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Design of a Smart Micro-hydro Monitoring System

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Abstract. Hydro potential energy, new and renewable energy, really needs to be developed as an alternative resource that is very environmentally friendly, one of which is a micro hydropower plant. At this time, the control of the micro-hydro water inlet is still operated manually. This fact is a problem because it consumes too many human resources, and if done manually, the level of accuracy is also not correct. The monitoring system used previously could only be monitored near the generator and could not be monitored remotely. To overcome the problems, it is designed so that the water inlet can be controlled automatically by using an application on a smartphone. In addition, the monitoring system will also be designed and programmed so that it can be monitored anytime and anywhere through an application on a smartphone. The results show that the system that has been built can work very satisfactorily.

Keywords. Micro-hydro model, Smart system, Monitoring, Internet of Things.

INTRODUCTION

The need for electrical energy continues to grow year after year [1]. This is due to the growing population and improvements in science and technology, which enable a growth in the use of products that require electrical power [2]-[4]. Thus, the potential energy of water, which is a new and renewable source of energy, must be developed as an environmentally benign alternative resource, one of which is the Micro-Hydro Power Plant (MHPP) [5]. A MHPP is a small-scale power plant that utilizes hydropower as a driving force, such as irrigation channels, rivers, or natural waterfalls, by exploiting the head and volume of water discharged [6]-[7]. The MHPP control of the water inflow is still operated manually at the moment. This is a problem since it requires an excessive amount of personnel and, when performed manually, the accuracy level is also inadequate. Previously, the monitoring system could only be observed in close proximity to the generator and could not be checked remotely. To address the shortcomings of the current MHPP, it is constructed and coded in such a way that the water inlet can be adjusted automatically using a smartphone application. Additionally, the monitoring system will be developed and configured in such a way that it can be monitored at any time and from any location via a smartphone application.

Suyono et al. [8] conducted a study on feeders in a 20 kV distribution system to determine the impact of renewable energy generation on the existing system. Wind Power Plants and Micro Hydro Power Plants have been implemented based on the available potential. The injection of two different types of renewable energy power plants can meet the system's electricity needs while also improving the system's voltage profile and power loss. The injection has a greater effect on the dynamic system than the prior system. The status of the system prior to and during the injection of renewable energy power plants into the distribution system demonstrates that it stays stable and within tolerance limits. Other studies related to the design of MHPP to improve its performance have been carried out by Ginting et al. [9] and Rahmat et al. [10].

The goal of this study was to ascertain the processes involved in designing and implementing the MHPP Monitoring and Controller System Prototype and to examine the system's operation. The reader can gain insight into

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the development of the MHPP Monitoring and Controller System Prototype by utilizing the blynk application as a result of this research. Additionally, it can serve as a guide for developing the MHPP Monitoring and Controller System Prototype.

FUNDAMENTAL

Micro Hydropower Plant

Micro-hydro or what does Micro-hydro mean A Small-scale Power Plant is a small-scale power plant that operates on the basis of water power, such as irrigation channels, rivers, or natural waterfalls, by utilizing the head and volume of water discharged. Micro-hydro, in its simplest form, harnesses the potential energy contained in falling water. The greater the height of the water drop, the more potential energy there is in the water that can be turned to electrical energy. Micro-hydro is also referred to as white resource or "white energy" due to the fact that these power plant installations utilize natural resources and are environmentally beneficial. MHP power plants are those with a capacity of less than 200 kW.

Micro-hydro comprises three major components, namely water (the source of energy), a turbine, and a generator. Water flowing at a specific capacity is routed to the installation house at a certain height. At the installation house, the water will strike the turbine, which will absorb the energy from the water and convert it to mechanical energy via the turbine shaft rotating. A connection then transmits the rotating shaft to the generator. Electrical energy is created by the generator and is then routed through the electric current control system to the load.

Micro-hydro has enormous potential and should be fostered by the state as a source of alternative energy capable of meeting the need for electricity in remote places. The new usage represents 13.5 percent of the 75,000 MW installed capacity. There are approximately 10,125 MW remaining that have not been fully utilized. The remaining 64,875 MW have not been used. Figure 1 shows the typical of a micro hydropower plant scheme.

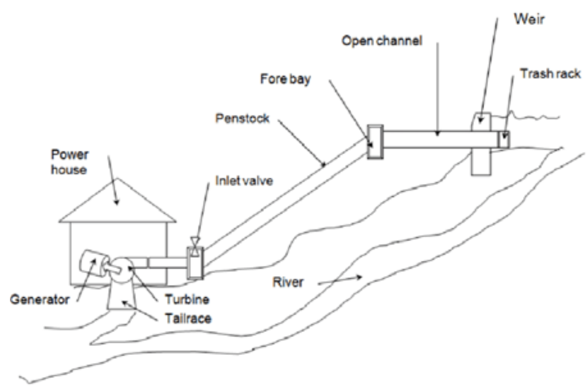

FIGURE 1. Typical of a micro hydropower plant scheme

Internet of Things (IOT)

The internet for everything, or more commonly referred to as the Internet of Things (IoT), is a concept that leverages the internet network to continually connect to something, such as sharing information from the resource management department in a particular area. Figure 2 illustrates the Internet of Things hierarchy. In its simplest form, the Internet of Things refers to an object that is designated as a virtual embodiment within an internet-based system. The Internet of Things was initially mentioned in 1999 by a character named Kevin Ashton. The Auto-ID Center at MIT popularized the term.

The IoT is a network of interconnected computing devices, mechanical and digital machines, objects, animals, and people that are assigned unique identifiers (UIDs) and are capable of exchanging data over a network without requiring human-to-human or human-to-computer interaction. On the internet of things, a thing can be a person implanted with a heart monitor, a farm animal implanted with a biochip transponder, an automobile equipped with built-in sensors that alert the driver when tire pressure is low, or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is capable of data transfer over a network.

Currently, IoT applications have penetrated many fields. Various industries and organizations have started to implement IoT a lot. Organizations across a range of industries are increasingly leveraging IoT to improve operational efficiency, better understand customers in order to provide superior customer service, improve decision-making, and raise the value of the business. An IoT ecosystem comprises of web-enabled smart devices that gather, send, and act on data acquired from their environments via embedded systems such as processors, sensors, and communication hardware.

The popularity of IoT has overtaken manual or semi-manual systems in various uses. IoT greatly benefits from the availability of an increasingly widespread internet network throughout the world. IoT devices exchange sensor data by connecting to an IoT gateway or other edge device, which analyzes the data either in the cloud or locally. Occasionally, these devices communicate with one another and act on the information they receive. Although humans can engage with the devices – for example, to set them up, give them instructions, or retrieve the data – the gadgets perform the majority of their work without human assistance.

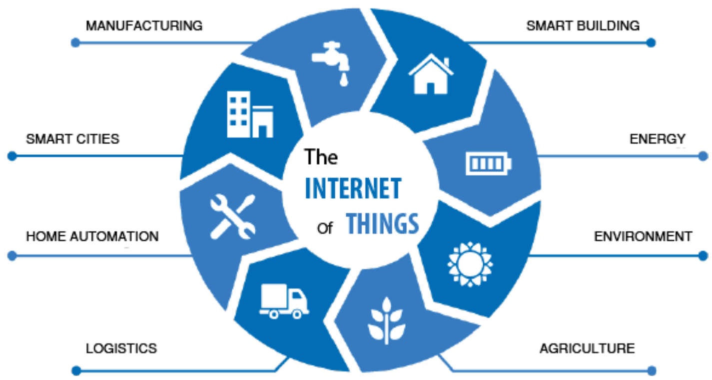

FIGURE 2. Internet of Things hierarchy

METHODS

In this study, the design of a monitoring and control system for an IoT-based MHPP was carried out. The design of the tool begins with making observations with the aim of collecting data so that it can answer the problem in detail and precisely. In addition to collecting data, it is also necessary to extract information from various sources in order to obtain accurate data. Research is also carried out directly in the tool design process. After getting the required data, block diagrams are made in order to get a picture of the system created, then the wiring system design, PCB design, component determination, and system simulation are carried out using software. Composition of an IoT-based MHPP is shown in Figure 3.

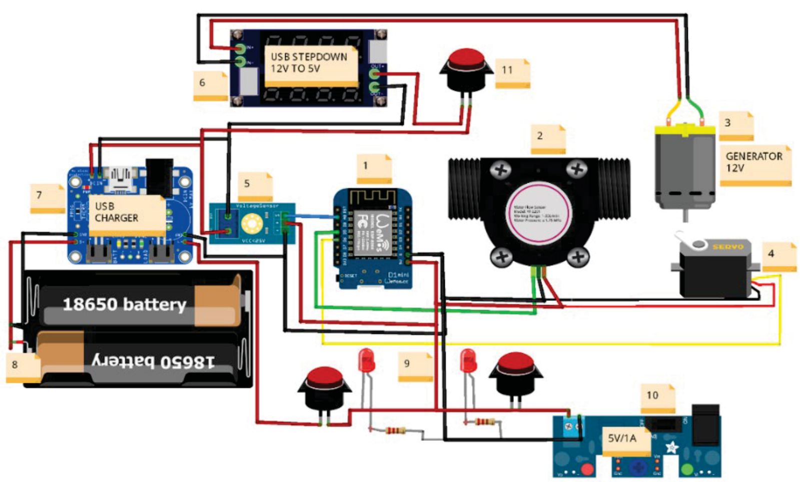

FIGURE 3. Composition of an IoT-based MHPP

After the system is designed, it is tested. Testing is conducted to confirm that the system operates as intended and in line with the specifications. At this stage, it is determined whether each sensor is operating properly or in sync with the Blynk application's output, and whether the generator can store enough electrical energy in the battery to power the LED light. If there is a problem with the system, a repair procedure is followed, and if everything works as intended, the system is returned to service.

Data retrieval is possible only if the complete system is operational. As a result, data gathering is the final stage of the study process. The goal of this data collection is to ascertain the proposed system's reaction and reliability. This step collects data from each sensor, specifically water flow sensors and voltage sensors. Data gathering can also be a determining factor in determining whether a system works well or not.

We developed a prototype monitoring system and MHPP controller using IoT in this project. Two sensors and one servo motor comprise the tool. Voltage sensors and water flow sensors are employed. This tool's voltage sensor measures the amount of voltage applied to the generator, while the water flow sensor measures the amount of water flowing. The servo motor is used to move the faucet in accordance with the blynk application's commands. As a result, when the tool is performed, all outputs from sensors and controllers are displayed on the blynk application. Additionally, this gadget utilizes a USB stepdown to reduce and balance the generator's voltage, converting it from 12 to 5 volts.

RESULTS AND DISCUSSION

Design of Blynk Software Interface

The results and discussion in this study discuss the results of testing the tool, and the limitations that exist in this tool. The results of the tool testing were carried out with qualitative and quantitative analysis. Qualitative analysis in the form of the success of the tool in storing electrical energy in the battery. Quantitative analysis on this tool is in the form of voltage values, water current discharge values which are influenced by changes in water volume. The limitations of this tool can be used as a comparison for further research.

The blynk program is required to provide a voltage monitoring interface on the MHPP that can be accessed from an Android-based mobile. The blynk application is available for free download from the Google Play Store. After launching blynk, navigate to >> Log In >> New Project >> Edit the project's name and device configuration >> Create. The authentication code in the blynk software makes use of a unique token. Copy the authentication code directly or send it via email, as illustrated in Figure 4.

We can add widgets to the blynk application as needed. The widget that was used is depicted in Figure 5. The Blynk application's widget will output data from the water flow sensor (V1, V2, V3, and V4), the voltage sensor (V6), and the servo motor's controller (V5).

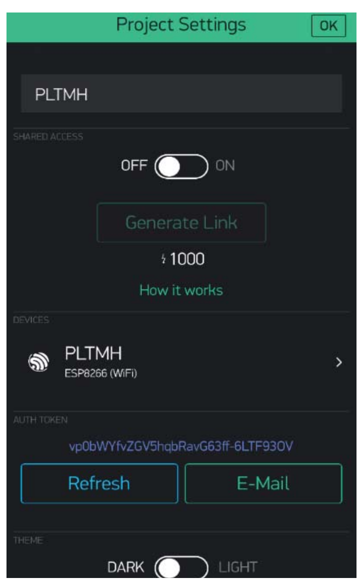

FIGURE 4. Project settings view on blynk application

FIGURE 5. Widget's display used in the blynk application

Testing the MHPP Monitoring System

The design of the MHPP model in this study was carried out using a mini wemos d1, generator, water flow sensor, servo motor, and several other components. Furthermore, using a voltage sensor and a battery as a store of electrical energy from the generator. The tool testing consists of measuring the voltage generated by the generator, the water flow rate on the water flow sensor, and testing the tool's success utilizing battery testing.

Voltage measurements are carried out to compare the voltage values in several conditions of the open tap until it is finally closed. The voltage measurement was carried out two times, namely measuring voltage without using step-down and with stepdown. Each experiment was carried out with six different tap conditions, ranging from fully open to closed taps. The results of voltage measurements without and with stepdown can be seen in Table 1.

TABLE 1. Results of voltage measurements without and with stepdown

Number of Testing	Valve position (°)	Water Discharge (L/minute)	Output AC Voltage (volts)	
			Without Stepdown	With Stepdown
1	0	0.34145	11.750	5.642
2	20	0.33336	11.701	5.568
3	40	0.30631	11.677	5.471
4	60	0.27575	6.622	1.349
5	80	0.22811	0	0
6	90	0	0	0

In Table 1, it can be explained that the maximum voltage obtained without stepdown is 11.750 Volts, and with step-down is 5.642 Volts. This difference in results can be because it follows step-down, namely as a voltage reducer, so that the generator with a maximum voltage of 12 volts becomes 5 volts. The use of stepdown in this tool aims to charge the battery, whose voltage is only 4.7 volts. If the voltage on the generator is not lowered, there will be an overvoltage. The voltage generated if the generator does not use step-down is unstable. However, after using stepdown, the voltage becomes stable according to the step-down function, adjusting the voltage.

From the results of these experiments, it can be said that the more the generator water discharge, the greater the electrical energy produced. This fact is following the potential energy it has. The greater the potential energy of an object, the greater it is electrical energy resulted.

CONCLUSION

Based on the research that has been done, it can be concluded that a generator installed under a water tap can produce the highest voltage reaching 11.750 Volts. After being installed, the stepdown produces the highest voltage reaching 5.642 Volts which has a water discharge of 0.3 Liters/minute. The monitoring and controller system on the Blynk application-based MHP prototype is running well. The two sensors used are the voltage sensor and the water flow sensor reading according to the input. The voltage sensor and water flow sensor stop reading if the water tap is closed by the servo motor at 80°. The servo motor runs well so that it moves according to the command on the Blynk application.

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