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A Microcontroller based Pico Hydro Hydroelectric Power Generation System for Fish Pond Lighting

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***Abstract*—The need of electrical energy for lighting is extremely necessary for Indonesian society especially those who lives in the unreachable area by PLN power source. Electrical generator which uses renewable energy is the best solution to resolve the electrical crisis nowadays. One of the currently renewable energy is Pico Hydro Hydroelectric Power Generator. This electrical power generator is a kind of similar with general Hydroelectric Water Power Generator, but this one operates in small scale. The utility of this Pico Hydro Hydroelectric Power Generator, it can use water as a media with minor current and smaller media width. We can find several examples of this utilization such as in ditch and fish pond irrigation. The water resource in Koka Village is very overflow that makes some villagers use it for fish pond irrigation, unfortunately the flowing water was wasted so brings idea for authors to design a Microcontroller based Pico Hydro Hydroelectric Power Generator as an alternative energy for fish pond lightning. This generator applies microcontroller-based technology as an alternative energy for fish pond lighting. The water resource being served as research site is very good and quite wet although it was a dry season. This Microcontroller based Pico Hydro Hydroelectric Power Generator consists of Controller, Driver, Sensor and Peripheral. The supply energy for this generator is 5 – 12 Volt DC. The controller part has 2 (two) interconnected components, i.e. sensor and peripheral. Sensor functions as an object detector that detects object and then send data to microcontroller to be processed while Peripheral roles as supporting component.**

***Keywords*—electrical power generator, renewable energy, microcontroller, DC, sensor.**

I. Introduction

The demand for electricity today is very high, even electricity has become an important part of daily life. Nowadays electricity has become a necessity that has an impact on every existing life, both in human life and natural life. Electricity has become our benchmark in the welfare of society.

There have been many government efforts to handle the development of electricity infrastructure, but there are still some that cannot be reached, also the existing population growth rate will make electricity become the main indicator in everyday life and this makes us forget about the nature around us. According to the projections of the BPPT MARKAL team, there are around 257.21 million people with 1.01% growth rate [3], so it can be assumed that electricity will become a basic resource in everyday life.

For this reason, power plants require renewable energy to overcome the high electricity demand in the future. And this can reach areas that do not yet have electricity supply, which of course can keep the natural surroundings beautiful and not polluted.

One of the renewable energies is the Microcontroller based Pico Hydro Hydroelectric Power Generation System for fish pond lighting. This generator can be the right choice for lighting fish ponds, it can work well. This can be seen from the high water flow so that it can rotate the turbine quickly. Pico hydro itself is a term commonly used for hydroelectric power plants by utilizing the flow of water flowing into fish ponds.

There are some researches that use this pico hydro, i.e. the development of a Pico Hydro Power Plant by utilizing an alternator to help lighting the Kebun Salak [4]. Research on the utilization of irrigation canals for Pico Hydro Power Plant in Dusun Pagi Penebel Tabanan conducted by I Putu Ardana and Lie Jasa aims to utilize the irrigation canals as an efficient alternative energy source even in the dry season [5].

Research on the design of a Radial Flux Permanent Magnet Alternator Prototype for a Pico Hydro Power Plant conducted by Fauzi Rahman, Didik Notosudjono and Dimas Bangun Fiddiansyah explained that a radial flux permanent magnet alternator can be defined as a converter of mechanical energy into electrical energy that will be used for generating electricity Pico Hydro Power [6].

Therefore, the author wants to take advantage of the surrounding environment in the form of water flows around the pond to be used as a Pico Hydro Hydroelectric Power Plant. This is very useful for the community, especially fish farmers whose ponds are not yet covered by PLN electricity. Thus, this plant can be the right solution and is very efficient and environmentally friendly.

II. Literature Review

2.1 Pico Hydro

The Pico Hydro Power Plant is one of the small-scale power plants. As is known, this plant uses natural water

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resources as an energy source, so it can be used as an alternative to electricity generator, because water is a relatively an easy source of energy.

Technically, it consists of three main components, namely:

1. Water as an energy source
2. Turbine (convert potential energy into energy of motion/mechanical)
3. Generator (convert mechanical energy into electrical energy)

The working principle of this plant is to take advantage of the difference in height of the amount of water discharge per second of the flowing water in a ditch, river or waterfall. This flow of water will rotate the turbine shaft to produce motion energy which is then converted into electrical energy by a generator.

2.2 Water Turbine

The water turbine is a driving machine, where the fluid energy serves to rotate the turbine wheel. The function of the water turbine is to convert potential energy into mechanical energy. On the working principle of a water turbine, the turbine wheel construction has a blade, which is a plate with a certain shape and cross section. Water as a working fluid flow through the space between the blades, thus the turbine wheel/runner will be able to rotate and on the blades, there will be a working force. This force will occur because there is a change in the momentum of the working fluid of water flowing between the blades. The blades should be shaped in such a way that there can be a change in the momentum of the water working fluid.

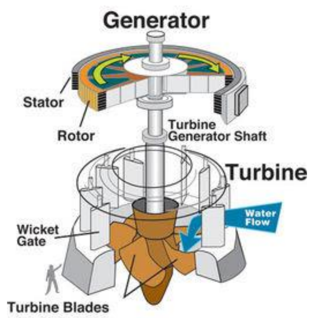

Figure 2.1. Water Turbine

2.3 Flow Sensor

Water Flow Sensor G1/2 is a tool that can sense the speed of fluid flow. Generally, this flow sensor is commonly used in flow meters, or flow loggers to be able to record the flow of liquids. A common practice with all sensors is the need for absolute accuracy for calibration measurements. There are various types of flow sensors and flow meters, some of which have a vane driven by liquid, and can push the potentiometer to rotate along with similar devices.

III. RESEARCH METHOD

3.1 Literature Study

Literature studies are needed to support research. So that in this literature study the author collects data and sources that support the design of a Pico Hydro Power Plant System.

3.2 System Design

After getting a reference from the literature study, the author continues in the system design stage. In this stage the system is first described using a block diagram to facilitate reading the workings of the system to be built.

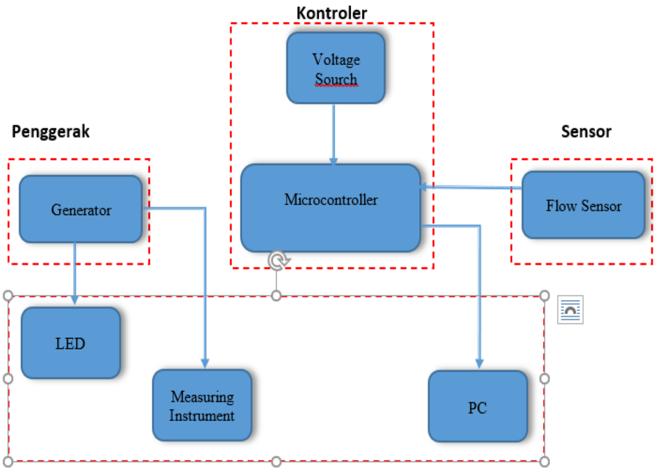

Figure 3.1. Peripheral

From the figure 3.1 there are some main components (the dotted line). There are 4 main components that build up the system, namely, controller, driver, sensor and peripheral.

In the controller there is a voltage source whose function is to supply energy to the microcontroller so that the microcontroller can be active and can process data. The voltage required by the microcontroller is 5-12 volt dc (direct current). In the controller section there are 2 main components that are interconnected, namely sensors and peripherals.

The sensor will detect objects and the data obtained from the sensor is sent to the microcontroller for processing, while the peripheral is the supporting component of the system created. In the sensor part we use a flow sensor to calculate the speed of water flow. Then in the peripheral part there is a PC (Personal Computer) to monitor the output of the flow sensor.

Generator is included in the driving component where this component is interconnected with peripheral. In peripheral, LED and measuring instrument are connected to the generator. The generator in the system is a Pico Hydro Powered Generator which indicates that the output voltage does not exceed 5000 Watts.

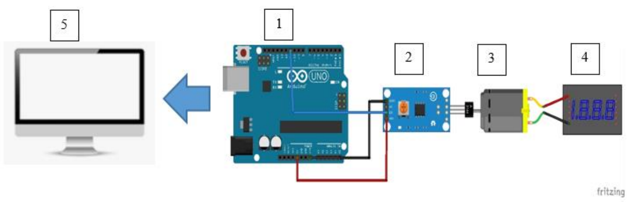

Figure 3.2. Wiring Diagram of Design System using Fritzing

The fritzing application allows for a 3D depiction of the system, making it easier to see the connectivity between components. The presence of 3D images will help further development of the existing system, as shown in figure 3.2. This figure shows a system design for testing the speed of a dc motor used as a generator of Pico Hydro. Visible numbering will help for easy reading. Component number 1 is a microcontroller with the Arduino Uno type, component number 2 is a sensor to detect the speed of a dc motor, component number 3 is a dc motor, which is used as a generator, component number 4 is a voltmeter to measure the voltage generated by the generator and number 5 is a generator. Figure 3.2 is a computer that will display the results of the rotational speed of the generator motor.

3.3 Data Retrieval

At this stage, taking into account the system that has been designed, the tools and materials must be prepared for the testing and data collection process.

IV. RESULT AND DISCUSSION

4.1 Pyco Hydro Plant Testing of a Flowing Water in Koka Village

After passing the system design stage, the author tested the system that had been built. This test aims to retrieve data that will be used for further analysis of the development of an existing system. Data retrieval was evidenced by several pictures and system test data. The pictures below are some tests to take data samples in Koka Village.

Figure 4.1. Hose Installation on Generator

In Figure 4.1, a modified hose that has been fed with water will be connected to a Pico Hydro Generator. And Figure 4.2 shows the dc motor used as a Pico Hydro Generator has been rotating. But at this stage it was not yet known the amount of voltage generated by the generator. To measure the voltage, we used a voltmeter.

Figure 4.2. Rotating Generator

Furthermore, Figure 4.3 is the result of data collection for voltage.

Figure 4.3. The results of data collection for voltage using voltmeter

It is the result of testing the installed generator. The data obtained was 0.74 volts with a dc motor (direct current).

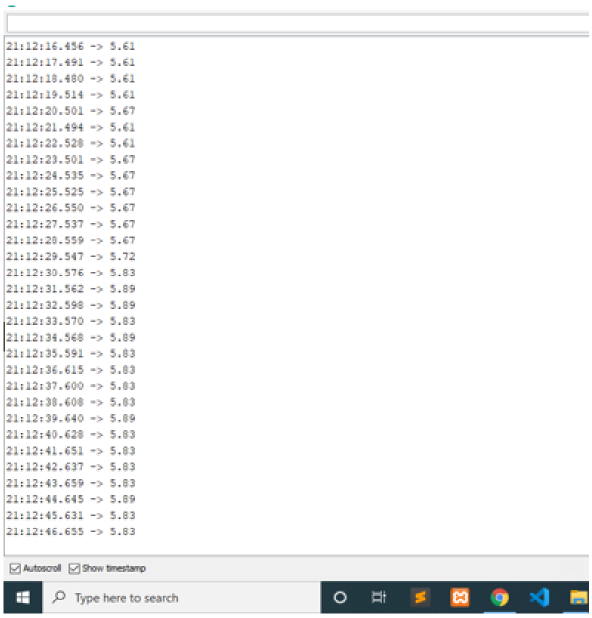

Figure 4.4. The results of data collection for RPS (Rotation Per Second)

Figure 4.4 above is the result of data collection for RPS (Rotation Per Second) or motor speed per second. The result showed 5.89 RPS for the highest value. The data was displayed on the monitoring screen using the Arduino serial monitor IDE application with a baud rate of 9600. The 5.89 RPS value was the result of the 0.74 volts voltage tested in figure 4.3. Weather data was also taken at the time of testing which can be seen in figure 4.5.

Figure 4.5. Screenshot of Weather using the Application of Weather Channel

Through the Weather Channel application, the position of the Koka Village has been read on the GPS system. Then from the weather details, the temperature that was read in the field was 38 degrees Celsius with 60% humidity, meaning it was a hot temperature and affected the water flow. The wind speed can also be seen in the application, which was 13 km/h.

4.2 **Pico Hydro Plant Testing on LED**

The next stage of testing was using LEDs. The test is no longer carried out in the Koka Village, but at the author's house. The test at this stage was to prove whether the designed Pico Hydro Plant can turn on the LEDs as lighting for fish ponds or not. By referring to the data that has been tested on the water flow in the Koka Village, which is 0.74 V with a temperature of 38 degrees Celsius, it means that the water is in less condition due to the high temperature so that the water flow decreases. Testing using LEDs is evidenced by table 1 and the following pictures.

Table 1. Testing of Pico Hydro Plant Generator

No	Tegangan(V)	Arus(mA)	Hambatan (Ohm)	RPM	*Counter* (Raw Data)	*Output*(V)
1	0.03 V	0.00 mA	3.33 Ω	12	55	0.03 V
2	0.22 V	0.00 mA	3.33 Ω	22	830	0.22 V
3	0.70 V	2.20 mA	3.33 Ω	588	2154	4.84 V
4	1.07 V	3.67 mA	3.33 Ω	816	3004	4.84 V
5	1.36 V	5.70 mA	3.33 Ω	1020	3743	4.84 V
6	1.74 V	8.87 mA	3.33 Ω	1320	4861	4.84 V

From table 1, it can be seen that the current started to be generated when it was in position no. 3. With a voltage of 0.70V, the resulting current was 2.20 mA with an output voltage of 4.84 V. The output voltage of 4.84 could turn on a 5 volt LED. This test could be proven by the test image below.

Figure 4.6. Testing on LEDs

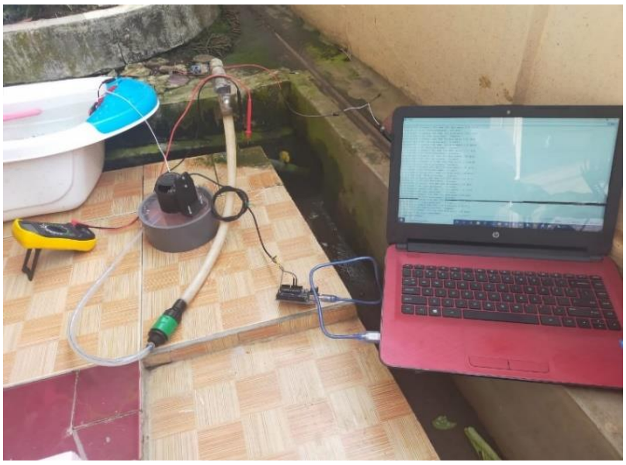

Figure 4.7. Testing and Monitoring of RPM

Figure 4.8 The Illuminated LED

From the pictures above, it clearly shows that several tests were carried out. For figure 4.6 the test was carried out by adding a 5 Volt LED to the Pico Hydro Plant. For figure 4.7 testing is done by adding a microcontroller as a monitoring RPM (Rotation Per Minute) of the generator. And figure 4.8 was the evidence of a LED that lights up with a rotation of 588 RPM, a voltage of 0.70V and a current of 2.20 mA.

The test voltage from table 1 is obtained from the results of testing using a faucet by measuring the degree of the faucet opening. For more details can be seen in table 2.

Table 2. Data of Voltage and Current Testing

Rotasi	Tegangan (V)	Hambatan(Ω)	Arus dengan beban (A)
0°	0 V	10 Ω	0 mA
15°	0,03 V	10 Ω	0 mA
30°	0,22 V	10 Ω	24,3 mA
45°	0,70 V	10 Ω	42,9 mA
60°	1,07 V	10 Ω	51,1 mA
75°	1,36 V	10 Ω	53,2 mA
90°	1,74 V	10 Ω	54,7 mA

The results described in table 2 show the amount of test voltage starting from the tap opening of 15 degrees with a voltage of 0.03 volts. The test was done by calculating the current using a load resistor with a value of 10 ohms. Table 2 also showed that the faucet opening with 45 degrees refers to the equation for testing the water flow in Koka Village, which was 0.70 V. And the result of a voltage with a value of 0.70V could turn on a 5 Volt LED. This is because at the output voltage, it can be seen in table 1 that it could produce 4.84 V.

The change in voltage at the output increase because the author added an additional booster circuit to amplify the current and voltage. Therefore, even though the voltage generated by the Pico Hydro Plant was below 5 volts, the LED could still light up because there was a voltage gain or voltage multiplier added to the Pico Hydro Plant system.

V. CONCLUSIONS

Observed from the results of data collection and testing on the system, it can be concluded several things:

1. Motor speed 5.89 RPS (Rotation Per Second) produces a voltage of 0.74 Volt.
2. The use of monitoring via a serial monitor using an Arduino IDE with a baud rate of 9600 to monitor the motor speed has been successful implemented with the highest output of 5.89 RPS.
3. The Weather Channel application can detect research locations via GPS.
4. A voltage of 0.70 Volt can turn on the LED.

Suggestions from system development, it is necessary to re-design both the motor generator and additional circuits to increase the voltage so that it can be accommodated in the battery and used as lighting.

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