Application of the IoT Concept to the Process of Controlling and Monitoring the PLTMH System

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ABSTRACT
This research relates to the implementation of a control and monitoring system in the process of micro hydro power generation (PLTMH), where the control and monitoring system is wireless based on the IoT concept, so that it can be monitored and controlled anywhere while connected to the internet. The monitoring process is related to the output voltage generated through the process of generating the PLTMH system, as well as the process of controlling the adjustment of the output voltage based on the condition of the electrical load, through the process of opening and closing the floodgates.

The test results show that the system can remotely monitor the output voltage from the PLTMH system operation process through the user's device, where the results of monitoring the output voltage of the generator are displayed via a web server, based on changes in voltage resulting from changes in electrical load conditions. This control and monitoring system can also calculate the amount of electrical energy in KWh based on the electrical load connected to the PLTMH power generation system, which is sent to a web server as electricity consumption information. In addition, the system can also perform a remote control process via the web server for the process of opening and closing the sluice gate, where when the sluice opening process is carried out, the data for the sluice opening process will be sent from the web server to the controller device via the internet network, to carry out the process. the. that. open the floodgates. Likewise for the process of closing the floodgates.

Keywords
Monitoring, Controlling, PLTMH, IoT

1. INTRODUCTION
Micro-hydro power generation is the process of generating electrical energy by converting kinetic energy based on water speed and pressure to drive a turbine to rotate the generator, with the generation of electrical energy ranging from 5 Kilo Watts to 50 Kilo Watts [1][2][3]. In producing electrical energy in a micro-hydro power generation system, it is very dependent on the potential energy of water in the process of driving a turbine to produce output power from a generator [4]. The output power of the generator is affected by changes in frequency, where large changes in frequency have a major impact on generator generation power, because the electric voltage generation system uses an excitation field [5], for this reason the generator output voltage must remain stable, even though the installed electric load changes. change [6]. To maintain the stability of the output power from the generator output based on changes in load by adjusting the generator rotation, by adjusting the turbine rotation speed. Turbine speed regulation can be done by adjusting the water discharge flowing into the turbine, through the process of opening and closing the floodgates [7].

In this research, a control and monitoring system will be created for the micro-hydro power plant (PLTMH) process, where the control and monitoring system is wireless based on the IoT concept, so that it can be monitored and controlled anywhere as long as it is connected to an Internet network. The process of monitoring related to the output voltage generated through the process of generating the PLTMH system, as well as the process of controlling the output voltage adjustment based on the condition of the electrical load, through the process of opening and closing the floodgates. In producing a system to control and monitor the generation process in the IoT-based PLTMH system, an integrated supporting module is needed, where the module includes: the ESP32 microcontroller which functions as a monitor for changes in generator voltage and the work controller for the PLTMH system, in terms of the process of opening and closing doors. water to maintain the stability of the generator output voltage [8]; the ACS 712 current sensor functions as a sensor to detect the amount of electric current consumption from the operation of the PLTMH system [9][10], where the detected data will later be processed by the controller, then informed as electricity consumption data in watt hours (Wh) and the data is sent to web servers. Liquid Crystal Display (LCD) which functions as an information medium, to inform the process of operating the PLTMH system, including information on the amount of electricity consumption, consumption of electric current and output voltage from the Generator [11], as well as a voltage sensor that functions as a detector for changes in the generator output voltage [12]. To run the control system and monitor the work of the IoT-based PLTMH system, a program is needed that is embedded into the ESP32 microcontroller, where the software used for making the program is the Arduino IDE, with reference to the flowchart made [13][14].

2. METHODOLOGY
In the process of making an IoT-based PLTMH control and monitoring system, the method used is the prototyping method, where the stages include: the design stage which consists of designing a system block diagram and designing software for operating the target system in the form of a flow chart. The next stage is the manufacturing process which consists of making a system with reference to the block diagrams that have been made and making software that refers to the flowcharts that have been produced. Next is the system testing stage.

2.1 System Design

The hardware design aims to represent the need for a control and monitoring system for the operation of the PLTMH, based on the block diagram of the system. The system block diagram illustrates the relationship between the controller section and the detection devices in this case the sensor, the driving part in this case is the actuator to move the motor and other supporting parts, such as the router (modem). As for the outline, the block diagram for the control system and monitoring of the operation of the PLTMH is shown in Figure 1.

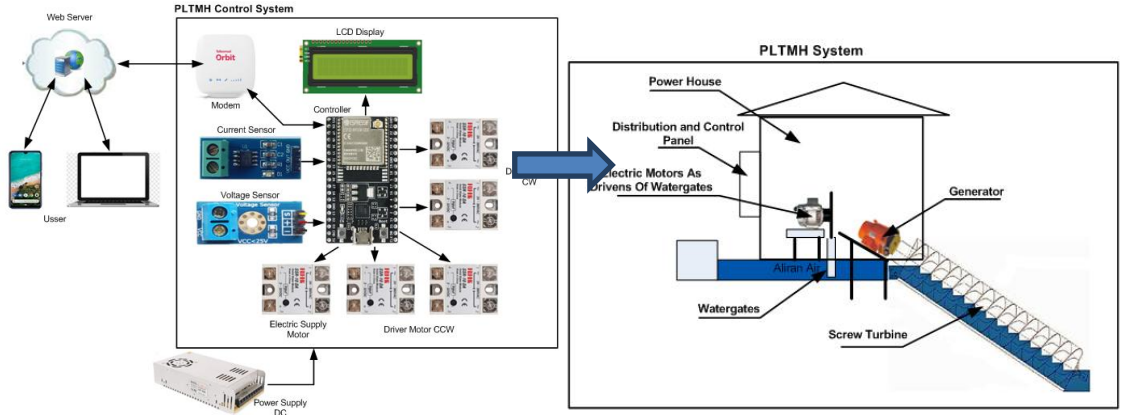

Fig 1: Block diagram system

The description of the Block diagram in Figure 1, is described as follows:

PLTMH System Section

1. The Distribution and Control Panel, functions as part of the distribution of electricity generated through the generation process from the PLTMH, as well as the control and monitoring part of the work of the PLTMH system, in connection with the process of monitoring changes in current and voltage generated through the generation process from generators and controlling work electric motors to carry out the process of opening and closing floodgates, based on changes in current and voltage, in order to adjust to the conditions of the distributed load.
2. Sluice gate, functions as part of regulating the distribution of water to the screw turbine section, as the driving force of the generator in producing electrical energy.
3. The electric motor driving the floodgates functions as a medium for opening and closing the floodgates.
4. Generator, functions as a medium for producing electrical energy, through the process of adjusting the rotational speed of the screw turbine.
5. Screw Turbine, functions as part of the rotational drive of the Generator in terms of generating electrical energy.

PLTMH Operation Control System Section

1. Controller, functions as part of the controller and work information for the PLTMH system. The process carried out by the controller in connection with the detection of changes in the output current and voltage of the generator, where data changes from current and voltage sensors will be processed and a decision-making process will be carried out by the controller which includes:
   a. Adjustment of generator rotation through turbine rotation to adjust to changing load conditions (based on changes in current and voltage data). Where the process of setting the generator rotation is regulated through the process of opening and closing the door which is driven by an electric motor.
   b. Calculating current and voltage input data into information displayed on the LCD screen and on the web server, where the information relates to changes in current values, changes in voltage values and the amount of electrical energy consumption in watt hours (Wh).
   c. Sending data from the processing of generation conditions from the PLTMH to the web server via internet communication.
2. LCD display, functions as an information medium for the work of the PLTMH system, where the information displayed on the LCD display relates to the current value, voltage value, value of the consumption of electrical energy generated by the Generator.
3. Current Sensor, functions as a detector for changes in the output current from the Generator, based on changes in the load distributed to consumers.
4. Voltage Sensor, functions as a medium for detecting changes in the value of the voltage generated from the Generator.
5. CW Motor Drive (clockwise rotation/right rotation), functions as part of the motor setting in the process of opening the floodgates.
6. CCW Motor Drive (counterclockwise rotation/left rotation), functions as part of the motor setting in the process of closing the floodgates.
7. Electrical supply, functioned to provide electrical power to the motor that opens and closes the floodgates.
8. Modem, functions as a wireless communication medium, through internet communication between the control system and the web server, in terms of sending data as work information from the PLTMH system or receiving data in connection with the control process, where the control process is related to the manual operation of the PLTMH system in terms of the process of opening the floodgates and the process of closing the floodgates.
9. Web server, functions as a media for receiving data from the controller, in connection with the work process of the PLTMH system. Besides that, the wb server also functions as an information medium for the work of the PLTMH system and functions as a medium for operating

the PLTMH system, in connection with the manual operation of the PLTMH system in terms of the process of opening the floodgates and closing the floodgates and the automatic operation of the PLTMH system.

10. Users, in this case are smart phone devices (Android) and laptop or PC devices, function as media for monitoring and controlling the work of the PLTMH system. Communication between the User and the controller via a web server that is connected wirelessly via an internet connection.
11. Control system power supply, functions as a medium for supplying electricity to the control system parts, which includes: Controller, current sensor, voltage sensor, LCD display, Modem, motor electricity supply, CW motor drive and CCW motor drive.

2.2 Flowchart System (Algorithm)

In producing a control system related to the work of PLTMH, besides the need for hardware, software is also needed as an operating system for the work of the control system (hardware). Before entering the software development section, the first stage that must be done is the software design stage in the form of a program algorithm, where this stage aims to design program flow in terms of operating the control system and monitoring the work of the PLTMH system. As for software design, using a flow chart (flow chart), as shown in Figure 2.

Flow Chart Working Principle:

1. The start section is the beginning of the program
2. Initialization section, is a section for carrying out the initialization process for variables to be used in the program, as well as a section for managing the function of each pin used on the controller, both functioning as input and functioning as output.
3. The connection part is the program part for connecting the hardware (controller) to the web server via a modem device, through User Name and Password authentication from the modem device, then when it is connected to the modem device, the program will run the part to connect the device (controller)) to the web server according to the address of the intended web server. If the connection process has not been done, then the controller will continue to run the connection program, until the device is connected to the wifi and web server.
4. After the connection process is complete (connected to the modem or web server), the part of the program that is executed is the data reading section, both reading current data through the current sensor and reading voltage data from the voltage sensor.
5. Then the current data and voltage data will be processed by the controller and the controller will calculate the value of the electrical energy (kWh) generated by the PLTMH system, based on the current data and voltage data.
6. Next, the controller will run a program to detect changes in voltage data and current data, based on the following conditions:
    a. If the current data drops and the voltage data drops, the controller will make a decision automatically to activate the electric motor for the process of opening the floodgates.
    b. If the current data increases and the voltage data drops, the controller will make a decision automatically to activate the electric motor for the process of opening the floodgates.
    c. If the current data drops and the voltage data rises, the controller will automatically make a decision to activate the electric motor for the process of closing the floodgates.
    d. If the current data increases and the voltage data increases, the controller will make a decision automatically to activate the electric motor for the process of opening the floodgates.

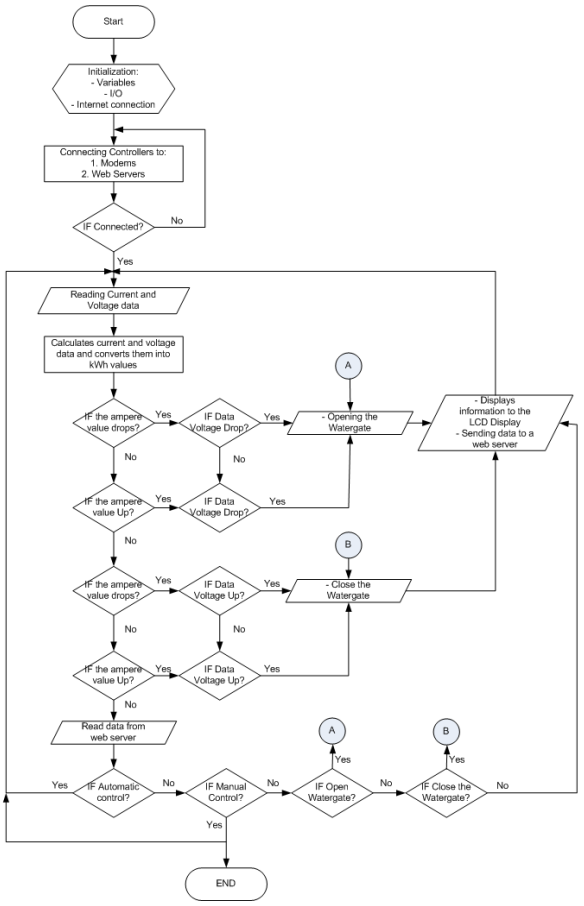

Fig 2:Flowchart system

7. Next, the controller will run the program part to display information related to the work of the PLTMH system through the LCD display and send the information to the web server. The information displayed and sent is related to current data, voltage data, the value of electricity consumption and the condition of the floodgates. Then the program will return to the current and voltage data reading section.
8. If there is no change, both current data and voltage data, then the controller will run the program part to read the information sent from the web server by the user. Where the information sent by the user from the web server includes:
    a. Automatic control, where if the user selects a section for automatic settings on the web server, this setting information will be sent by the web server to the controller device (controller). When the controller receives data input regarding the work settings of the PLTMH system automatically, the controller will carry out the work cycle of the PLTMH system continuously for the process of monitoring current and voltage data, the process of

opening and closing doors and the process of sending data to the web server as well as the process of displaying information on the work of the PLTMH system through the LCD display.

b. Manual control process, where the user can manually select the process of controlling the work of the PLTMH system on the web server. The things that can be done by the user in the manual control section include:
- The process of controlling the opening of the sluice gate, where when the user selects the process to open the sluice gate, this information will be sent to the controller, and the controller will carry out the process: opening the sluice gate, displaying information related to the ongoing process to the LCD display, sending information to web server regarding the ongoing process.
- The control process closes the sluice gate, where when the user selects the process to close the sluice gate, this information will be sent to the controller, and the controller will carry out the process: closes the sluice gate, displays information related to the ongoing process to the LCD display, sends information to web server regarding the ongoing process.

2.3 Web Server Design

The design stages for a web server aim to give the programmer an overview of the appearance of the web server User Interface) as well as the functions of the parts on the web server. The design for the web server display is shown in Figure 3.

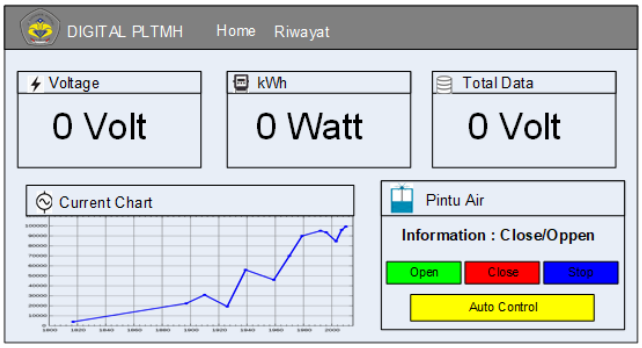

Fig3:Web Server Design

Figure 3 Caption:

1. The HOME Dashboard section functions as a section to go to the main page of the web server
2. The HISTORY section functions to display the data download section on the operation of the PLTMH system, where data searches are related to the consumption of electrical energy from the operation of the PLTMH system.
3. Voltage Section, is a section to inform the state of the voltage generated by the Generator during the electricity generation process in the PLTMH system
4. The kWh section, is a part to inform the consumption of electrical energy for loads connected to the PLTMH system
5. The Total Data Section, is the section that informs the total data that enters the web server received from the controller device, as a monitoring tool for the work process of the PLTMH system
6. The Current Chart section, is a display of information regarding electric current data according to load conditions connected to the PLTMH system
7. Watergate section, is the work control part of the PLTMH system, where the watergate section consists of:
   a. Information section on the state of the floodgates, whether they are in the process of opening the floodgates or closing the floodgates
   b. The Auto Control section is the part of automatically controlling the work of the PLTMH system. Where when the Auto Control section is selected.
   c. The Manual Control section is the part for operating the process of opening and closing the floodgates in the PLTMH systemIn the manual control, it can be seen that the user can open the sluice directly through the web server, when the sluice is selected (by pressing the Open section), information regarding the sluice opening process will be sent to the control device, and the controller device will activate the work of the electric motor to carry out the process of opening the sluice, and the control device will send information to the web server that the sluice opening process is in progress, via a message displayed in the Information section in the form of Open information. To switch to the process of closing the floodgates, the user must first press the Stop section. When the stop section is selected, the web server will send information to the controller device, and the controller device will process it to stop the electric motor from working. Then the user can select the Close section for the process of closing the floodgates. When the Close section is selected, the web server will send information to the controlling device to carry out the process of closing the sluice, and the controlling device will send information to the web server that the sluice closing process is in progress, via a message displayed in the Information section in the form of Close information. And to end the process of closing the floodgates, the user can select the Stop section.

2.4 Making A Control System

The next stage after the design, both hardware design in the form of system block diagrams and control panel design is the hardware manufacturing stage, in this case the manufacture of

the control panel, where the control panel installs each predetermined component. After each component has been installed on the control panel, the next step is to integrate each component so that it becomes a unified system, in this case the control and monitoring system for the operation of the MHP system. the results of making a control system in the form of a control panel are shown in Figure 4.

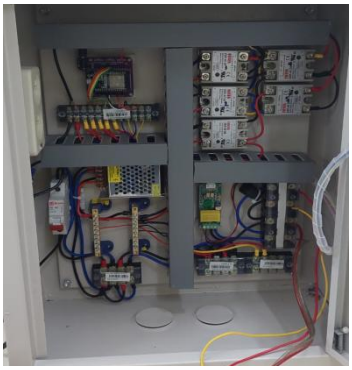

Fig4:Making a Control System

Making the Software for the Operation of the Work Control System for the PLTMH System

The stages of making software for the operation of the work control system for the PLTMH system refer to the flow charts that have been produced in the software design process. The process of making software uses the Arduino IDE program, where the manufacturing process is shown in Figure 5.

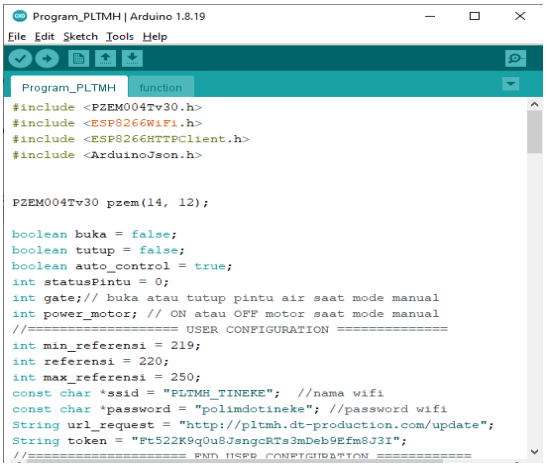

Fig5:Making the software

3. RESULT AND DISCUSSION

System work testing is carried out through the process of integrating each module so as to form an integrated integrated system. System integration includes a controller module that functions as a data processing center, where the data to be processed is related to the voltage and current detection data generated through the PLTMH system. The controller module will be integrated with current and voltage sensors to detect current and voltage values, as well as a relay module that functions as an actuator in the process of opening and closing floodgates, as well as integration of the wifi module as a communication medium between the controller and the web server through the username and password data authentication process. Figure 6 shows the process of testing the PLTMH control and monitoring system.

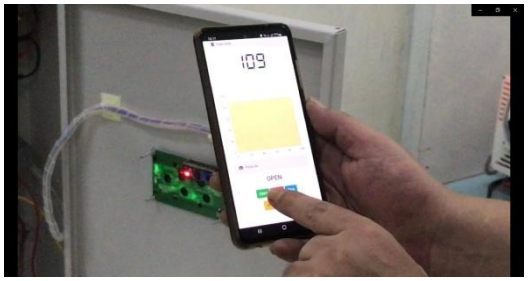

Fig6:Testing the work of the control system and monitoring the work of the PLTMH

The working principle of the system is as follows:
When the system is activated, the system will process the connection with the wifi device, through username and password authentication. If the authentication process is successful, the system will run the program part to read the input from the temperature and voltage sensors, then process the current and voltage data into electrical energy consumption (kWh) data. The part of the program that is carried out is as follows:

```
if (WiFi.status() == WL_CONNECTED) {
  float voltage = pzem.voltage();
  float energy = pzem.energy();
  float current = pzem.current();
  float power = pzem.power();
  if (isnan(voltage)) {
    voltage = 0;
  }
  if (isnan(energy)) {
    energy = 0;
  }
  if (isnan(current)) {
    current = 0;
  }
  if (isnan(power)) {
    power = 0;
  }
}
```

Then the system will run part of the control condition detection program whose control data is received from the web server. If the control data received from the web server is automatic control, then the system will run the program part for the automatic control process. The part of the program being implemented is as follows:

```
if (auto_control) { //mode auto ON
  Serial.println("> AUTO MODE");
  Serial.print("Voltage is Normal : ");
  Serial.print(voltage);
  Serial.println(" v");
  if (voltage < min_referensi) {
    Serial.println("===Open the floodgates===");
    digitalWrite(R_1, HIGH);
    digitalWrite(R_2, HIGH);
    digitalWrite(SSR1, HIGH);
        digitalWrite(SSR2, HIGH);
```

When the Auto mode program section is executed, the control system will carry out the process of detecting changes in the value of the generator output voltage, where if the detected voltage value is in the range of 220 Volts to 240 Volts, the controller will make a decision to deactivate the electric motor, so there is no process of opening or closing the floodgates. The part of the program being implemented is as

follows:

```
if (voltage >= referensi) {
        Serial.println("===Open the floodgates OFF===");
        digitalWrite(R_1, HIGH);
        digitalWrite(R_2, HIGH);
        digitalWrite(SSR1, LOW);
        digitalWrite(SSR2, LOW);
        buka = false;
        updateGate(0);
        break;}
```

If the detected voltage value is below 219 Volts, the controller will automatically activate the motor work by configuring it to open the floodgates, which aims to regulate the generator rotation through the turbine rotation, in order to increase the output voltage of the generator. The part of the program being implemented is as follows:

```
if (voltage <= referensi) {
        Serial.println("===Close the floodgates
OFF===");
        digitalWrite(R_1, HIGH);
        digitalWrite(R_2, HIGH);
        digitalWrite(SSR1, LOW);
        digitalWrite(SSR2, LOW);
        tutup = false;
        updateGate(1);
        break; }
```

If the detected voltage value is above 240 Volts, the controller will activate the motor with a configuration to close the floodgates, where this condition aims to regulate the generator rotation through the turbine rotation, in order to reduce the output voltage from the generator. The part of the program that is executed is as follows:

```
if (voltage > max_referensi) {
      tutup = true;
      buka = false;
      Serial.println("===Close the floodgates ON==");
      digitalWrite(R_1, LOW);
      digitalWrite(R_2, LOW);
      digitalWrite(SSR1, HIGH);
      digitalWrite(SSR2, HIGH);
```

The process of sending voltage data and electricity consumption data to a web server, as information to users about the operation of the PLTMH system, as well as the process of controlling the work of the PLTMH system on the web server. The information display on the web server is shown in Figure 7.

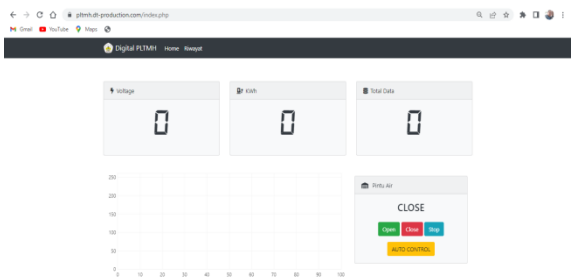

Fig7:Display of the PLTMH Control system web server Testing the process of monitoring and controlling via Smart Phone

Testing the process of controlling and monitoring the work of the control system for the process of monitoring and controlling the PLTMH system can be done through a Smart Phone device. Where to carry out the control and monitoring process, first of all input the address of the intended web server via a web browser. If the address matches, then the display will be directed to the authentication process by inputting username and password data. If the authentication process is successful, the display will be directed to the main page of the PLTMH IoT system, where the display is shown in Figure 8.

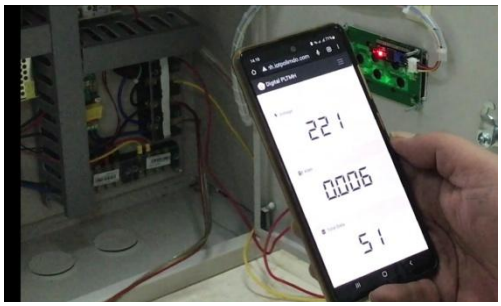

Fig 8: Testing of the PLTMH Control System via Smart Phone

From the results of the tests carried out as shown in Figure 8, it can be seen that when the PLTMH control system is connected to the web server, the monitoring process of the operation of the PLTMH system can be monitored through the main page of the web server. The information displayed relates to the voltage data generated by the Generator which appears to be 221 Volts, the electrical load data attached to the PLTMH system (kWh) appears to be 0.006 kWh and information regarding the amount of incoming data (voltage data and kWh data) recorded .

Aside from being a media monitoring, the web server also functions as a media for remote control of the work of the MHP system, where the control process consists of two control parts, namely automatic control and manual control. Figure 9 shows the Automatic control and manual control sections.

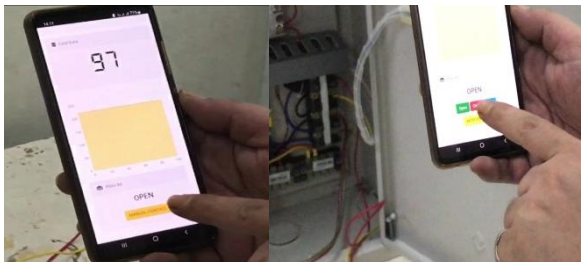

Fig 9: Automatic control and manual control via web server

When automatic control is selected, the controller will respond to the process of automatic control of the process of opening and closing the floodgates in the MHP system, where the response of the control system to selecting the operating mode of automatic control is shown in Figure 9.

Fig 10: Automatic Control

From the test results as shown in Figure 9 and Figure 10, it can be seen that when the automatic mode setting is selected, the control system will automatically set the control mode for the work process of the PLTMH system in automatic regulation mode (DTRL = A). The automatic control process is carried out on the sluice gate, where if the detected voltage value is in the range of 220 Volts - 240 Volts, then the sluice gate is not operating (neither closed nor open). If the detected voltage value is below 219 Volts, the control system will respond by opening the floodgates to increase the voltage value, until it is detected at a value of 220 Volts. If the detected voltage value is above 240 Volts, the controller will respond by closing the floodgates to lower the voltage value to 220 Volts.

The control process can also be set in Manual mode, where when the control selection in manual mode is selected, the control system will adjust it by switching from automatic operation mode to manual operation mode, as shown in Figure 11.

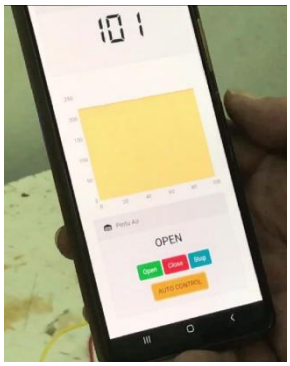

Fig 11: Manual Control

In manual control, the user can open the floodgates through the web server by pressing the Open button. When the open button is pressed, the data will be sent to the control system to open the floodgates. When the controller receives data to open the sluice gate, the controller will activate the electric motor with a clockwise (CW) rotation to open the sluice gate. To stop the sluice opening process, what is done is to press the Stop button on the web server, where when the controller receives data to deactivate the sluice closing process, the controller will deactivate the work of the Electric Motor. To carry out the process of closing the floodgates, what is done is to press the Close button on the web server, where when the controller receives data to carry out the process of closing the floodgates, the controller will respond by activating the work of the motor which is set to rotate in the CCW state.

4. CONCLUSIONS

Based on the results of tests that have been carried out on the work of the control system and monitoring of the operation of the IoT-based PLTMH, it can be concluded that the system created can perform remote monitoring via a web server of the work of the PLTMH system, where the monitoring data is related to changes in the voltage value of the Generator output, as well as data on electricity consumption for loads connected to the PLTMH system. Aside from being a medium for remote monitoring via a web server, this system can also perform remote control of the operation of opening and closing sluice gates, where this process can be selected for operating modes, which include controlling automatic operating modes and manual operating modes. For example, the selected control process is manual control mode, where when this operating mode is selected, the things that can be done to the system via the web server are to open the floodgates, close the floodgates and deactivate work on the process of opening and closing the floodgates. The purpose of controlling the opening and closing of the floodgates is related to the conditioning of the output voltage from the Generator based on changes in the condition of the electrical load served by the PLTMH system.

5. ACKNOWLEDGMENTS

Many thanks to the organizers of the International Journal of Computer Application (IJCA) which has provided an opportunity for authors to publish this paper and to the Ministry of Research and Technology who has funded this research so as to produce a scientific work as well as to the Manado State Polytechnic Institute as well Colleagues who have helped so much that the author can complete this writing.

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