Prototype of Electrical Power Breaker Automation ON PHB-TR Using Microcontroller-Based IOT For Flood-Prone Areas

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***Abstract*—The flood disaster caused losses for PT PLN consumers whose areas were flooded. To prevent electric shock accidents due to flooding, PT PLN took steps to extinguish distribution substations whose areas were affected by flooding. This step was taken to maintain the safety of the flood-affected community from being electrocuted, but this resulted in a loss for PT PLN, namely the selling of kWh that was not distributed. In this study, the method used is research and development, where the author makes an idea to overcome the problem of the length of power outage due to flooding by making a PHB-TR Control Prototype for Distribution Substations. Where this prototype is an innovation to replace the main switch on the PHB-TR with MCCB and MCB, which are applied in the box panel. With this prototype, PT PLN officers can speed up the process of blackout areas experiencing flooding quickly by controlling the MCCB and MCB at the PHB-TR distribution substation from the PLN office, but still maintaining the reliability of the 20 kV medium voltage network. This prototype is based on the Internet of Things and can be controlled remotely using the Blynk application, which can be operated on smartphones and computers. This prototype design is expected to assist PLN officers in cutting off the PHB-TR load either from the PLN office or remotely. Additionally, it offers several benefits for PT PLN, including saving unutilized kWh and maintaining a positive image by ensuring the reliability of the electrical distribution system.**

Keywords*—*Flood Simulation, Controller, MCCB, MCB, Internet of Things (IoT), Microcontroller

I. INTRODUCTION

One of the natural disasters that often occurs in urban areas is flooding. Flooding is a form of natural phenomenon that occurs due to high rainfall intensity where there is excess water that cannot be accommodated by a system [1]. Flood disasters cause great losses for many people, especially for PT PLN electricity customers whose areas are prone to flooding. To prevent electric shock accidents due to flooding. PT PLN took steps to turn off the distribution substations in areas affected by flooding by operating PHB-TR directly to the distribution substation location by the operator on duty.

This disaster response step was taken by PT PLN to maintain the safety of people affected by flooding from electric shock accidents, but it also caused losses for PT PLN itself, namely kWh sold by PLN that were not distributed. In this study, the author took the background of the problem in an area with a radial network configuration type that was affected by flooding. Where the disadvantage of the radial configuration type is that if there is a disruption at one point, the other points will not be electrified [2]. Apart from experiencing material losses, this problem also has an impact on the image of PT PLN in the community, especially for people whose areas were not affected by flooding, but because the area around them was affected by flooding, they also had to experience the blackout.

With the background of these problems, in this study the author created an idea or development to overcome the problem of the length of the power outage due to flooding, namely by creating a Prototype Design of PHB-TR Distribution Substation Controller. This prototype is an innovation by replacing the main switch on the PHB-TR with an MCCB which is applied in the panel box. With this prototype, PLN officers can speed up the process of turning off the electricity network in areas experiencing flooding quickly by controlling the MCCB on the PHB-TR distribution substation from the PLN office, but without disturbing or maintaining the reliability of the 20 kV Medium Voltage Network (JTM).

This prototype utilizes the Internet of Things (IoT) which can be controlled and controlled remotely connected to the internet network using an application called Blynk which can be operated from a smartphone and laptop/computer as has been implemented for automatic switch control devices for electrical equipment and electrical power monitoring devices based on the Internet of Things (IoT) [3]-[6]. So that in the design of the prototype based on the Internet of Thing (IoT), it can help PLN officers to disconnect low voltage loads from the PLN office or remotely without having to operate directly to the distribution substation location, as well as several benefits that PT PLN can receive from this tool innovation, namely saving kWh that are not distributed and reducing the SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) figures [7]. In addition, a positive image for PT PLN will be maintained by maintaining the reliability of the electricity distribution system.

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II. METHODS

This research is experimental design-build research that ultimately produces a prototype product in the form of a prototype MCCB and MCB PHB-TR controller. The research method begins with the hardware design and programming of the NodeMCU ESP8266 microcontroller system with Arduino IDE software. In this study, several devices are arranged into a block diagram as shown in Figure 1. Figure 1 is a block diagram of the MCCB and MCB PHB-TR controller prototype which includes input, process and output equipment. The MCCB and MCB PHB-TR controller prototype receives input from the HC-SR04 Ultrasonic sensor used to measure water levels in flood simulations, the PZEM-004T sensor used to measure current and voltage used as parameters to determine the success of the servo motor in moving the MCCB and MCB levers, and the operating button to control the servo motor in the Blynk application. After the input signal is given, it will be processed by the NodeMCU ESP8266 microcontroller connected to the internet network, then sends the sensor reading data and control of the operating buttons from the Blynk application to the Blynk cloud, which will later display the sensor reading value on the monitor display in the Blynk application and will also control the servo motor to move the lever on the MCCB and MCB, and will activate the buzzer as a warning sign for the water level limit in the flood simulation.

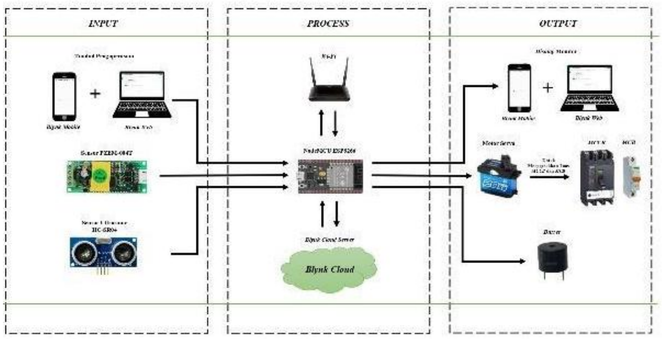

Figure 1. Block Diagram

The research steps taken are as follows:

1. Conduct a literature study to explore basic theories related to the creation of MCCB and MCB PHB-TR controller prototypes.
2. Create a prototype design for the MCCB and MCB PHB-TR controller consisting of selecting the specifications of the components to be used, the placement or layout of the components on the panel box, and the wiring diagram.
3. Conducting software system design, namely programming the NodeMCU ESP8266 microcontroller to control the servo motor, measurement with the HC-SR04 Ultrasonic sensor, measurement by the PZEM-004T sensor, and use of the buzzer, as well as to connect to the Blynk application.
4. Carry out electrical system design, namely wiring each component used.
5. If all the designs have been completed, the next step is system integration to connect physically and functionally.
6. Conduct commissioning tests on the prototype installation and all components used, as well as performance testing of the MCCB and MCB PHB-TR controller prototypes.
7. Conduct data collection and data analysis.

After the design and integration of the entire system has been completed, then in this study several tests were carried out, including: Component installation testing which aims to ensure that all components are properly connected and safe to operate, component function testing which aims to functionally test all the main components used, and performance testing of the MCCB and MCB PHB-TR controller prototypes which aims to test the success of the prototype when operated in accordance with the design concept and how the prototype works.

If all has been done, the next step is to collect data and analyze data. Data analysis is carried out by comparing the prototype design with the realization of the prototype that has been made.

III. RESULT AND DISCUSSION

The results of the overall hardware circuit design of the prototype are shown in Figure 3, where the NodeMCU ESP8266 microcontroller circuit has been integrated with the input and output components on the prototype.

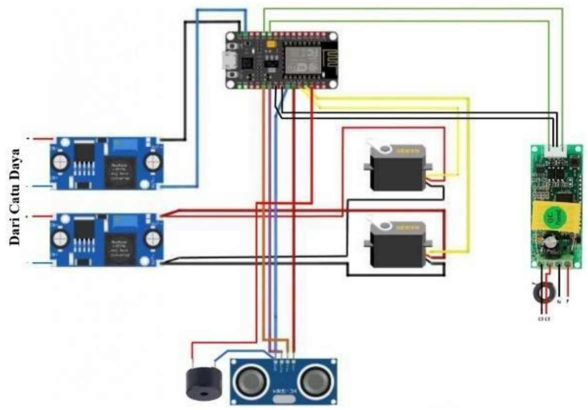

Figure 2. Wiring Diagram NodeMCU ESP8266

From Figure 2, it can be seen that the image is a picture of the wiring diagram of the servo motor, HC-SR04 ultrasonic sensor, PZEM-004T sensor, and buzzer with NodeMCU ESP8266, where the servo motor functions as a lever controller on the MCCB and MCB, the HC-SR04 ultrasonic sensor functions to detect water levels in flood simulations, the PZEM 004T sensor functions to read current and voltage measurement values, and the buzzer functions as an indicator that the water in the flood simulation has exceeded the specified limit, and the NodeMCU ESP8266 microcontroller functions to communicate the ultrasonic sensor, PZEM-004T sensor, and servo motor with Mobile Blynk and the Blynk Wi-Fi Website, so that the plant that is made can be controlled from anywhere and anytime.

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In addition, there are also the results of the interface design on the Blynk application. The Blynk application interface is one of the most important parts in the overall design, because this interface is the part that is most often used by users to run the functions in this system. The Blynk application interface is created and functions to monitor water levels in flood simulations, control servo motors to move the MCCB and MCB levers, to monitor the current and voltage used where this current and voltage are parameters to determine the success of the servo motor in moving the MCCB and MCB levers according to the work description or the system is running well and properly. All input and output components are connected to the NodeMCU ESP8266 microcontroller. For the design of the Mobile Blynk interface on smartphones and the Blynk Web dashboard on laptops or computers can be seen in Figures 3 and 4.

Figure 3. Interface on Mobile Blynk on Smartphone

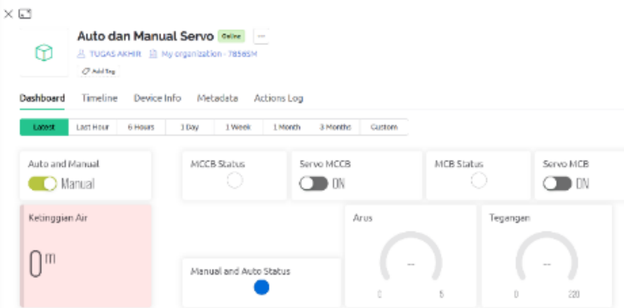

Figure 4. Interface on the Blynk Webdashboard on a laptop/computer

A. *Comparison of Prototype Design and Realization*

In the implementation of design and construction, there are several factors that must be considered such as the suitability between design and realization, the safety of the tool, and the efficiency of the tool used. The comparison between the design and realization of the prototype can be seen in Figures 5 and 6.

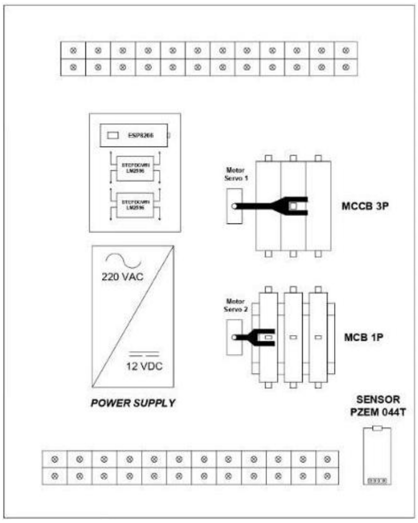

Figure 5. Design Model of the Prototype

Figure 6. Design Model of the Prototype

Visually, it can be seen that the realization of the layout on the prototype that was made is in accordance with the layout design on the prototype.

B. *Component Installation Test Results*

The prototype of the MCCB and MCB PHB-TR controllers consists of various components ranging from input, process, and output components, so it is necessary to test the installation of components that have been installed on the prototype. Where this test aims to ensure that all components are properly connected and safe to operate.

Table 1. Test Result Data for Component Installation Under Voltage Conditions

Component	Testing Procedure	Condition	Information
MCCB	Testing using a voltmeter and test pen	Good	Get voltage from source
MCB	Testing using a voltmeter and test pen	Good	Get voltage from source
PZEM-004T Sensor	Testing using a voltmeter and test pen	Good	Get voltage from source

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Table 2. Component Installation Test Result Data for Non-Voltage Conditions

Component	Testing Procedure	Condition	Information
MCCB	Testing using an ohmmeter	Good	Well connected
MCB	Testing using an ohmmeter	Good	Well connected
NodeMCU ESP8266	Testing using an ohmmeter	Good	Well connected
Power Supply	Testing using an ohmmeter	Good	Well connected
Modul *Step Down* 2596	Testing using an ohmmeter	Good	Well connected
Motor Servo	Testing using an ohmmeter	Good	Well connected
Ultrasonic Sensor HC-SR04	Testing using an ohmmeter	Good	Well connected
PZEM-004T Sensor	Testing using an ohmmeter	Good	Well connected

After the test has been carried out, the test result data is obtained under voltage and non-voltage conditions as can be seen in Tables 1 and 2. Based on the test results data, namely installation tests under live and non-live conditions, it shows that all components function properly and are safe to operate.

C. *Component Function Test Results*

In this component testing, the aim is to functionally test all the main components used. The results of testing each component and data collection are expected to be able to obtain valid data and the prototype works according to its function and purpose as designed and expected. With good inspection and testing results, it is believed that the condition of each component is safe when operated. Component test result data can be seen in Table 3.

Table 3. Component Test Result Data

Component	Condition	Information
NodeMCU ESP8266	Good	NodeMCU ESP8266 can receive input and provide output and can receive programs provided
Power supply	Good	The power supply is capable of providing the required voltage.
Modul *Step Down* LM2596	Good	The LM2596 Step Down Module is capable of lowering the required voltage.
Motor servo	Good	Servo motors can function according to a given program
Ultrasonic Sensor HC-SR04	Good	Ultrasonic sensor can measure distance and display it in the blynk app
PZEM-004T Sensor	Good	The PZEM-004T sensor can measure current and voltage and display them in the blynk application.

Based on the test results of each component, it can be said that all components used can function well and according to the datasheet specifications. [8]–[15].

D. *HC-SR04 Ultrasonic Sensor Module Test Results*

This test aims to determine the accuracy of the HC-SR04 ultrasonic sensor by comparing the actual distance measurement with the distance measured by the HC-SR04 ultrasonic sensor, as well as the percentage of error in the test. The results of the HC-SR04 ultrasonic sensor test can be seen in Table 4. The calculation of the percentage of error and the average error of the HC-SR04 ultrasonic sensor test are as follows:

$$\%\ Error = \frac{Measured\ Value - Sensor\ Value}{Sensor\ Value} \times 100\% \quad (1)$$

Table 4. HC-SR04 Ultrasonic Sensor Module Test Result Data

Water Level (cm)			
Testing to-	**Actual Water Level**	**Water Level Read Sensor**	**Error (%)**
1	3	3	0
2	6	5,9	0,01
3	9	8,6	0,04
4	12	11,7	0,02
5	15	14,8	0,01
Error Average			**0,08**

Based on the data from the sensor reading test results, the comparison between the actual distance and the distance measured by the HC-SR04 ultrasonic sensor obtained an average percentage value of sensor reading error of 0.08%. This shows that the HC-SR04 ultrasonic sensor module is quite precise and accurate in detecting objects, and this sensor is very relevant for use in flood simulations in this study.

E. *PZEM-004T Sensor Module Test Results*

This test aims to determine the performance of the PZEM-004T sensor measurement to measure electrical parameters properly and accurately. The performance of the PZEM-004T sensor module is measured by comparing current and voltage measurements using an ammeter and voltmeter with the current and voltage measured by the PZEM-004T sensor, as well as the percentage of error in the test. The results of the PZEM-004T sensor test can be seen in Tables 5 and 6. The calculation of the percentage of error and the average error of the PZEM-004T sensor test are as follows:

$$\%\ Error = \frac{Measured\ Value - Sensor\ Value}{Sensor\ Value} \times 100\% \quad (2)$$

Table 5. PZEM-004T Sensor Module Current Test Result Data

Measurement Results (A)			
Burden	**Measurable Value Measuring Instrument**	**Sensor Measured Value**	**Error (%)**
Light 100 W	0,43	0,45	0,04
Light 200 W	0,88	0,91	0,03
Light 300 W	1,31	1,35	0,02
Error Average			**0,03**

Based on the data from the sensor reading test results, the comparison of current and voltage measurements between the measuring instrument and measurements by the PZEM-004T sensor obtained an average percentage value of sensor reading error for current of 0.03% and for voltage of

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0.0004%. This shows that the PZEM-004T sensor module is quite accurate and precise in measuring current and voltage, and this sensor is very relevant for use in this prototype.

Table 6. PZEM-004T Sensor Module Voltage Test Result Data

Measurement Results (V)			
Voltage (V)	**Measurable Value Measuring Instrument**	**Sensor Measured Value**	**Error (%)**
120	120,1	119,6	0,004
140	140,1	139,5	0,004
160	160	159,7	0,001
180	180	179,8	0,001
200	200,1	200	0,0005
220	220,2	220,1	0,0004
	Error Average		**0,0001**

F. Servo Motor Test Results

In the data collection of servo motor testing on MCCB and MCB control, it is divided into two, namely based on a minimum voltage of 4.8 VDC and a maximum voltage of 6 VDC according to the specifications on the component datasheet. The results of the servo motor test can be seen in Tables 7 and 8. In this test, the initial condition of the MCCB and MCB is in the ON condition.

Table 7. Servo Motor Test Result Data Against MCCB

Servo Type	**Volatge (*VDC*)**	**Torsi (Kg.cm)**	**Servo Condition**	**MCCB Condition**
SPT-	4,8	29	Move	*OFF*
5435LV	6	35	Move	*OFF*
SPT-	4,8	29	Move	*OFF*
5435LV	6	35	Move	*OFF*
SPT-	4,8	29	Move	*OFF*
5435LV	6	35	Move	*OFF*

Table 8. Servo Motor Test Result Data Against MCB

Servo Type	**Volatge (*VDC*)**	**Torsi (Kg.cm)**	**Servo Condition**	**MCCB Condition**
Power HD	4,8	16,5	Move	*OFF*
LF-20MG	6	20	Move	*OFF*
Power HD	4,8	16,5	Move	*OFF*
LF-20MG	6	20	Move	*OFF*
Power HD	4,8	16,5	Move	*OFF*
LF-20MG	6	20	Move	*OFF*

Based on the test results data conducted by giving the servo motor minimum and maximum working voltage, it can be seen that the greater the working voltage given to the servo motor, the greater the torque produced by the servo motor. Thus, from both tests, the servo motor can work well with a success rate of 100%. However, it is recommended to use the maximum working voltage of both types of servo motors in order to obtain maximum torque strength from the servo motor so that the performance of this prototype works optimally.

IV. CONCLUSION

The conclusion of this study is that the prototype of the MCCB and MCB controller on the PHB-TR which is designed to be able to work based on the Internet of Things (IoT) to make it easier for operators to control the load on the PHB-TR from anywhere and at any time without the need for operators to operate the PHB-TR directly to the distribution substation has been successfully created and functions well according to the design concept.

Based on the test results in this study, all components used can function properly and run according to the code that has been created in the Arduino IDE software. Testing on the Blynk application has also been successful because it is able to control the servo motor to move the MCCB and MCB levers, and is able to display the readings of the HC-SR04 Ultrasonic sensor and the PZEM-004T sensor in the application according to the program code that has been created and in accordance with the design concept. The Blynk application has an important role because it is a liaison between the user and the prototype so that they can control and monitor remotely in real time. Thus, overall, the system has functioned well according to the design that has been made, both in terms of hardware and programming.

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