DESIGN OF MICROCONTROLLER-BASED CUBICLE SUBSTATION CONTROL AND MONITORING SYSTEM USING LORA MODULE AT THE AIRPORT

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Abstract

The cubicle is one of the power distribution devices that acts as an input from a voltage source that will be distributed to all airport loads. Currently, cubicle monitoring at airports in Indonesia is still done manually. Thus, when a fault occurs, repairs will take a long time because the exact location of the problem cannot be determined. Therefore, this tool is designed to improve the work efficiency of technicians during repairs for smooth flight operations at the airport. This tool is designed to control, monitor and know if there is a disturbance, especially overload or voltage drop in the cubicle remotely. In this tool design there are 2 tools, namely the transmitter and receiver modules. In the transmitter using a PZEM 004-T voltage current sensor and an Arduino Uno microcontroller with a lora module as a remote communication. While in the Receiver module this tool is also equipped with a Lora module and NodeMCU Esp32 as a wifi module whose data will be displayed through the Blynk Application. In designing this tool in the form of a prototype and the results, if this tool works properly it will provide a warning to the user that there is a disturbance in the cubicle. this tool can effectively increase the technician's time to complete field repairs.

Keywords: Cubicle, PZEM-004T, Arduino Uno, Esp32 MCU Node, Lora Module

INTRODUCTION

The need for development in the world of electric power systems in the long term is driven by the need that PT PLN (Persero) must have an efficient investment plan, in the sense that PT PLN (Persero) will not carry out electric power projects without good trust. planning and availability of electricity in the right amount and quality is one of the factors that support development planning in various sectors, as well as increasing community productivity. Electric energy providers, in this case PT PLN (Persero), must be able to provide optimal electrical energy services in accordance with consumer needs. This section actually supports the distribution of electrical energy to consumers, for which it is necessary to plan and operate with an adequate power distribution network. (Hasyim, 2019)

An airport is an area on land or on water with certain boundaries that is used as a place to take off, land, pick up passengers, load and unload goods, internal transhipment and intermodal areas equipped with security, aviation safety and security facilities, as well as main facilities and other supporting facilities outlined and in law number 1 of 2009 concerning aviation and airports. The airport certainly has an airport electrical system that is installed to ensure the smooth operation of the flight, this system is useful for the safety and comfort of air transportation service users and the aircraft itself. Therefore, it is very important to pay attention to the comfort factor.

Over time, the number of passengers at an airport increases which is influenced by economic factors. The higher the economic level of the community, the higher the tendency to use airplanes as a means of transportation.

The choice of aircraft as a means of transportation for people whose economy is sufficient because they want to save travel time so as not to interfere with their work. Thus, the higher the economic level of the community, the greater the desire to use aircraft as a means of transportation, so that the number of passengers at the airport is increasing. With the increase in the number of passengers, electricity consumption at the airport also increases, which is used for flight services such as ticketing, passenger check-in (re-check-in), aircraft storage and maintenance, and aircraft passenger services. external services that provide comfort at this airport such as wifi equipment, shipping, television. The airport also offers free chargers and catering facilities as all facilities used at the airport are electrically powered.

In this era, electricity is a very important necessity for human life. Since the discovery of electricity, the use of electricity has expanded and become an indispensable source of energy to support daily activities. Electrical energy can be generated by generators using other energies such as hydropower (PLTA, PLTMh), wind (PLTB), gas (PLTG), steam (PLTU), geothermal and nuclear. Electrical energy is needed because electrical energy can move, heat or cool electrical equipment, and has the ability to regenerate mechanical equipment.

According to Suripto in 2016, electrical energy is the result of a process in the electrical system. In the power supply system there are devices that support it, as well as in the distribution system there is a power supply device in the form of a cubicle. Inside the cubicle, several devices help the process of delivering electric power. Therefore, the performance of the cubicle itself and the equipment it contains must be maintained properly. (Suripto, 2016)

In the power distribution system, before electricity is distributed to consumers, electricity from the PLN substation is channeled through a distribution substation. Inside there are equipment such as electrical panels, transformers and separators. Therefore, PLN tries to minimize the disturbances that occur at the substation. One of the disturbances that occurs is an overvoltage disturbance or a voltage drop that occurs in the cubicle / connected equipment. Connecting equipment according to the PUIL definition is a device that controls, distributes electrical energy, and protects electrical circuits in the use of electrical energy. Its function is to control, connect, protect and share power from electrical energy sources.

Cubicles are designed for classes 3-30 kV and are used forload centers or power centers. cubicles have a cabinet-like shape and are sealed on all sides, so there is no contact with live parts during operation. Because the building is closed on all sides, the installation of this type of connection board (PHB) does not need to be in a closed and locked place or can be installed in public places wherethere are electrical facilities. (Andi, 2020)

Of course this cubicle is at the distribution station. In the distribution substation there is a 20 kV medium voltage which is a connecting device, divider, insulator and protection device for the 20 kV distribution power system.Inside the distribution substation there are input, output, connection and transformer compartments. In the distribution of household electricity, devices are needed that are able to divide, disconnect, connect and protect so that the use of electricity can be efficient, economical and safe for users. One device that can be useful for distributing electricity is the cubicle. (Candra, 2018)

The cubicle also functions as a breaker, divider, connector and protector of medium voltage electrical installations, usually installed in the electrical distribution substation room. When medium voltage is installed in the cubicle, the thing to note is a tool to facilitate monitoring or maintenance so that electrical equipment is more durable. Over time, the cubicle has also experienced a decrease in service quality, so that now the cubicle section continues to be developed. cubicle panels play an important role in maintaining the stability of electricity distribution from the distribution system to consumers, ensuring no interference, quality and safety for the publicand technicians. (Nur, 2019).

Cubicles are also subject to service degradation over time, so maintenance efforts must be made to maintain or regain their original level of performance and to operate with high reliability, ensuring continuity of electrical services can be achieved. Cubicles used today have many problems, one of which is load imbalance interference which can result in currentloss due to currents arising on the neutral side.

At airports in Indonesia, technicians who work in thefield control and monitor the cubicle manually, so that when there is a disturbance that causes the cubicle to be disturbed, the technician must conduct a manual investigation. Manual here means that the technician checks the cubicle by looking directly at the position of the cubicle. According to observations during *on the job training*, although the cubicle has a security system, it will be difficult for technicians to check the condition of the cubicle because the distance between the cubicles is far apart, so it will be very difficult to take time if they have to find the source of the problem themselves. Because the cubicles are far from the maintenance power house and checking the cubicles is always done manually and takesa long time. Therefore, support is needed to help technicians control and monitor cubicles from the maintenance power house so that no disturbances may occur, saving time when technicians perform maintenance.

The current condition has many shortcomings, namely in the distribution substation or substation the technicians still manually check the cubicle, this results in inefficiency in time, because opening the cubicle takes a lot of time and if there is a troubelshoot it is only detected by the indicator light.

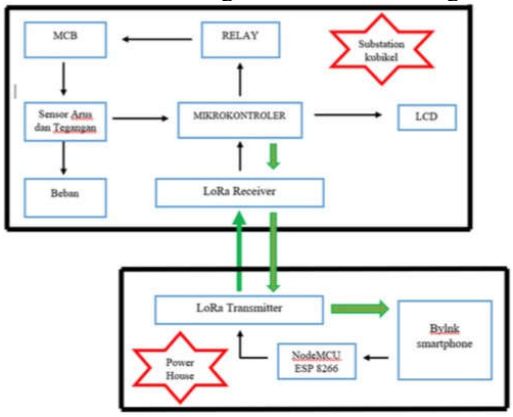
The desired condition is that in the distribution substation or substation there is a cubicle in which there are current and voltage sensors that are connected to the microcontroller and displayed through the 16x2 LCD screen and from the microcontroller will issue a signal through the Lora module so that it can be controlled and monitored through a multimedia interface without having to do manual verification. From the desired conditions, the author expects that the design of this tool can facilitate technicians in carrying out maintenance and reduce the shortcomings of the current conditions.

From this background, the idea was obtained in making this final project with the title "Design of a MICROCONTROLLER-BASED SUB STATION CUBICLE CONTROL AND MONITORING SYSTEM USING LORA MODULES AT AIRPORT". With this tool, the author hopes that it can be used for the learning process and can be utilized in the community.

RESEARCH METHODS

Based on Figure 1 below, the design block diagram of the microcontroller-based cubicle control and monitoring system using the LoRa module starts from the PZEM-004T sensor, which is a sensor that functions to detect current and voltage. This sensor takes big data about the current and voltage flowing through the cubicle.

Block diagram of research design



Based on Figure 2 below, the flowchart that has been made is the process of how the beginning of this tool works. In this study there are 2 flowcharts, namely the transmitter and receiver. For the transmitter itself begins with starting and then initializing the data after that thereis a sensor that will read the current and voltage data, after which it is observed whether there is a disturbance that occurs. If so, the technician sends the cubicle off commandusing the Blynk application and the command is sent usingthe lora module.

For the receiver itself after receiving the cubicle off command from the transmitter, the command is sent to the arduino to process the data so that the arduino can order the relay to normally open so that it can turn off the cubicle.

Flowchart of transmitter and receiver

Hardware

In making tools, the thing that needs to be prioritizedis the component device. The hardware used is as follows:**Miniature Circuit Breaker (MCB)**

The main function of this MCB is as a protective device for electrical equipment to prevent short circuiting,damage or burning due to excessive current or temperature. MCB works with the bimetal principle to protect against short or excessive currents. When a current overflow occurs, the bimetal strip begins to bend to limit the arc. After that, the arc is cooled by the arc channel, an insulated metal strip.

The deflection of the bimetal strip off the latch turns the MCB off by cutting off the current in the circuit. This helps protect equipment and devices from overcurrent. To get the current flowing again, the MCB is switched on manually.

short-circuit, the current may rise suddenly resulting in electromagnetic displacement of the plunger associated with the solenoid. The plunger touches the trip lever activating the latch release mechanism. As a result the MCB opens.

MCBs have bimetal contacts that can expand and contract as the temperature changes. Under normal operating conditions, the bimetallic contacts allow current to flow through the MCB. However, as soon as the current exceeds the set point, the bimetallic contacts begin to heat up and expand until they reach the MCB *operating* lever, causing the current to be cut off.

Arduino Uno

Arduino Uno is an Atmega-based microcontroller which is a data processor with 14 digital pins, namely pin 0 as a program receiver, pin 1 as a program transmitter, the remaining 12 output pins. A USB connection is used to send programs from a computer, where an adapter cable is used as the Arduino's main input using AC power, ICSP pins and a reset button to repeat the program. Arduino is also an open hardware platform for anyone who wants to prototype electronic devices based on flexible and easy-to-use hardware and software.

Relay Module

relays have the same working principle as magnetic contractors where both are based on the magnetism produced by the coil, if the coil is powered by electricity. Based on the input power, the relay is divided into 2 types, namely DC relays and AC Volt relays, the amount of DC voltage entering the relay coil varies according to the size listed on the relay including relays with a voltage of 6 Volts, 12 Volts, 24 Volts, 48 Volts, while for AC voltageof 220 Volts. Relays consist of coils and contacts, coils are coils of wire that receive current, while contacts are a type of switch whose movement depends on the presence or absence of current in the coil circuit. There are 2 types of contacts: open (initial condition before opening) and close (initial condition before closing).

Sensor PZEM-004T

The PZEM-004T sensor is a type of sensor that can monitor electric current, voltage and frequency in alternating current (AC). The PZEM-004T module is equipped with a current transformer winding with a diameter of 3 mm which is used to measure currents up to 100 A.

LoRa Module

LoRa is one of the new technologies of wireless communication. This communication technology can be given to objects that are considered necessary for communication between other objects. LoRa only requires one battery as the main power source in order to function properly. the application of LoRa on these objects is quite simple because it does not require complicated installation. This makes it easy for anyone who wants to build and design an IoT-based system.

Software Blynk App

Blynk is a platform that allows developers and hobbyists to create mobile apps that connect to various physical devices, such as microcontrollers (like Arduino, Raspberry Pi, ESP8266, etc.) and other smart devices. The Blynk app allows you to control these devices through a smartphone or tablet

Wifi Connection

Wi-Fi stands for Wireless Fidelity which is a wireless data transmission medium that can be used to communicate or transmit programs and data with very fast capabilities. Wi- Fi can also be understood as a technology that uses electronic devices to exchange data with radio waves (wireless) through computer networks including internet connections.

RESULTS AND DISCUSSION

Analysis Result

In this stage the researcher analyzes the material, namely by identifying problems, identifying tools that are in accordance with the laws and regulations, and thinkingabout the tools to be developed. In making this tool, researchers found a problem, namely the inefficiency of time in maintaining electrical equipment at airports so thatit can take a lot of time.

So that every airport must have facilities that can help smooth the operation of the airport itself, namely electrical facilities, one of which is the cubicle distribution substation. This means that electricity has an important role in creating passenger comfort.

As time goes by, the quality of cubicle service also decreases so that the cubicle component continues to develop until now. cubicle panels play an important role in maintaining the stability of electricity distribution fromthe distribution system to the hands of consumers, ensuring no interference, quality and safety for the community and employees. The current condition of the airport in Indonesia has many shortcomings, namely in the distribution substation or substation the technicians still manually check the cubicle, this results in inefficient time, because opening the cubicle takes a lot of time and if there is a troubelshoot it is only detected by the indicator light. So a tool is needed to be able to control and monitor remotely.

Design

Next is the design stage where at this stage a form of design is needed for the instrument to be produced. The layout of the components and the making of references for the installation of the tool will be carried out. This stage is in the form of a framework before tool development, which is in the form of components to produce tools in this final project. This is the form of the prototype used.

In Figure 3 below is an overall picture of the prototype tool circuit. The discussion of the results of this test begins with the results of the MCCB test, where in this tool there are 2 main parts, namely 1 transmitter module which functions as sending data from the MCCB and for 1 receiver module which has an esp32 nodeMCU as a wifi module to receive data and display on the LCD screen and blynk application. Furthermore, the transmitter module tests the sensors used to take data from the load used, measuring the input and output voltage, and for the receiver module to carry out monitoring operations via the application or software until the end of the system work process, namely cubicle monitoring using the internet of things (IoT) based blynk application/web.

Figure 3. Picture of the Prototype Tool as a Whole With this tool testing, the goal is to understand the operation of the tool and analyze the reliability, shortcomings, and limitations of the component specifications and applications used.

Development

At this stage the author makes a tool in the form of system control and cubicle monitoring with various stages that are passed starting from analysis, design and up to tool development. Therefore, various components are needed to assemble the tool so that this tool can later function and work as it should. For its manufacture as follows:

Hardware Manufacturing

In this sub-sub chapter the author will explain the components of the

The main tools that will be assembled and tested. The following components are used:

1. MCB
2. Sensor PZEM-004T
3. Mini 560 DC-DC Converter
4. Arduino Uno
5. Relay
6. NodeMCU ESP 32 LoRa module
7. 16x2 LCD

Miniature Circuit Breaker (MCB)

1 MCB 3 Pole 10 ampere is used in hardware as a 3 phase electricity simulation. These three poles each have phases R, S, and T. MCB gets input from an AC power source and has an output to the PZEM-004T sensor where each 1 Pole is connected to 1 PZEM-004T sensor.

Sensor PZEM-004T

In hardware manufacturing, this tool uses 3 PZEM-004T sensors. This sensor can measure voltage, current, and power. This sensor has an input from the MCB to detect current and voltage and has an output to the Arduino Uno. Each of the three sensors is connected by Phase R, S,and T.

Mini 560 DC-DC Converter

In designing this tool, a step down buck converter is needed, aiming to reduce the voltage generated from the rectifier. This buck converter module is used to reduce the voltage to 5VDC which functions as power to turn on the ESP32 which functions for monitoring and Arduino Uno which functions as a control for the internet of things.

Arduino Uno

Here the author uses Arduino Uno as an electronic circuit board microcontroller to function as the main brain in this tool mockup because it can control the input, process and output of the circuit. the data received by Arduino from the PZEM-004T sensor is then processed into number form and displayed on the LCD layer.

Contactors

In the hardware of this tool using a 220VAC Contactor as an auxiliary contactor that functions as a control circuit where when a failure occurs in one of the phases (R, S, and T) the Contactor will cut off all electricity. The contactor has input from a relay which is the driver in the event of a failure.

Solid State Relay

In order for the contactor to work, a switch is needed. Relay is used as a contactor drive switch so that it can cutoff electricity in the event of a failure in one of the phases(R, S, T), when the voltage rises beyond 250V and when the voltage drops to 50%. Relay has input from MCB and output to contactor.

NodeMCU ESP32

In designing this tool requires a microcontroller in the form of ESP32 as the internet of things. This ESP32 gets a power supply from a battery that has been reduced in voltage by a buck converter module to 5V. This ESP32 functions to receive and send data in the form of voltage and current which will be displayed on the blynk application which requires a WiFi connection.

LoRa Module

The LoRa module in this tool has a function as a data sender that has been processed from Arduino Uno and then uses ESP32 as a wifi module to connect to the blynk application/web on a smartphone or computer. This LoRa module has specifications to send data with a distance of ± 10 km with minimal conditions of obstructions from people's homes and stronger additional antennas.

Liquid Crystal Display (LCD)

Liquid Crystal Display (LCD) circuit with Arduino Nano serves to display the writing that has been made in the Arduino IDE application with the display of current (I) and voltage (V).

Implementation

At this stage, namely testing of the tools made, testing this Lora module is carried out in several places as far as possible so that the Lora module cannot send data anymore.

from the results of Figure 4.1 it can be seen that the receiver module can receive data well

Figure 4.1 Testing the lora module at a distance of 1.608 M

From the results of the monitoring layer below, it is found that the receiver module is still good enough to receive data at a distance of approximately 3km.

Figure 4.2 testing the lora module to a distance of 3.167 M

It can be seen in the picture below that the receiver module can still receive and send data signals even though there is a 5-6 second delay.

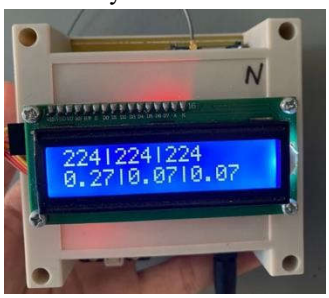


Figure 4.3 Testing the lora module 4.557 M away

Judging from the picture below, the lcd layer is blank, indicating that the receiver module can no longer receive data with a distance of 5 km.

Figure 4.4 Testing the lora module at a distance of 5,100M

The results of testing 1,2,3 and 4, the author can conclude that this lora module is able to provide signals over long distances. The time delay is due to factors from the environment and many buildings. This lora module can also provide further with an additional antenna.

The delivery of lora data can be summarized in the following table:

Table 4.1 Testing the Lora Module

NO	distance	Light load	Phase 1	Phase 2	Phase 3
1	1,608 M	60w 8w 8w	V:224 A: 0,27	V:224 A: 0,07	V:224 A: 0,07
2	3,167 M	60w 8w 8w	V: 225 A: 0,27	V: 225 A: 0,07	V: 225 A: 0,07
3	4,557 M	60w 8w 8w	V: 224 A: 0,27	V: 224 A: 0,07	V: 224 A: 0,07
4	5,148 M	60w 8w 8w	-	-	-

From Table 4.1 above, the results of testing the Lora Module with a predetermined distance are obtained. It is found that this Lora module functions and works well.

CLOSING

Conclusion

From the research observations after making the final project tool with the title "Microcontroller-Based Cubicle Substation Control and Monitoring System Design Using the Lora Module at the Airport", the following conclusions are made:

1. By using this Lora module, data can be sent with a very long distance of up to 4,500 M with conditions that are quite densely populated and buildings.
2. It can be seen in table 4.2 that there is a difference in the value of the measurement results of the PZEM 004-T sensor using a Multimeter with measurements in blynk with a tolerance value of about 0.0V to 0.5V so that it can be said that phase 1 with a 60W lamp load the voltage on the sensor is 227 V and reads 227.5 V on the Multimeter. Phase 2 with a lamp load of 8W the voltage on the sensor is 227 V and reads 227.2 V on the multimeter. Phase 3 with a lamp load of 8W, the voltage on the sensor is 227 V and reads 227.3 V on the multimeter.

Advice

Then based on the existing conclusions, several realizations of the tool are made so that in the future it can be further developed as follows: 1.For further research, it may be possible to add a notification display in the Blynk application if there is a failure in the operation of the cubicle.

For the use of the Lora communication module, it can send data further by adding an extended antenna as a signal amplifier to make it more stable and the data sent further.

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