as Temperature 1 (back of the motor) and Temperature 2 (front of the motor), both measured in degrees Celsius (°C). The next two columns display the vibration readings of two sensors, labeled as Vibration 1 (back of the motor) and Vibration 2 (front of the motor), and measured in G (gravitational

acceleration unit). The data reveals a clear trend: Temperature 1 gradually increases throughout the day, suggesting the pump is operating and heating up. Temperature 2 also increases until noon, then fluctuates around a slightly lower value. The vibration readings fluctuate significantly over time, with both sensors showing both positive and negative values, indicating different directions of vibration. There doesn't appear to be a clear trend in the vibration data, the values seem more erratic and likely reflect the pump's operation and potential mechanical issues. Overall, this table provides information about the performance of the chiller system, revealing the temperature changes and vibration levels within the system. To interpret the significance of these readings, it's essential to understand the normal operating parameters of the specific chiller unit and consult the manufacturer's specifications or a maintenance expert.

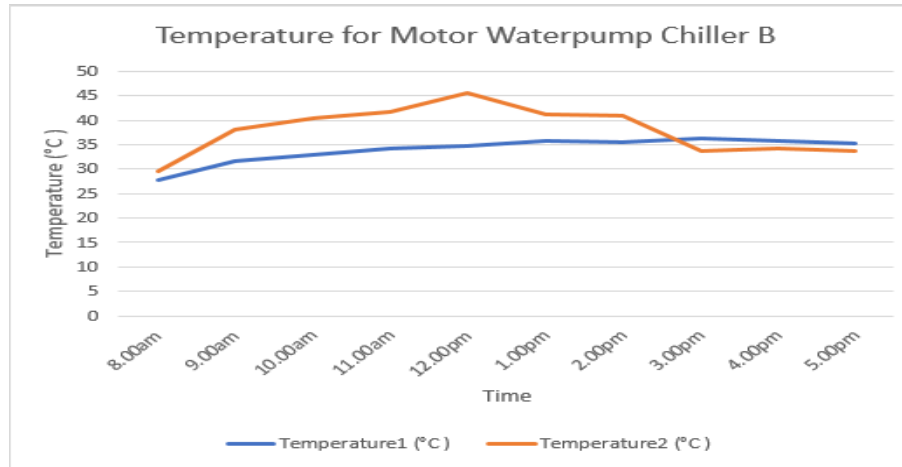


Figure 6: Graph Temperature for Motor Water Pump Chiller B

The graph displays temperature readings from two DS18B20 sensors: one located at the back of the motor water pump chiller (Temperature1) and the other at the front (Temperature2). Between 8:00am and 12:00pm, both temperatures generally increase, peaking at approximately 35°C for Temperature1 and 45°C for Temperature2. After 12:00pm, temperatures decrease, with Temperature1 stabilizing around 34°C and Temperature2 dropping to about 32°C by 5:00pm. Note that these readings are snapshot measurements and do not reflect the average temperature across the entire chiller.

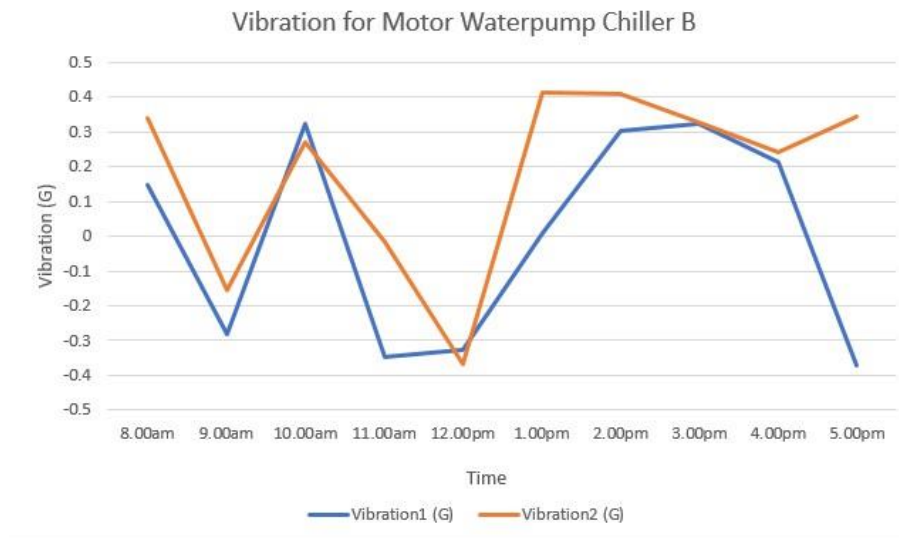


Figure 7: Graph Vibration for Motor Water Pump Chiller B

The graph illustrates the vibration levels of a motor water pump chiller, recorded at two locations: Vibration 1 (at the back of the motor water pump chiller) and Vibration 2 (at the front of the motor water pump chiller). Measurements were taken using an ADXL 335 accelerometer and an ADS1115 ADC. Vibration 1 begins at a higher level, with notable peaks at 10:00 AM and 4:00 PM. In contrast, Vibration 2 starts at a lower level but shows a significant increase at 1:00 PM.

5.0 CONCLUSIONS

In conclusion, the motor vibration and temperature detector using IoT technologies marks a significant advancement in industrial maintenance. The integration of sensors and connectivity enables continuous real-time monitoring of crucial parameters, offering valuable insights into the condition of essential machinery. This proactive approach allows for early detection of potential issues, enabling maintenance teams to resolve problems before they escalate, thus minimizing downtime and associated costs. Additionally, the IoT capabilities of this detector not only support remote monitoring but also pave the way for predictive maintenance strategies. The extensive data collected can be analysed to identify patterns and trends, facilitating the implementation of predictive maintenance schedules. By leveraging technology, this system enhances the reliability of industrial equipment and lays the foundation for a more efficient and cost-effective maintenance approach in the evolving realm of smart industries.

Authors Contributions

Muhamad Rostan: Writing and editing. Hawa Asmizan: Conceptualization, investigation, methodology, design and development. Mohd Anuar: Investigation, design and development, supervision.

Conflict of Interest

The authors declare that they have no known competing financial interests of personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors acknowledge the University College TATI for providing the equipment that makes this work possible.

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