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IoT-Based Three-Phase Induction Motor Monitoring System

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Abstract
This paper describes how to use the Internet of Things to control and monitor induction motors. Because it can be utilized from anywhere via Wi-Fi, IoT is more convenient and efficient to control the system. The purpose of this monitoring system is to prevent induction motor failure by implementing preventive measures. Induction motors are used in a variety of applications such as in industry due to their many advantages such as self-starting, high power factor, and rugged design. As a result, using the best available smart protection techniques, it is imperative to detect flaws in the motor at an early stage to improve the efficiency of the motor and ensure safe and reliable operation. The voltage, current and temperature of the induction motor can be monitored remotely with the Blynk IoT application. The monitoring results will determine the error in the motor operating parameters that caused severe damage to the motor. Three PZEM-004T sensors to obtain parameters of each R, S, and T phase of the motor in real-time and relays to control the motor are used in this system to monitor and regulate using IoT. Information from the sensor is received by the microcontroller unit, which processes the sensing data. If an abnormal value is detected, the system automatically generates a control signal to start or stop the motor.
Keywords: Induction Motor, IoT, Monitoring, Controlling, PZEM-004T

Introduction
Induction motor is one type of motor that is popularly used throughout the world to support production processes in the industrial sector. Especially the most widely used three-phase induction motor. The use of three phase induction motors can be found in tools such as pumps, manufacturing equipment, centrifugal machines, crushers, conveyors, elevators, blowers, compressors and many more (Syafrudin & Hasibuan, n.d.). Induction motors are also used in various applications such as electric vehicles, industrial, and agricultural areas due to their many advantages such as self-starting, low cost, high power factor, and sturdy design (Hasibuan & others, 2011) (Mamatha & Thejaswi, 2021).

Based on its role and function, the operation of a three-phase induction motor must have a high level of reliability so that stability and continuity are maintained properly (Nasution et al., 2020). For this reason, it is necessary to know the types of disturbances that can potentially interfere with the function and work of the three-phase induction motor itself(Ashmitha et al., 2021).

Induction motor as a driver in the industrial sector is required to work continuously without stopping. Then routine maintenance is needed, one of which is by knowing the disturbance in the motor. Fault identification of a three-phase induction motor can be seen by measuring the working values of the motor such as voltage, current, temperature, and rotational speed when the fault occurs (Natalis Hengky Richardo, Junaidi, 2017).

In the industrial world, three-phase induction motors are usually monitored by an operator. The operator is in charge of supervising the monitoring of the induction motor while it is operating (Nasution & Hasibuan, 2018). The process of monitoring a three-phase induction motor that still uses conventional methods by making direct measurements. This causes monitoring to be inefficient and requires a lot of time and effort. Therefore we need equipment that can easily and efficiently monitor the temperature, current and voltage of a three-phase induction motor. Efficient measuring instruments can be made with the help of microcontrollers and wireless technology. An integrated monitoring system with the application of connected microcontrollers and sensors, so that it is able to transmit current, voltage and temperature information wirelessly to a cloud server on a computer or smartphone application. This monitoring system is designed by implementing an automatic monitoring system to maintain the performance of a three-phase induction motor.

Basic Theory
1. Internet of Things

The Internet of Things (IoT) is a network of physical devices embedded with electronics such as software, sensors, actuators and connectivity (Parashar et al., 2016), enabling these objects to interconnect and exchange data. With technical advances, our interactions with information systems change, both at work and during leisure time. Information technology, sensors, and networks are becoming smaller, more powerful, and used more frequently. Society no longer only encounters information technology at meeting points in their lives, such as in the office or at a desk, but as information and communication infrastructure, which is present in more and more areas of daily life. These infrastructures are characterized by the fact that they include not only classic devices (Le Galès, 2011), for example, PCs and mobile phones, but that information and communication technologies are also embedded in objects and environments (Ashmitha et al., 2021).

2. Sensors

A sensor is a tool or device used to convert physical quantities into electrical quantities (Borghetti et al., 2020). Sensors are devices used to detect induced signals originating from the conversion of an energy such as electrical energy (Bašić, 2019), physical energy, chemical energy, biological energy, mechanical energy and others. Sensors can also function in implementing a device that can work automatically when using the sensor used (Maulana, 2014).

a. PZEM-004T

PZEM-004T sensor is a hardware device that plays a role in measuring voltage, current, active power, frequency, power factor and active energy, the board without display function, the information is read through the TTL interface (Mamatha & Thejaswi, 2021).

Figure 1 PZEM-004T

3. NodeMCU ESP8266

The NodeMCU ESP8266 microcontroller is an electronic board based on the ESP8266 chip made by Espressive Systems, has a microUSB port that functions for programming or power supply. NodeMCU supports the Arduino (Integrated Development Environment) IDE software (Ouldzira et al., 2019).

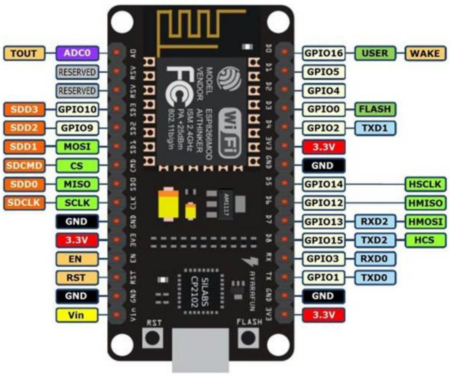

Figure 2 NodeMCU ESP8266

4. Relay

A 5V relay is used in this project, which is directly connected to the NodeMCU ESP8266. The ESP8266 pulse signal is sent to the relay (Ragavi et al., 2022). If the sensor data has a deviating value, Arduino identifies it and sends a command to the relay. A single pole throw relay was used in this project. NO (normally open), NC (normally closed), 5V, GND and common pins are the five pins on the relay (Sung et al., 2019).

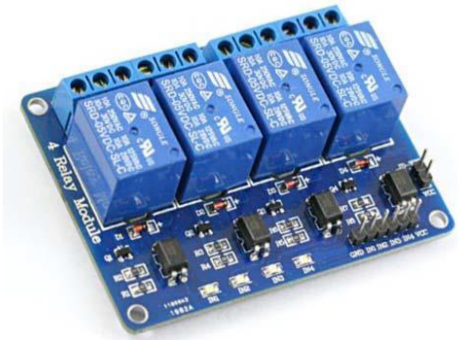

Figure 3 Relay

5. LCD I^2C

LCD (Liquid Crystal Display) Inter-Integrated Circuit (I^2C) or liquid crystal display is a hardware device that can display a character of letters (Pyrgas et al., 2016), numbers or symbols. LCD is made with CMOS (Complementary Metal Oxide Semiconductor) logic technology which works by not producing light but refracting the surrounding light towards the frontlit or transmitting light from the backlit (Heru Susanto, 2018).

Figure 4 LCD $\mathbf{I^2C}$

6. Blynk IoT

Blynk IoT as an IoT platform that provides remote hardware control and monitoring systems (Artiyasa et al., 2020). The Blynk application can run on all operating systems such as Android and IOS as well as website platforms (Karuppusamy, 2020). Blynk operation control can be applied with microcontrollers such as the ESP8266, Arduino, and Raspberry Pi modules. The user interface on Blynk IoT is simpler and easier to understand, users only need to create a device by setting a widget and configuring a virtual pin with the widget (Blynk.io, n.d.).

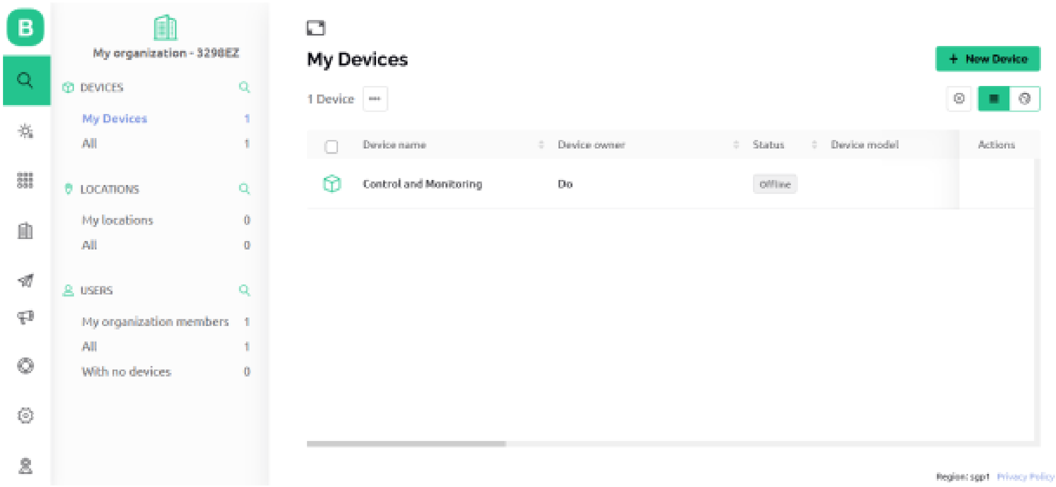

Figure 5 UI Blynk

Research Method

From the flow chart above, it can be described as follows.

a) Study of Literature, conducting a literature review related to the issues discussed so as to provide confidence that this research can be carried out and also reduce errors in research.

b) Identification of Needs, identifying and analyzing needs of the problems discussed so that this research can be carried out.

c) System Planning, properly managing the design of the problems obtained and there are three parts to the process, namely mechanical design, electronic design, and program design.
d) Monitoring System Realization, carrying out the overall design of the system to be implemented.
e) Testing and Data Collection, testing the design that has been realized in the hope that the system can run well.
f) Functional Testing, testing the components used to determine whether the components are functioning as they should. Functional testing consists of testing sensor PZEM-004T, NodeMCU, and Relays.
g) Performance Testing, conduct overall testing of the designed system. If the performance obtained is not in accordance with the design, corrections and improvements are made.
h) Result and Discussion, conduct a review and analysis of test data so as to find new ideas to draw conclusions.

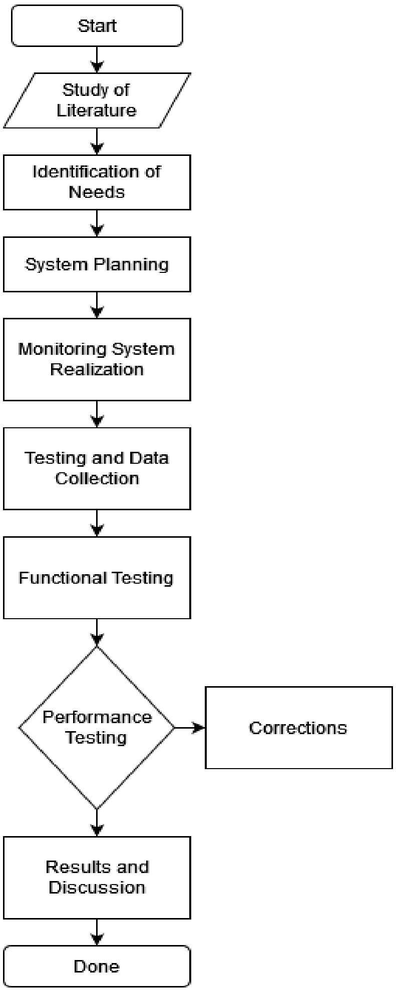

Figure 6 Flowchart Research

All designs are made by following the research stages. All control components used for monitoring three-phase induction motors are arranged according to the NodeMCU ES8266 pin configuration, which can be seen in Figure 7. the entire control circuit is installed on the panel box to see the performance of the system the tool can work according to the arduino IDE program that has been made.

Figure 7 Realization of an IoT-based Three-phase Induction Motor Monitoring System

Results and Discussion

This test was carried out on a working system monitoring system for motor performance reading voltage and current values from the PZEM-004T sensor which is displayed via the LCD and Blynk as well as relay performance tests for remote control systems.

Table 1 Voltage Monitoring Result

No	Voltage (V)	PZEM-004T Phase R (V)	PZEM-004T Phase S (V)	PZEM-004T Phase T (V)	Multimetere (V)	Eror (%)
1	90	90.2	91.	90	89	1.35%
2	120	120.	120.5	120.30	119	0.84%
3	150	149.9	150.3	150	150	- 0.07%
4	180	180.2	180.6	180	180	0.11%
5	220	219.4	218.6	219	219	0.18%
Total						0.5%

Table 2 Ampere Monitoring Result

No	Voltage	PZEM-004T Phasa R (A)	PZEM-004T Phasa S (A)	PZEM-004T Phasa t (A)	Multimeter	Eror %
1	90	0.79	0.79	0.79	0.80	-1.3%
2	120	0.75	0.75	0.75	0.74	1.35%
3	150	0.81	0.81	0.81	0.80	1.25%
4	180	0.96	0.96	0.96	0.95	1.1%
5	220	1.35	1.35	1.35	1.34	0.7%
Total						0.6%

Table 3 Blynk Control Motor with Relay Test

No	Range	ESP8266 Memory Usage	Delay
1	1 meter	1494.00	0 detik
2	5 meter	1494.00	1 detik

3	10 meter	1494.00	1 detik
4	20 meter	2079.00	2 detik
5	25 meter	2079.00	3 detik

The monitoring results of PZEM-004T read the voltage and current values of the induction motor when operating with different supply voltage data, with the aim of seeing the performance of the sensor whether it succeeds in reading the values accurately. From the table above, testing is carried out on the PZEM-004T sensor up to five times in order to get error values and error persetage. The calculation of error values is obtained from the results of the comparison of PZEM-004T measurement data with multimeter measuring instruments. Then the average error value at the voltage of the induction motor is 0.5%, and the error value at the measurement of the current value is obtained by 0.6%.

Relay testing refers more to the EPS8266's ability to receive instruction data from the blynk IoT application, before being received by the relay and triggering the contactor so that it can control the induction motor. Distance is a parameter for comparing EPS8266 performance, shown in Table 3 where the relay works well even though there is a delay of a few seconds. This happens because of differences in distance and the ability of the wifi connection used. The ON/OFF control of this motor can be used if there is a disturbance in the operation of the motor without having to think about the time and distance.

Conclusions

In this paper the concept of the Internet of Things to start remote monitoring of motor systems. The system has the ability to combine various parameters of the induction motor's tengangan and current in real time and improve the accurate detection of various operating values occurring in the motor. Monitoring the motor system provides measurements of different parameters i.e. supply voltage and motor current. The concept of IoT is presented here for remote motor monitoring and control. Using visual basic, the data received from the controller node is represented graphically. The data is also displayed serially. Updated work that can be controlled remotely without thinking about distance and time. The application of this system is necessary today for any vehicle of industrial electrical and automation systems that require greater safety. The system has special advantages, less maintenance, easy and fast control and remote data access.

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References

Artiyasa, M., Kusumah, I. H., Suryana, A., Sidik, A. D. W. M., Junfithrana, A. P., & others. (2020). Comparative Study of Internet of Things (IoT) Platform for Smart Home Lighting Control Using NodeMCU with Thingspeak and Blynk Web Applications. *FIDELITY: Jurnal Teknik Elektro*, *2*(1), 1–6.

Ashmitha, M., Dhanusha, D. J., Vijitlin, M. S., & George, G. B. (2021). *Real Time Monitoring IoT Based Methodology for Fault Detection in Induction Motor*. *5*(June), 72–83.

Bašić, P. (2019). *Fiber-optic sensor cable for simulateneous distributed measurement of multiple physical quantities.* University of Zagreb. Faculty of Electrical Engineering and Computing~….

Blynk.io. (n.d.). *Blynk IoT.pdf.*

Borghetti, M., Cantù, E., Sardini, E., & Serpelloni, M. (2020). Future sensors for smart objects by printing technologies in industry 4.0 scenario. *Energies*, *13*(22), 5916.

Hasibuan, A., & others. (2011). Early detection of rotor-bar faults of three-phase induction motor using motor current signature analysis method. *Proceedings of The Annual International Conference, Syiah Kuala University-Life Sciences \& Engineering Chapter*, *1*(2).

Heru Susanto, A. N. (2018). *Desain Dan Implementasi Sistem Monitoring Tegangan Dan Arus Motor Induksi Tiga Phase Menggunakan Konsep Internet of Things (Iot)*. *11*(1), 54–63.

Karuppusamy, P. (2020). A sensor based IoT monitoring system for electrical devices using Blynk framework. *Journal of Electronics and Informatics*, *2*(3), 182–187.

Le Galès, P. (2011). Policy instruments and governance. *The SAGE Handbook of Governance*, 142–159.

Mamatha, G., & Thejaswi, A. H. (2021). *Induction Motor Condition Monitoring and Controlling Based on IoT*. *4*(9), 220–225.

Maulana, E. (2014). Sensor dan Tranduser (Bahan Ajar). *Bahan Ajar Elektronika Kontrol - Sensor Dan Transduser*.

Nasution, E. S., & Hasibuan, A. (2018). Pengaturan Kecepatan Motor Induksi 3 Phasa Dengan Merubah Frekuensi Menggunakan Inverter Altivar 12P. *Jurnal Sistem Informasi*, *2*(1).

Nasution, E. S., Zambak, M. F., Suhendra, S., & Hasibuan, A. (2020). Simulasi Pengoperasian Motor Pompa Air Berbasis Programmable Logic Control. *Inventory| Industrial Vocational E-Journal On Agroindustry*, *1*(2), 78–82.

Natalis Hengky Richardo, Junaidi, A. H. (2017). *Rancang Bangun Sistem Proteksi Motor Induksi Tiga Fasa Berbasis Mikrokontroler Atmega 16*. 2–5.

Ouldzira, H., Mouhsen, A., Lagraini, H., Chhiba, M., Tabyaoui, A., & Amrane, S. (2019). Remote monitoring of an object using a wireless sensor network based on Nodemcu ESP8266. *Indonesian Journal of Electrical Engineering and Computer Science*, *16*(3), 1154–1162. https://doi.org/10.11591/ijeecs.v16.i3.pp1154-1162

Parashar, R., Khan, A., & Neha, A. K. (2016). A survey: The internet of things. *International Journal of Technical Research and*

Applications, 4(3), 251–257.

Pyrgas, L., Kalantzopoulos, A., & Zigouris, E. (2016). Design and implementation of an open image processing system based on nios ii and altera de2-70 board. *Journal of Engineering Science and Technology Review*, *9*(5), 51–55.

Ragavi, P., Keerthana, G., Arthi, T., Dharaneesh Kumar, D., & Gogula Varsini, S. (2022). *Domestic Water Supply Monitoring andTheft Identification System*.

Sung, G. M., Shen, Y. S., Keno, L. T., & Yu, C. P. (2019). Internet-of-Things Based Controller of a Three-Phase Induction Motor Using a Variable-Frequency Driver. *2019 IEEE Eurasia Conference on IOT, Communication and Engineering, ECICE 2019*, 156–159. https://doi.org/10.1109/ECICE47484.2019.8942676

Syafrudin, S., & Hasibuan, A. (n.d.). Early Detection of Rotor-bar Faults of Three-phase Induction Motor Using Motor Current Signature Analysis Method. *1st Syiah Kuala University Annual International Conference 2011*.