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Design of automated power factor monitoring and repair tool for industry in real time based on Internet of Things

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Abstract

The current electricity crisis is caused by the following things; The consumption of electrical energy continues to increase, the supply of electrical energy is limited, there is often a waste of electrical energy due to the use of electrical energy that should not be used (wasteful), as well as the need for electrical energy control that can control the electrical load remotely, and the power factor is lacking. Both resulting in reactive power losses and resulting in an increase in electric current which will have an impact on higher conductor energy losses. It has been discussed a lot, but in reality it still happens a lot, it is necessary to save electrical energy in addition to saving costs but also preventing a power supply crisis by making monitoring tools and power factor improvements that can be controlled remotely based on IoT. This study aims to design and design an automatic power factor monitoring and improvement tool for industry in real time based on the internet of things starting from architecture, display monitors and hardware systems as well as conducting feasibility testing. The method used in this study is the ADDIE method (Analysis, Design, Development, Implementation, and Evaluation) through a literature review and analysis approach. The results of this study are expected to provide appropriate design recommendations and have system and material advantages and to be implemented. The impact of this research is that future research will be much better because in this study a feasibility test of the system has been carried out by conducting simulation trials.

Keywords: Power factor; Adafruit.IO; PZEM004; Control monitoring; Real time; Industrial automation

1. Introduction

Electrical problems that often occur, such as the use of energy that is not in accordance with the needs (wasteful) [1] , the increasing need for electrical energy accompanied by an increase in electricity tariffs, have been widely discussed but in reality there is still the use of electrical energy that is not ideal. The need for saving electrical energy in addition to saving costs, also preventing the occurrence of electricity supply crises, namely by making monitoring devices that can be controlled remotely in previous studies that have been made and are currently being added with other features, namely power factor improvements [2] . The importance of improving the power factor that does not meet the minimum factor value limit set by PLN is 0.85 so that it can have an impact on the possibility of being subject to kVAR fines by PLN and making the electrical system less than optimal due to high reactive power consumption so that the capacity of the electricity network is reduced [3] . A small power factor results in large currents and larger losses. With a large power capacity, it will affect the transformer capacity at the PLN distribution substation serving to be larger and the transformer price will also be high [4]. Based on these problems, it is very important to improve the power factor. The solution to overcome these problems is to make a power factor improvement tool by utilizing the Internet of Things (IoT) to make it easier for users when monitoring power factor improvements. Many previous studies have been carried

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out to improve power factor, but in general they still use manual methods to monitor working power factor, namely by installing an analog power factor measuring device (cos phi meter manual) [4]or by using VAR logic switching mounted on the capacitor panel. bank, this is certainly very difficult for technicians to be able to monitor because they have to always go to the capacitor bank panel in order to find out the power factor that is working and change the kVAR capacitor so that the power factor value can always be more than what is set by PLN which is 0.85 manually by the technician via the push button [5]. Time effectiveness and lack of flexibility have resulted in the need for an innovative power factor improvement system that can monitor and change kVAR capacitors remotely, from anywhere, and at any time by using a smartphone, laptop or computer as long as it is connected with good internet access [6] .

The development of science at this time encourages efforts to update technology that can support the process of advancing automation in the industrial world. Industrial automation can be said as a system in the industrial world that uses control devices in terms of controlling operating processes [7] . The process is very possible to be done automatically without involving much human intervention. The benefit of this industrial automation is that the company can reduce errors in the operation of a production equipment and improve product quality. With the aim of increasing productivity and reducing production costs that use human labor. This industrial automation can also plan, collect data, and make decision processes to support the company's manufacturing activities to be more integrated [8] .

One of the innovations with industrial automation is an automatic power factor improvement tool that utilizes the latest Internet of Things technology. Internet of Things (IoT) is defined as the ability of various devices that can be connected and exchange information with each other through the internet network. Internet of Things (IoT) is a technology that allows for control, communication, collaboration with various hardware [9] , and data through the internet network. So it can be said that the Internet of Things (IoT) is when we want to connect something thinking things that are not operated by humans via the internet. However, the Internet of Things (IoT) is not only related to controlling devices remotely, but also how to share data, visualize real things in the form of the internet, and so on [10] . The internet becomes a liaison between one device and another automatically. In addition, there are also users or users who serve as regulators and supervisors of the work of the tool directly. The benefit of using Internet of Things (IoT) technology is that the work done by humans becomes faster, younger and more efficient. The use of the Internet of Things (IoT) in industrial automation still cannot be comprehensive and still has shortcomings due to the use of systems and equipment that are still conventional and still have to involve a lot of human labor and are still not efficient, there is a need for automation in the industrial world to increase the effectiveness and efficiency of production by utilizing the Internet of Things (IoT) [11] .

The industrial world cannot be separated from the use of electrical energy in all aspects such as the use of production machines[12], the use of electronic equipment, and the use of lighting to support the production process[13]. The equipment is not only a secondary need but has become a primary need. However, many electrical and electronic equipment in the industry are generally inductive in nature so that it will cause a phase difference between the voltage and the current flowing[14]. The inductive electrical load is a problem for PLN consumers because it causes a low quality of power factor (Cos < 0.85 lagging) as a result, PLN's subscription costs are higher[15]. The power factor is good when it is close to one or when the voltage is in phase with the current. Many studies have been carried out but tend to lead to efforts to improve power factor as an effort to increase electrical efficiency or discuss the effect of electrical load on power factor (cos), electrical efficiency and power capacity as well as measuring the value of power factor (cos) on various types of electricity. burden. Previous research still uses a conventional power factor improvement system that has not implemented and utilized a system based on the Internet of Things (IoT)[16].

2. Methods

The research method used is Analysis, Design, Development, Implementation, Evaluation (ADDIE). The ADDIE research method is one method that is often used in research to produce an industrial product or appropriate technological tool. This study aims to create a system that can control electrical loads and can monitor it in real time and can even be controlled remotely using the internet, this system provides ease of use and flexibility in operating time[17] , can be seen in Figure 1 for the method research and pictures.2 for detailed explanations at each stage of the research method.

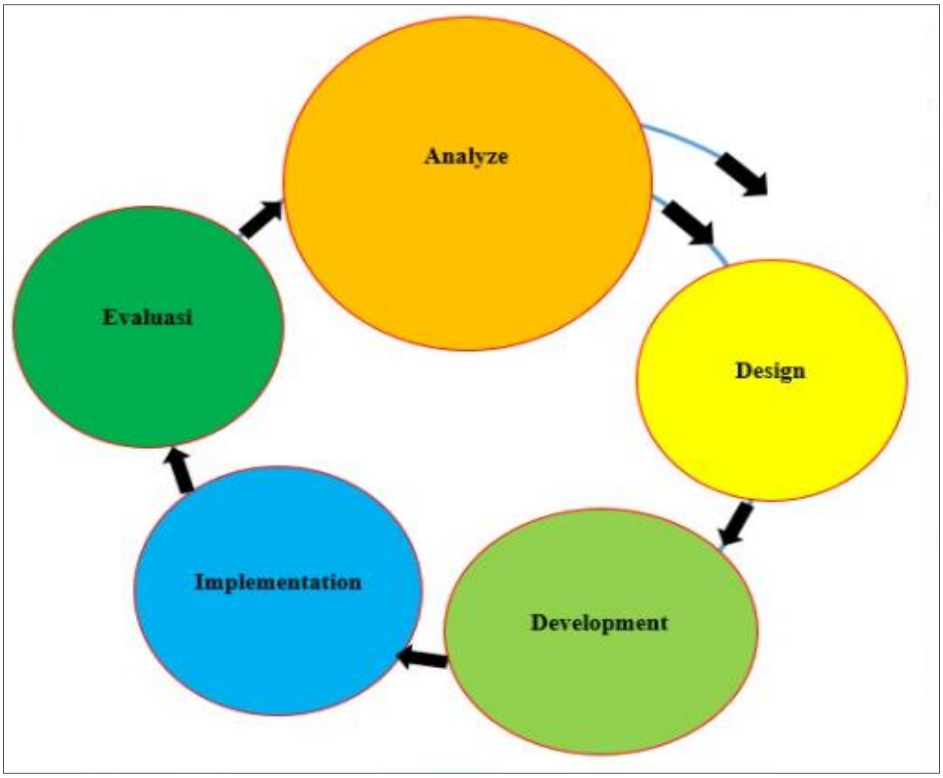


Figure 1 Research method flowchart

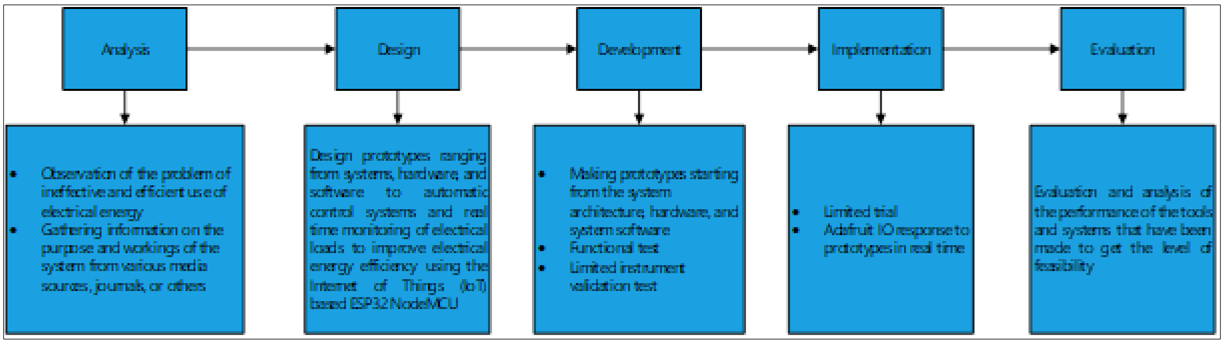


Figure 2 Flow of research methods carried out

Based on Figure 3, it can be seen the flow of the use of this system starting from the user to the electricity load, later users who are already connected to the internet can access the adafruit.io server which is already connected to a WIFI router and nodemcu esp32 [18] which will later connect the user with the electrical load for can be monitored anytime and anywhere as long as it is connected to the internet.

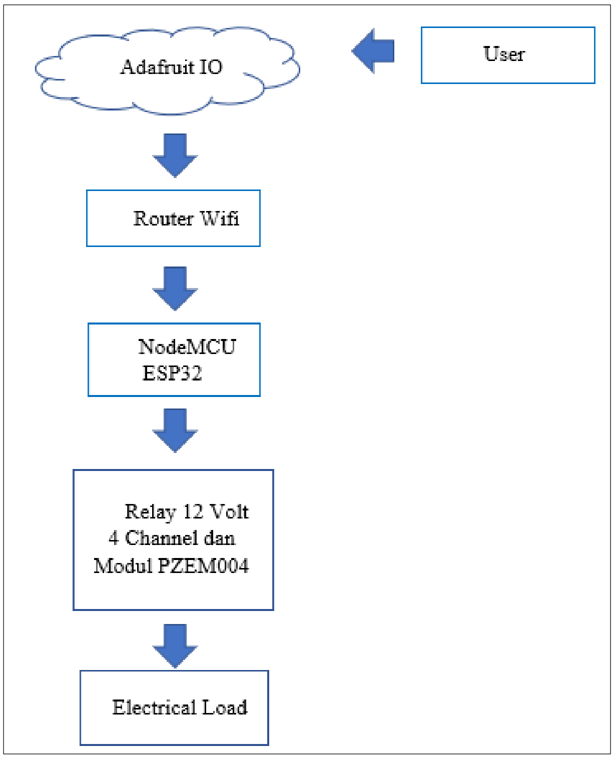


Figure 3 System Usage Flow

2.1 Adafruit IO Account Settings with Nodemcu Esp32

AdaFruit IO is a website-based flatfoam company that is engaged in the manufacture of open source hardware and also provides a server that can be connected to the NodeMCU ESP32 to be able to control it remotely, using [19] Adafruit IO users do not need to download applications or other supporting software, they only need to open a website that is already available, the steps that must be taken to be able to set up NodeMCU ESP32 with the AdaFruit IO server can be seen in Figure 4.

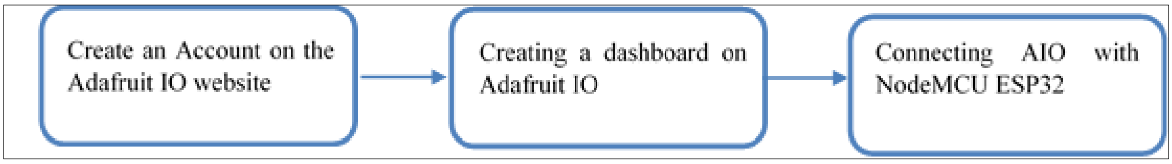


Figure 4 System Architecture starting from user, internet and system, and up to loads

3. Results and discussion

3.1 System Architecture

Based on Figure 5, it can be seen the architecture of the system, on the part the user can use a smartphone, laptop, or computer that is connected to internet access, later the user only needs to log in to the adafruit.IO MQTT server that has been provided but must have access in the form of a user ID and password. In the internet and systems section there is a server that connects the user and the electrical load that is already connected to the internet access point, in the loads section the load is controlled by a relay connected to the power source and also Nodemcu esp32 so that there is a direct relationship between the user and the loads.

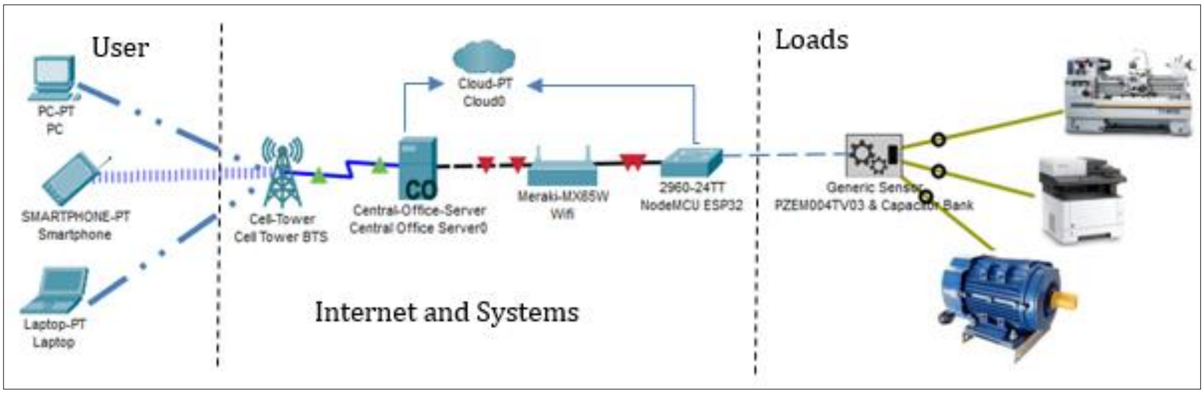
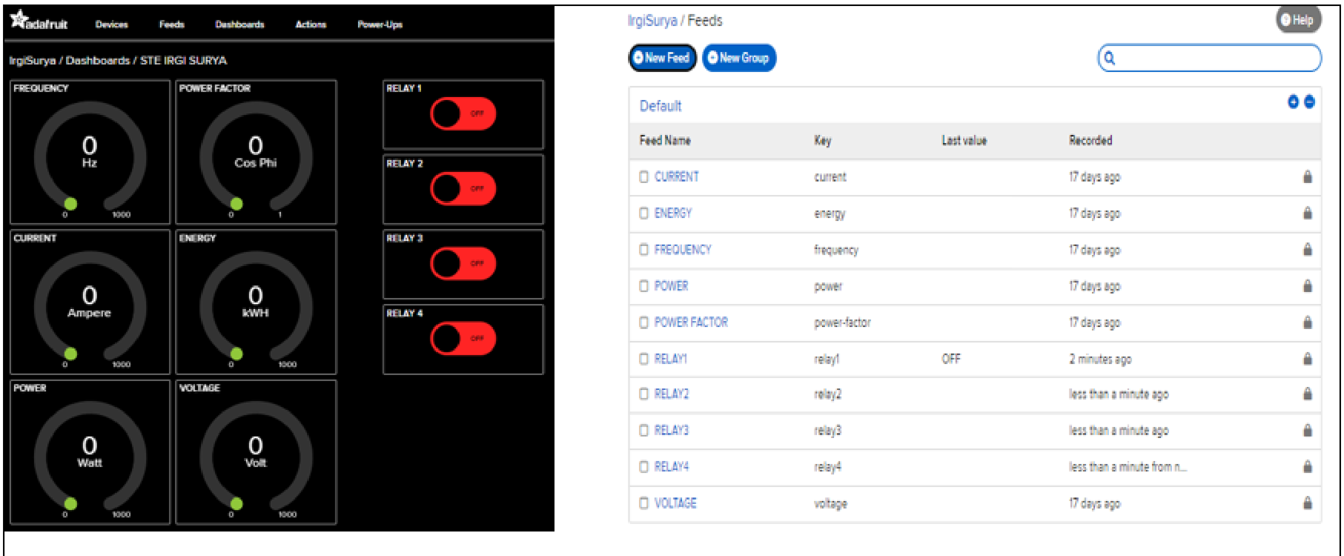


Figure 5 System Architecture starting from user, internet and system, and up to loads

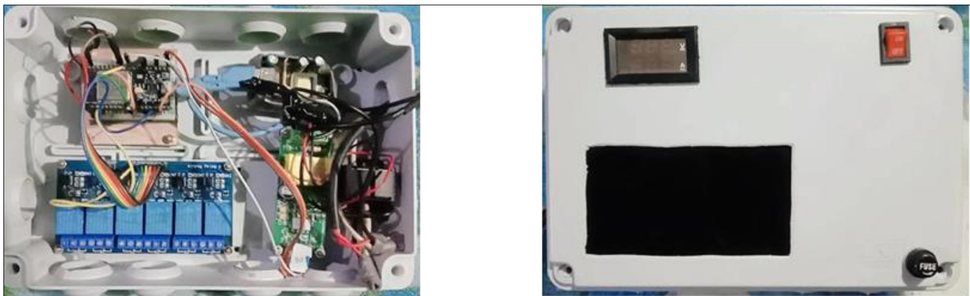
3.2 Monitoring and Wiring Design



(a) (b)

Figure 6 (a). Display monitoring on the server, (b). Feeds on each monitoring block

Based on Figure 6.(a) it can be seen that the main part of the display that has been made on the adafruit.io MQTT is equipped with 6 monitoring displays for power, energy, current, voltage, frequency and power factor. While on the left there are 4 switches that can be used to control the load while improving the power factor. In Figure.6.(b) is the address of the feeds used for coding the program.



(a) (b)

Figure 7 (a). View of the inner tool, (b) View of the outer tool

Based on Figure .7. (a) It can be seen that the inside of the components and wiring that have been made in the prototype, and in figure. Network safety.

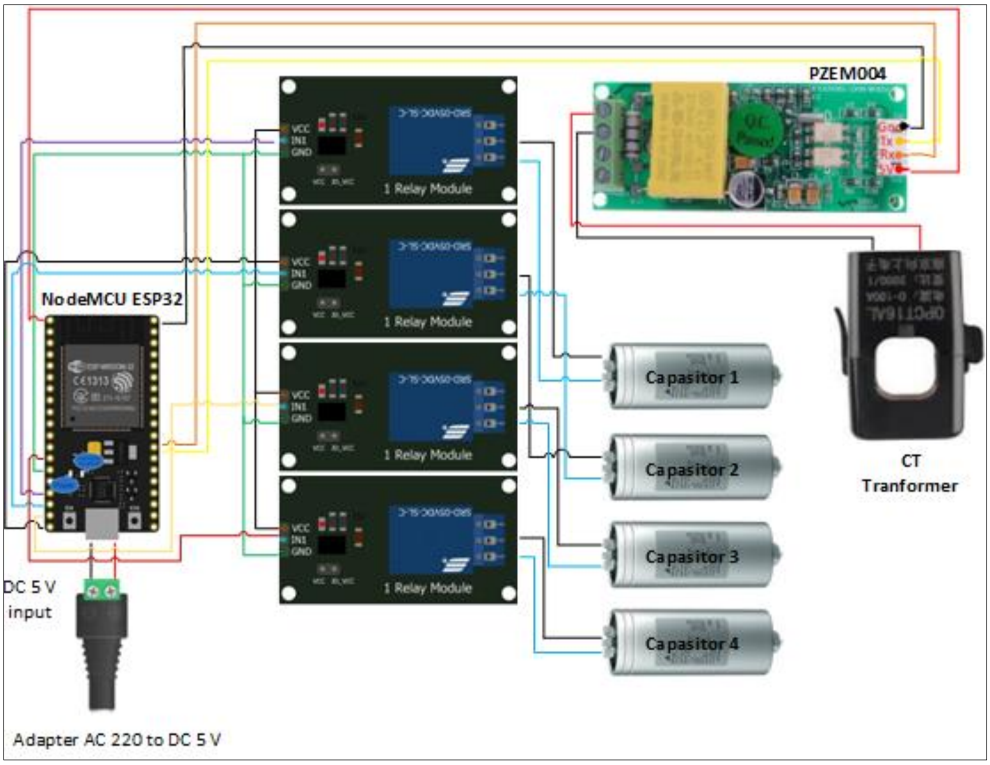


Figure 8 Wiring of each connected component

3.3 Test results by conducting simulations

Table 1 Relationship between pins on ESP32, Relay, and PZEM004

ESP32 pin	pin relay	PZEM004 pin
Vin	Vcc	Vcc
Gnd	Gnd	Gnd
GPIO 9	1	-
GPIO 10	2	-
GPIO 11	3	-
GPIO 12	4	-
GPIO 16	-	Tx
GPIO 17	-	Rx

Based on table 1, it can be seen the relationship between the pins on the ESP32, Relay, and PZEM004, these three components both require an input of 5V dc obtained from the ESP32 Vin and Ground which are all connected directly. GPIO pin 9 is connected to pin 1 of Relay, GPIO 10 pin is connected to pin 2 of Relay, GPIO pin 11 is connected to pin 3 of Relay, GPIO pin 12 is connected to pin 4 of Relay. The GPIO pin 16 is connected to the Tx pin PZEM004, and the GPIO pin 17 is connected to the Tx pin PZEM004.

Based on Table 2, it can be seen that there is a significant influence between WIFI internet speed, user internet speed, and the delay that occurs. In the 0-10 MBPS range, WIFI internet speed and user internet speed are installed in the 0-5 MBPS range, the delay that occurs is 1 second, in the 11-20 range WIFI speed and user internet speed is installed in the 6-10 MBPS range, the delay that occurs which is 0.8 seconds, and in the range of 21-30 WIFI internet speed and user internet speed is installed in the 11-15 MBPS range, the delay that occurs is 0.6 seconds, meaning that the WIFI internet speed and user internet speed are directly proportional to the delay in this system, the more The higher the WIFI internet speed and the user's internet speed, the smaller the delay that occurs in this system.

Table 2 Tests on the system measure WIFI internet speed, user internet speed and delays that occur

Speed of Internet WIFI (MBPS)	Speed of Internet Users (MBPS)	Delay (S)
21-30	11-15	0.6
11-20	6-10	0.8
0- 10	0-5	1

4. Conclusion

This study aims to design and design an automatic power factor monitoring and improvement tool for industry in real time based on the internet of things starting from architecture, display monitors and hardware systems as well as conducting feasibility testing. To save electrical energy and improve power factor and can be controlled remotely. To design this system using the NodeMCU ESP32 microcontroller as a control and local materials that are cheap and easy to obtain. The results of this study are expected to provide appropriate design recommendations and have system and material advantages and to be implemented. The impact of this research is that future research will be much better because in this study a feasibility test of the system has been carried out by conducting simulation trials . Our target is to create and implement this system in industry so that it can prevent wastage of electrical energy and the crisis of electrical energy . The entire system operates automatically , so it does not require an expert to operate it. This design has a lot of room for future research and development. This tool is expected to be able to solve problems related to energy regulation and saving electrical energy. Although in this project there are still many shortcomings that must be investigated in the future.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors state that there are no personal, financial, or organizational conflicts of interest that may affect the output of this research.

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