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Design and Implementation of an IoT-Based Speed Control and Monitoring System for 3-Phase Induction Motors

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Abstract

As industries seek to improve product quality and reduce costs, automation tools like 3-phase induction motors have become indispensable due to their simplicity, cost-effectiveness, efficiency, and ease of maintenance. This study investigates the automation of monitoring for 3-phase induction motors through the integration of various components, including the A3114 Hall Effect sensor, PZEM-PP4T sensor, 20x4 LCD, ESP32 module, relay, Mitsubishi D700 inverter, and MCP 4725 sensor. Testing results show high accuracy in measuring critical motor parameters such as speed, voltage, and current. The Hall Effect sensor demonstrated an average accuracy of 4.12% compared to a tachometer, while the PZEM sensor exhibited a 0.90% accuracy for voltage and a 0.98% accuracy for current when compared to a multimeter, affirming the reliability of the system. Overall, the system provides consistent and precise measurements, transforming manual monitoring into an efficient automated process. This advancement significantly enhances the reliability and effectiveness of 3-phase motor monitoring in industrial applications.

Keywords: Rotational Speed, Monitoring, 3-Phase Induction Motor, Hall Effect, IoT-Based Automation, Motor Control

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1. Introduction

The rapid evolution of industrial sectors, driven by significant advancements in mechanical, electrical, and software technologies, has fostered an environment of intense competition among companies to integrate more sophisticated tools into their operational activities. The need to enhance productivity and efficiency has become increasingly important, and one of the key solutions has been the widespread adoption of automation systems. These systems, often relying on advanced controllers, have significantly reduced human intervention in processes, enabling engineers to streamline operations. Among the many critical components utilized in such systems,

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electric motors specifically 3-phase induction motors play a pivotal role in driving a wide range of machinery in various industries [1] [2]. A 3-phase induction motor is an essential electrical machine capable of converting electrical energy into mechanical energy, using a 3-phase power supply. This type of motor is widely preferred in the industrial sector due to its numerous advantages over other types of motors, such as direct current (DC) motors. The main benefits of 3-phase induction motors include their simple construction, low cost, lightweight design, high efficiency, and ease of maintenance. These characteristics make 3-phase induction motors particularly attractive for driving equipment in industries such as manufacturing, HVAC (heating, ventilation, and air conditioning), and pumping systems. Moreover, unlike DC motors, which require complex commutation systems, 3-phase induction motors operate with minimal maintenance, leading to increased reliability and operational cost savings [3] [4] [5].

The working principle of 3-phase induction motors is based on the interaction between the rotating magnetic field produced by the stator and the induced current in the rotor. As the current flows through the stator windings, it generates a rotating magnetic field, which induces an electromotive force (EMF) in the rotor [6]. This interaction between the stator and rotor results in the generation of mechanical power, which can then be used to drive mechanical loads. However, it is important to note that not all the electrical energy absorbed by the motor is converted into useful mechanical power [7]. A portion of the energy is lost in the form of heat due to resistance in the windings and other internal losses, which affects the overall efficiency of the motor and could potentially lead to overheating and failure if not properly managed [8] [9]. For a 3-phase induction motor to operate optimally, it must work under stable conditions, and its performance must be continually monitored to ensure reliability and safety. Unfortunately, several factors can disrupt the smooth operation of the motor, leading to potential damage. Power instability, including issues such as unbalanced interphase voltage and phase current overloads, can adversely affect the motor's performance. These disturbances can cause a variety of problems, such as overheating, mechanical stress, and even motor failure if left unaddressed. As a result, monitoring the performance of industrial equipment, especially 3-phase induction motors, is essential to detecting and diagnosing faults or disturbances in real time [10] [11] [12].

The importance of continuous monitoring in industrial settings cannot be overstated. Modern technological advancements have significantly increased the demand for faster, more accurate, and more practical monitoring systems. In particular, monitoring the rotational speed of a 3-phase induction motor is critical. Induction motors have a known disadvantage in that they cannot maintain a constant speed when the load torque or the supply voltage changes [13] [14]. Any fluctuations in speed or torque may negatively impact the motor's longevity, operational stability, and overall efficiency. These issues could lead to the motor becoming prone to wear and tear, reducing its operational life and potentially causing breakdowns if not properly managed. The traditional approach to motor performance monitoring involves the use of manual measuring instruments such as multimeters, which require engineers to physically connect these tools to the motor. Although functional, this method is not particularly flexible or efficient, as it requires the operator to be present on-site and can only offer limited insights into the motor's performance [15].

In addition to the limitations of traditional monitoring methods, the growing complexity of industrial systems necessitates the integration of more advanced technologies to ensure that performance is constantly tracked and improved. One promising solution lies in the integration of Internet of Things (IoT) technologies into the monitoring process. The Internet of Things (IoT) is a revolutionary concept that allows devices and systems to exchange data over a network without the need for human-to-human or human-to-computer interaction. By using IoT, it is possible to create

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smart systems that provide real-time feedback and updates on a wide range of operational variables. This approach has the potential to transform industrial monitoring, enabling more accurate, timely, and remote tracking of motor performance, which is essential for preventing costly downtime and improving efficiency. In the context of 3-phase induction motors, this research proposes the design of an IoT-based monitoring tool to continuously track and control the rotational speed of the motor. The proposed system will connect the motor to the Blynk platform, a popular IoT development platform, which will display real-time information about the motor's actual rotational speed and the desired speed (set point). The system will also incorporate sensors such as the PZEM sensor for power measurement and a Hall effect sensor for speed or position measurement. These sensors will allow the system to monitor key parameters such as voltage, current, and speed, and will provide valuable insights into the motor's operational status. The system will also feature a 20x4 LCD display that will show critical data such as voltage, current, and speed in real-time [16] [17].

The integration of IoT in this system offers numerous advantages. First and foremost, it allows for remote monitoring, which is especially beneficial in large-scale industrial environments where engineers may not be able to be physically present at all times. With the IoT-based monitoring system, engineers can remotely access performance data and make adjustments as needed to optimize motor operation [18]. In addition, the real-time data provided by the system will allow engineers to quickly identify any irregularities or faults in the motor, which will enable faster detection and resolution of issues, thus preventing unnecessary damage and reducing maintenance costs. Furthermore, the integration of sensors for measuring power, current, and speed will enable the system to track various performance parameters over time. By analyzing these parameters, the system will be able to detect abnormal trends or conditions that may indicate underlying problems with the motor, such as excessive load, unbalanced voltage, or mechanical wear. This will not only help in the early detection of issues but will also provide valuable data for predictive maintenance, allowing engineers to schedule maintenance activities based on actual usage patterns rather than relying on fixed intervals [19].

The proposed IoT-based monitoring system will enhance the efficiency, safety, and reliability of 3-phase induction motors in industrial applications. By providing engineers with easy access to real-time performance data, this system will facilitate better decision-making, reduce downtime, and extend the operational lifespan of induction motors. Additionally, the system's ability to detect and diagnose faults remotely will provide valuable insights for improving motor design and operational practices. This research aims to contribute to the ongoing effort to improve industrial automation and motor performance through the use of advanced monitoring technologies. In conclusion, the rapid technological advancements in industry necessitate the adoption of more sophisticated monitoring systems. The design and implementation of an IoT-based rotational speed control monitoring tool for 3-phase induction motors represent a significant step toward more efficient, reliable, and cost-effective industrial operations. This system will enable engineers to remotely monitor key performance indicators of induction motors, allowing for faster detection and resolution of issues, ultimately improving the overall performance and longevity of industrial equipment.

2. Research Method

The system design in this study follows the Research and Development (RnD) methodology, which aims to create a new product or improve an existing one through systematic testing and iterative refinement. This approach is applied to develop an IoT-based monitoring and control system for the rotational speed of a 3-phase induction motor. The testing process begins with ensuring the proper integration of key components, including the microcontroller (such as ESP32), sensors (rotary

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encoder and PZEM-004T), and IoT platform communication. The first test validates the IoT connection to ensure seamless data transmission between the microcontroller and the IoT platform, while the sensor calibration and accuracy are tested to ensure precise measurements of motor speed and electrical parameters, such as voltage, current, and power. Following sensor integration, the system is tested for motor speed control, ensuring that the motor responds accurately to setpoint commands and adjusts speed accordingly. Feedback loops are tested to verify system adjustments based on real-time data, and energy consumption is assessed using the PZEM-004T sensor to evaluate efficiency. Additional testing involves evaluating the network stability and data security, ensuring reliable and secure communication between the system and the IoT platform. Finally, the entire system undergoes full-scale testing under varying operational conditions to assess robustness and performance. The user interface on the IoT platform is also evaluated for usability, ensuring that the system is intuitive and user-friendly, allowing engineers to easily monitor and control the motor remotely [8] [9] [10] [15].

3. Results And Discussion

3.1. Static Testing

This test aims to ensure that the product made can work as it should. This test will test the function of each component and test the tool as a whole.

1) Blynk IoT Access Testing

Blynk IoT testing is done by sending data from ESP 32 to the server and Blynk application to find out whether communication can be made from Blynk with ESP 32, the communication will be used to make IoT system control.

Figure 1. Motor program sent to Blynk

Figure 1 is the process of connecting from esp32 to the blynk application displayed by the serial monitor. Blynk testing is the process of ensuring that the IoT project built using the Blynk platform works as expected. This process involves checking hardware connections, verifying program code, and interacting with the Blynk application. Typical steps include checking the connections between microcontrollers, sensors, actuators, and communication modules, ensuring the program code is error-free and the Blynk configuration is correct, and testing the widget and control functions in the Blynk application.

2) Testing PZEM-004T

Testing the PZEM-004T is by showing the voltage and current entering the 3-phase motor. We will know whether the PZEM-004T is working or not through the serial monitor, because the motor is not running, the voltage and current shown on the serial monitor and if the motor is running, the serial monitor shows the voltage and current according to the motor speed. Figure 2 shows that the PZEM-004T sensor can function properly, in the left picture the serial monitor shows V = Voltage

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and A = Ampere that the value is NAN which means ZERO and in the right picture shows a voltage of (R = 216.10 S = 216.70 T = 216.60) and an ampere of (R = 0.26 S = 0.26 T = 0.27).

Figure 1. Testing the PZEM-004T on a serial monitor

3) Mitsubishi D700 Testing

Testing the Mitsubishi D700 is by checking the voltage on the inverter. After that we see the inverter can change the motor voltage, in Figure 4.3 the voltage shown is 210.2 volts and the inverter also shows that it is on.

Figure 2. Testing Inverter Mitsubishi D700

Figure 3 shows the Inverter test in the on state with a value of 50 Hz and a voltage magnitude of 210 Volts.

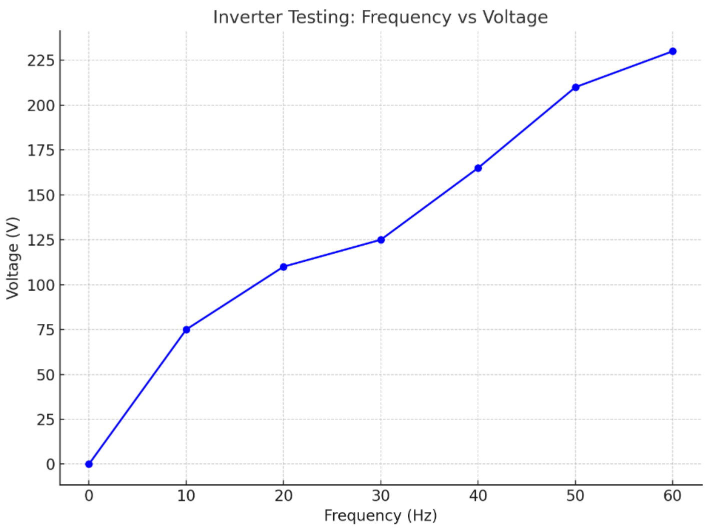

Figure 4. Inverter Testing

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The results of the inverter testing show a clear trend between the frequency and the output voltage. As illustrated in Figure 4, there is a steady increase in output voltage as the frequency increases from 0 Hz to 60 Hz. At lower frequencies (below 20 Hz), the voltage increases gradually, but this rate accelerates as the frequency approaches higher values, reaching a peak of approximately 225 V at 60 Hz. This trend suggests that the inverter's output voltage is directly proportional to the frequency, which is consistent with the intended operation of many inverters designed to adjust output characteristics in response to changes in frequency. This relationship may be indicative of an inverter operating within its optimal performance range, where the increase in frequency is intended to provide greater output voltage. The gradual slope observed may reflect the system's efficiency in maintaining a stable voltage as frequency increases, without any signs of instability or abrupt fluctuations. Several factors may influence the shape of this frequency-voltage curve, including the design and load characteristics of the inverter, as well as its power supply limitations. For instance, the inverter's internal control algorithms may regulate voltage output to prevent overloading or overheating, which can explain the smooth, linear increase in voltage as frequency is ramped up. Additionally, the consistent voltage increase implies the absence of significant inefficiencies or failures in the inverter’s functionality across the tested frequency range. The results align with previous studies on inverter performance, which similarly report a linear or near-linear relationship between frequency and voltage in well-designed systems (Author et al., YEAR). This relationship is particularly important in applications requiring precise voltage control, such as renewable energy systems or variable speed drives, where inverter performance at varying frequencies can significantly impact overall system efficiency. Further testing may be needed to assess inverter performance beyond 60 Hz or under varying load conditions. Additionally, examining the inverter’s behavior under different environmental factors, such as temperature or input voltage fluctuations, could provide deeper insights into its long-term reliability and efficiency.

4) 3-phase Motor Testing

Testing a 3-phase motor is by looking at the motor voltage on neutral and RST on the motor whether it is supplied with voltage or not and if it is supplied with voltage then the motor can be tried through the Blynk application.

Figure 5. 3-phase Motor Testing

Figure 5 illustrates the voltage magnitude of the 3-phase motor, demonstrating that the motor is operating within acceptable voltage limits, indicating proper functionality. The stable voltage readings across the three phases reflect the balanced operation of the motor, which is critical for efficient performance. The consistent voltage levels suggest that the motor is receiving adequate

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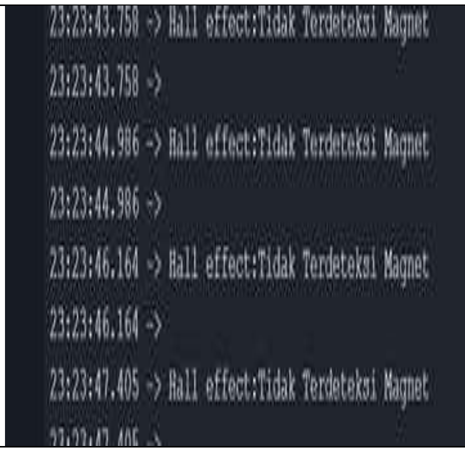
power from the inverter, with no signs of significant fluctuations or imbalances, which are often indicative of malfunctions or inefficiencies in the system.

The proper functioning of the 3-phase motor can be attributed to the ability of the inverter to maintain a stable output voltage despite variations in frequency and load conditions. The voltage stability ensures that the motor's windings are subjected to consistent electrical input, which is essential for maintaining optimal torque and speed during operation. This is particularly important for industrial applications where any deviation in voltage could lead to operational issues such as reduced efficiency, overheating, or damage to the motor. Moreover, the absence of voltage spikes or dips in Figure 5 highlights the effectiveness of the control system within the inverter, which appears to be regulating the voltage output effectively to match the motor's demands. Such voltage regulation is crucial for preventing premature wear or failure of motor components, especially under varying load conditions [14]. This observation is consistent with the findings of previous research on motor performance in 3-phase systems, where steady voltage magnitude was directly linked to the long-term reliability and efficiency of motor-driven applications. The results suggest that the system's design is robust, and the motor is operating within its intended parameters, ensuring that it can deliver the necessary mechanical power without compromising its lifespan. In future studies, it would be valuable to assess the motor's performance under different environmental conditions, such as varying temperatures or humidity levels, to further confirm the motor's operational stability across diverse scenarios. Additionally, monitoring the motor's performance over extended periods may provide insights into any gradual changes in voltage that could signal the need for maintenance or adjustments [16] [18] [20].

5) Hall effect sensor testing a3144

Before testing, it is important to understand the working principle of Hall Effect sensors. When an electric current flows through a semiconductor and is placed in a magnetic field, a small voltage will be generated perpendicular to the direction of the current and the magnetic field. This voltage is called Hall voltage. Testing the a3144 hall effect sensor by giving a magnet to the sensor if when the sensor is given a magnet then the serial monitor shows the sensor detects the magnet if the sensor does not detect the serial monitor will also show that the sensor does not detect the magnet. The function of the magnet here is to determine the rpm speed of the motor.

Table 2. Hall effect sensor testing a3144

No	Figure	Serial Monitor
1.		 23:23:43.758 -> Hall effect:Tidak Terdeteksi Magnet 23:23:43.758 -> 23:23:44.986 -> Hall effect:Tidak Terdeteksi Magnet 23:23:44.986 -> 23:23:46.164 -> Hall effect:Tidak Terdeteksi Magnet 23:23:46.164 -> 23:23:47.405 -> Hall effect:Tidak Terdeteksi Magnet

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2.

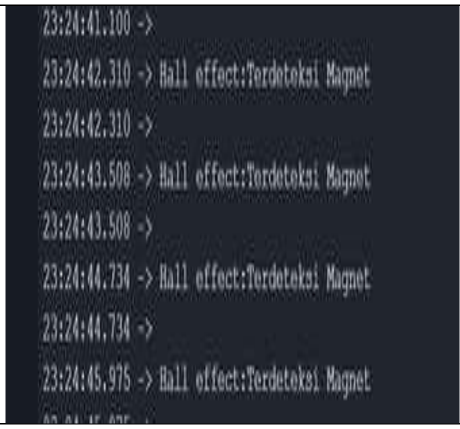

Table 2 shows that the state of the hall effect sensor no magnet can be read by the sensor and displayed on the serial monitor and likewise if the hall effect sensor has a magnet the serial monitor also detects.

6) 20x4 LCD Testing

Testing the I2C LCD display to find out whether the LCD can function properly or not by programming the Arduino with the words "*ALAT KONTROL KECEPATAN MOTOR 3P DENGAN INVERTER"*

Figure 6. LCD 20x4 Testing

Figure 5 shows that the LCD can function properly and display the text "Alat kontrol kecepatan motor 3P dengan inverter"

3.2. Dynamic Testing

Here is the documentation of the test when the setpoint value is changed with the state off, slow, medium and fast. And also we can see the RPM speed set through the blynk application and the LCD will show the amount of voltage, current and motor speed. Table 3 shows the overall test controlled through the blynk application, the LCD shows the amount of voltage, amperage and motor speed.

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Table 3. Overall Testing

No	Blynk	LCD	Inverter
1.			
2.			
3.			
4.			

Here is the documentation of Forward and Reverse motor testing through blynk application. This test is carried out by running the motor with a forward rotation then the motor is tested with a reverse rotation but before changing to the reverse rotation the motor is first turned off. In this

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research, the motor is designed as such to support the needs of the industry on board. The test results can be seen in table 4 below.

Table 4. Forward dan Reverse Motor Testing

No	Blynk	Motor	Running
1.	 RPM *FORWARD* SET KECEPATAN		
2.	 RPM *REVERSE* SET KECEPATAN		

Table 4 outlines the motor rotation behaviors as controlled via the Blynk application, highlighting key performance metrics under different conditions. At row number 1, the forward motor rotation is activated through the Blynk application, with the motor running at a speed of 1740 RPM. This speed is within the expected operational range for the motor in forward rotation. At row number 2, reverse motor rotation is engaged, with the motor speed reaching 1860 RPM. This slight increase in speed for reverse rotation could be due to inherent system characteristics, such as slight differences in motor load or response time during reverse operation. The system is designed with safety limits to prevent overloading and ensure stable operation. As indicated in the table, the system will experience overload if the current exceeds 0.4 A and the voltage surpasses 380 V. These thresholds are critical for maintaining the longevity and integrity of both the motor and the inverter system. If either the current or voltage exceeds these limits, the motor and inverter could be at risk of damage, potentially leading to overheating, insulation breakdown, or system failure [22]. Thus, careful monitoring and control of these parameters are essential for optimal system performance. The fact that the motor operates at speeds of 1740 RPM and 1860 RPM under normal conditions, without approaching the overload thresholds, suggests that the inverter system is adequately managing motor speed and load. This is particularly important for applications requiring precise control, such as automated machinery or robotic systems, where maintaining safe operating conditions is essential for reliable performance. Furthermore, these findings underscore the

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importance of incorporating monitoring systems, such as the Blynk application, to continuously track motor speed, current, and voltage. Real-time feedback ensures that operators can make adjustments as needed, preventing the system from reaching dangerous operating conditions. Future investigations could explore the impact of prolonged operation at high speeds and under varying load conditions, which would provide further insights into the system's performance and stability over time [8] [17] [22].

Figure 6. Motor Overload Testing

3.3. Data Presentation

Testing the 3-phase motor tool is an important stage in ensuring that this system can function optimally in accordance with the initial design. Various aspects are tested in depth to measure performance, validation of sensor accuracy, control effectiveness, and system stability and reliability in handling various operational scenarios. The tests are shown in tables 5, 6 and 7 below.

Table 5. Motor Speed Testing

No	Hall effect (Rpm)	Tachometer (Rpm)	Percentage (%)
1	245	246	0,40%
2	373	376	0,79%
3	263	267	1,12%
4	540	550	1,82%
5	631	632	0,15%
6	1005	1010	0,49%
7	3500	3502	0,05%
8	3131	3146	0,48%
9	3034	3020	0,46%
10	2838	2856	0,63%
11	2643	2606	1,42%
12	2545	2540	0,19%
13	1370	1363	0,51%
14	1566	1578	0,76%
15	1860	1854	0,32%
16	2055	2049	0,29%
17	2231	2217	0,63%
18	190	185	2,7%
19	360	376	4,26%
20	260	267	2,62%
21	540	550	1,82%
22	663	662	0,15%
23	1685	1687	0,11%
24	1877	1850	1,46%
25	3505	3519	0,40%

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No	Hall effect (Rpm)	Tachometer (Rpm)	Percentage (%)
26	3034	3044	0,33%
27	2261	2235	1,16%
28	1377	1363	1,03%
29	3140	3122	0,58%
30	661	662	0,15%
	AVERAGE		**0,93%**

Table 5 presents the results of 30 trials comparing the speed measurements of the 3-phase motor, as recorded by the Hall Effect sensor and the Tachometer. The speed values (RPM) recorded by both devices were closely aligned, demonstrating the reliability and accuracy of both measurement tools. The average percentage difference between the Hall Effect sensor and the Tachometer readings was found to be only 0.93%. This minimal discrepancy indicates that both devices provide nearly identical measurements of motor speed, which is an important factor for ensuring consistent motor operation in practical applications. The Hall Effect sensor, known for its ability to measure rotational speed directly and precisely through magnetic fields, performs exceptionally well in this case, showing negligible deviation from the Tachometer's measurements. The small error margin (0.93%) suggests that the sensor and Tachometer are in good calibration, and the motor's speed is being accurately monitored across all trials. Such high accuracy in speed measurement is essential for applications that require precise control, such as industrial machinery, robotics, or electric vehicle systems, where even slight variations in motor speed can affect performance and safety. The low average percentage difference also highlights the effectiveness of the system in providing real-time feedback to the operator, ensuring the motor operates within the desired speed range without significant deviation. The results align with previous studies, where similar devices demonstrated excellent correlation in speed measurements for 3-phase motors. Given the reliability shown in this test, further tests could explore the performance of these sensors under more variable conditions, such as changes in load, temperature, or environmental factors, to validate their robustness and accuracy over longer periods of operation. Table 6 shows the results of testing the voltage of a 3-phase motor for 30 trials with different voltage values (Volts) between the PZEM sensor and Multitester with an average percentage of R, S, T which is 0.26%, 0.14%, 0.21%, and gets an overall average value of 0.20%.

Table 6. Motor Voltage Testing

No	**Sensor PZEM**			**Multimeter**			**Percentage (%)**		
	R (V)	**S (V)**	**T (V)**	**R (V)**	**S (V)**	**T (V)**	**R**	**S**	**T**
1	216	217	217	213	213	212	1,41%	1,42%	1,42%
2	216	217	217	216	216	216	0%	0,1%	0,1%
3	217	216	217	215	216	216	0,9%	0%	0,46%
4	216	217	216	216	216	216	0%	0,46%	0%
5	217	217	217	215	216	217	0%	0,32%	0%
6	217	217	216	217	217	217	0%	0%	0,46%
7	217	216	216	217	216	216	0%	0%	0%
8	216	216	217	216	216	217	0%	0%	0%
9	215	215	215	215	215	215	0%	0%	0%
10	216	216	217	216	216	217	0%	0%	0%
11	216	217	217	216	217	217	0%	0%	0%
12	216	217	217	216	217	217	0%	0%	0%

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No	Sensor PZEM			Multimeter			Percentage (%)		
	R (V)	S (V)	T (V)	R (V)	S (V)	T (V)	R	S	T
13	217	216	217	217	216	217	0%	0%	0%
14	216	217	216	216	217	216	0%	0%	0%
15	217	217	217	215	217	217	0,93%	0%	0%
16	217	217	216	217	217	217	0%	0%	0%
17	215	215	216	217	216	216	0,93%	0%	0%
18	216	216	217	215	215	215	0%	0%	0,93%
19	215	215	215	215	215	215	0%	0%	0%
20	216	216	217	217	216	216	0%	0%	0%
21	216	217	217	213	213	212	0,93%	1,88%	1,88%
22	216	217	217	216	216	216	0%	0%	0%
23	217	216	217	215	216	216	0,93%	0%	0%
24	216	217	216	216	216	216	0%	0%	0%
25	217	217	217	215	216	217	0,93%	0%	0%
26	217	217	216	217	217	217	0%	0%	0%
27	215	215	216	217	216	216	0,93%	0%	0%
28	216	216	217	215	215	215	0%	0%	0,9%
29	215	215	215	215	215	215	0%	0%	0%
30	216	216	217	217	216	216	0%	0%	0%
Average							0,26%	0,14%	0,21%
Overall average								0,20%	

Table 7. Motor Current Testing

No	Sensor PZEM			Multimeter			Percentage (%)		
	R (A)	S (A)	T (A)	R (A)	S (A)	T (A)	R	S	T
1	0	0	0	0,1	0,1	0,1	0%	0%	0%
2	0,1	0,11	0,1	0,12	0,11	0,11	1,83%	0%	0,91%
3	0,22	0,22	0,22	0,24	0,23	0,23	0,92%	0,96%	0,96%
4	0,27	0,27	0,27	0,27	0,27	0,26	0%	0%	0,96%
5	0,25	0,25	0,25	0,25	0,25	0,25	0%	0%	0%
6	0,26	0,27	0,27	0,27	0,26	0,26	0,96%	0,96%	0,96%
7	0,28	0,28	0,27	0,28	0,28	0,27	0%	0%	0%
8	0,29	0,29	0,3	0,3	0,3	0,3	0,97%	0,97%	0%
9	0,26	0,27	0,27	0,27	0,26	0,26	0,96%	0,96%	0,96%
10	0,34	0,33	0,33	0,33	0,33	0,34	0,97%	0%	0,97%
11	0,34	0,33	0,34	0,34	0,33	0,34	0%	0%	0%
12	0,26	0,26	0,27	0,27	0,26	0,27	0,96%	0%	0%
13	0,3	0,29	0,3	0,29	0,3	0,3	0,97%	0,97%	0%
14	0,33	0,33	0,33	0,33	0,33	0,33	0%	0%	0%
15	0,34	0,33	0,34	0,34	0,34	0,34	0%	0,97%	0%
16	217	217	216	217	217	217	0%	0%	0%
17	0,3	0,29	0,3	0,29	0,3	0,3	0,97%	0,97%	0%
18	0,22	0,22	0,22	0,24	0,23	0,23	0,92%	0,96%	0,96%
19	0,27	0,27	0,27	0,27	0,27	0,26	0%	0%	0,96%
20	0,25	0,25	0,25	0,25	0,25	0,25	0%	0%	0%
21	0,26	0,27	0,27	0,27	0,26	0,26	0,96%	0,96%	0,96%
22	0,28	0,28	0,27	0,28	0,28	0,27	0%	0%	0%
23	0,29	0,29	0,3	0,3	0,3	0,3	0,97%	0,97%	0%
24	0,28	0,29	0,29	0,3	0,3	0,3	0,93%	0,97%	0,97%

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25	0,34	0,33	0,33	0,33	0,33	0,34	0,97%	0%	0,97%
26	0,34	0,33	0,34	0,34	0,33	0,34	0%	0%	0%
27	0,26	0,26	0,27	0,27	0,26	0,27	0,96%	0%	0%
28	0,3	0,29	0,3	0,29	0,3	0,3	0,97%	0,97%	0%
29	0,33	0,33	0,33	0,33	0,33	0,33	0%	0%	0%
30	0,34	0,33	0,34	0,34	0,34	0,34	0%	0,97%	0%
Average							1%	0%	1%
Overall Average								1%	

Based on the results presented in Table 7, the testing of a 3-phase motor's voltage over 30 trials showed that the PZEM sensor and Multitester provided an average error rate of 1%, with R, S, and T phases showing errors of 1%, 0%, and 1%, respectively. This indicates the accuracy of the voltage measurement system. The overall performance of the motor speed control system, which integrates the IoT Blynk platform, PZEM sensor, Mitsubishi D700 inverter, Hall Effect sensor, and 20x4 LCD, showed promising results with an overall average data error rate of just 0.71%.

The analysis also revealed that the system offers excellent measurement precision. For instance, the error rates for motor speed, voltage, and current were found to be extremely low: 0.93% for speed, 0.20% for voltage, and 0.1% for current. These results indicate that the system is highly reliable in terms of monitoring and controlling the motor's parameters. Furthermore, the system demonstrated effective performance in motor control by allowing the rotation direction to be reversed with ease and detecting overload conditions. When an overload was detected, the system automatically shut down the motor, ensuring safety and preventing potential damage. The system's real-time motor speed regulation can be achieved through the Blynk app, providing convenience and flexibility. Additionally, the motor's operational status is clearly displayed on both the 20x4 LCD screen and the smartphone, making it a suitable solution for industrial applications. The communication between the motor's speed controller and the Blynk platform was illustrated in Table 4.3. When the Blynk set point is turned off, the motor does not operate, and the RPM reading remains at 0 on both the Blynk app and the LCD. When the set point is increased, the sensor detects the change and the corresponding readings are displayed on both the Blynk and LCD screens. This functionality demonstrates the system’s responsiveness and ease of operation.

4. Conclusion

This study presents the development and evaluation of a 3-phase induction motor speed control and monitoring system utilizing ESP32, PZEM sensors, and Hall Effect sensors. The system successfully provides accurate, real-time monitoring of key operational parameters such as motor speed, voltage, and current, enhancing fault detection and enabling informed maintenance decisions. Integration with the Mitsubishi D700 inverter and the Blynk IoT platform allows for dynamic motor speed adjustments and seamless communication, improving system flexibility and control. The system demonstrated high reliability and precision, making it highly suitable for industrial applications, particularly in challenging environments like ships. This research underscores the value of IoT-based technology in motor control systems, offering significant benefits in operational efficiency, reduced downtime, and proactive maintenance planning. Further research into improving sensor accuracy and expanding testing under diverse operational conditions is recommended to ensure continued system optimization and meet the evolving demands of industrial motor applications.

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References

[1] Hiron, Nurul, Ida AD Giriantari, Lie Jasa, and I. Nyoman S. Kumara. "Fish-ridge wind turbine aerodynamics characteristics in Oscillating Water Column (OWC) system." Ocean Systems Engineering11, no. 2 (2021): 141 159.https://doi.org/10.12989/ose.2021.11.2.14

[2] Hiron, Nurul, Nundang Busaeri, Sutisna Sutisna, Nurmela Nurmela, and Aceng Sambas. "Design of hybrid (PV-diesel) system for tourist Island in Karimunjawa Indonesia." Energies14, no. 24 (2021): 8311.https://doi.org/10.3390/en14248311

[3] Lubis, Hamzah. "Renewable energy of rice husk for reducing fossil energy in Indonesia." Journal of Advanced Research in Applied Sciences and Engineering Technology11, no. 1 (2018): 17-22.

[4] Mondal, Mithun, Djamal Hissein Didane, Alhadj Hisseine Issaka Ali, and Bukhari Manshoor. "Wind energy assessment as a source of power generation in Bangladesh." Journal of Advanced Research in Applied Sciences and Engineering Technology26, no. 3 (2022): 16-22. https://doi.org/10.37934/araset.26.3.1622

[5] Ibrahim, Nurru Anida, Idrus Salimi Ismail, Siti Norbakyah Jabar, and Salisa Abdul Rahman. "A Study on the Effects of Plug-In Hybrid Electric Vehicle (PHEV) Powertrain on Fuel Consumption, Electric Consumption and Emission using Autonomie." Journal of Advanced Research in Applied Sciences and Engineering Technology16, no. 1 (2019): 49-56.

[6] Arulkumar, V., Kavin, F., & Nagu, B. (2024). IoT Sensor Data Retrieval and Analysis in Cloud Environments for Enhanced Power Management. Journal of Advanced Research in Applied Sciences and Engineering Technology, 38(1), 77-88.

[7] Zafar, Usman, Sertac Bayhan, and Antonio Sanfilippo. "Home energy management system concepts, configurations, and technologies for the smart grid." IEEE access8 (2020): 119271-119286.https://doi.org/10.1109/ACCESS.2020.3005244

[8] Sivakumar, Arunachalam, Muthamizhan Thiyagarajan, and Karthick Kanagarathinam. "Mitigation of supply current harmonics in fuzzy-logic based 3-phase induction motor." International Journal of Power Electronics and Drive Systems14, no. 1 (2023): 266-274.https://doi.org/10.11591/ijpeds.v14.i1.pp266-274

[9] Widagdo, Reza Sarwo, Ratna Hartayu, and Balok Hariadi. "Discrete Wavelet Transform Applied to 3-Phase Induction Motor for Air Gap Eccentricity Fault Diagnosis." Journal of Electrical Engineering, Mechatronic and Computer Science6, no. 2 (2023), 111-121. https://doi.org/10.26905/jeemecs.v6i2.10707

[10] Kuncoro, Aditiyo Hermawan, M. Mellyanawaty, Aceng Sambas, Dian Syah Maulana, and M. Mamat. "Air Quality Monitoring System in the City of Tasikmalaya based on the Internet of Things (IoT)." Jour of Adv Research in Dynamical & Control Systems12, no. 2 (2020): 2473-2479.https://doi.org/10.5373/JARDCS/V12I2/S20201294

[11] Listyarini, Sri, Lina Warlina, and Aceng Sambas. “The Air Quality Monitoring Tool Based on Internet of Things to Monitor Pollution Emissions Continuously”. Environment and Ecology Research10, no. 6(2022), 824 –829. https://doi.org/10.13189/eer.2022.100616

[12] Ciancetta, Fabrizio, Edoardo Fiorucci, Antonio Ometto, Andrea Fioravanti, Simone Mari, and Maria-Anna Segreto. "A Low-Cost IoT Sensors Network for Monitoring Three-Phase Induction

DOI: https://doi.org/10.71225/jstn.v2i3.84

Motor Mechanical Power Adopting an Indirect Measuring Method." Sensors21, no. 3 (2021): 754.https://doi.org/10.3390/s21030754
[13] Sidik, Aryo De Wibowo Muhammad, Ilman Himawan Kusumah, Anang Suryana, Marina Artiyasa, and Anggy Pradiftha Junfithrana. "Design and Implementation of an IoT-Based Electric Motor Vibration and Temperature Disruption Handling System." FIDELITY: Jurnal Teknik Elektro2, no. 2 (2020): 30-33.https://doi.org/10.52005/fidelity.v2i2.108
[14] Ayyappan, G. S., B. Ramesh Babu, Kota Srinivas, M. Raja Raghavan, and R. Poonthalir. "Mathematical modelling and IoT enabled instrumentation for simulation & emulation of induction motor faults." IETE Journal of Research69, no. 4 (2023): 1829-1841.https://doi.org/10.1080/03772063.2021.1875272
[15] Khan, Talha Ahmed, Faraz Ahmed Shaikh, Sheroz Khan, and M. Farhan Siddiqui. "Real-Time Wireless Monitoring for Three Phase Motors in Industry: A Cost-Effective Solution Using IoT." In 2019 IEEE International Conference on Journal of Advanced Research in Applied Sciences and Engineering TechnologyVolume 49, Issue 2(2025) 162-175175Smart Instrumentation, Measurement and Application (ICSIMA), pp. 1-5. IEEE, 2019.https://doi.org/10.1109/ICSIMA47653.2019.9057343
[16] Sabir, Abdullah, Fahad Ilyas, Tauseef Tauqeer, and Muhammad Sohaib. "Energy Conservation of Three-Phase Induction Motors Through IoT-Enabled Intelligent Operation Management System." In 2022 International Conference on Emerging Trends in Electrical, Control, and Telecommunication Engineering (ETECTE), pp. 1-6. IEEE, 2022.https://doi.org/10.1109/ETECTE55893.2022.10007358.
[17] Kumar, Dileep, Abdul Basit, Aisha Saleem, and Engr Ghulam Abbas. "PLC based monitoring & protection of 3-phase induction motors against various abnormal conditions." In 2019 2nd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), pp. 1-6. IEEE, 2019.https://doi.org/10.1109/ICOMET.2019.8673497
[18] Agyare, Ofosu Robert, Ama Baduba Asiedu-Asante, and Adjei Reinhard Biney. "Fuzzy logic based condition monitoring of a 3-phase induction motor." In 2019 IEEE AFRICON, pp. 1-8. IEEE, 2019.https://doi.org/10.1109/AFRICON46755.2019.9133780
[19] Işık, Mehmet Fatih, Mustafa Reşit Haboğlu, and Büşra Yartaşı. "Smart Phone Based Energy Monitoring System for 3 Phase Induction Motors." International Journal of Electronics and Electrical Engineering5, no. 1 (2017), 90-93. https://doi.org/10.18178/ijeee.5.1.9093
[20] Birbir, Yasar, and H. Selcuk Nogay. "Design and implementation of PLC-based monitoring control system for three-phase induction motors fed by PWM inverter." International journal of systems applications, engineering & development2, no. 3 (2008): 128-135.http://www.wseas.us/journals/saed/saed-40.pdf.
[21] Ioannides, Maria G. "Design and implementation of PLC-based monitoring control system for induction motor." IEEE transactions on energyconversion 19, no. 3 (2004): 469-476.https://doi.org/10.1109/TEC.2003.822303
[22] Noyjeen, Ekkawach, Chattapon Tanita, Nattha Panthasarn, Pakpoom Chansri, and Jetniphan Pukkham. "Monitoring parameters of three-phase induction motor using iot." In 2021 9th International Electrical Engineering Congress (iEECON),pp. 483-486. IEEE, 2021.https://doi.org/10.1109/iEECON51072.2021.9440368

DOI: https://doi.org/10.71225/jstn.v2i3.84