Development of a Low Cost Portable Hydro and Wind Power as Emergency Power Source

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Abstract. Many outdoor activities are often carried out by the community. An emergency power is required to recharge the batteries of lighting equipment, communication equipment and other electronic equipment. Power bank as emergency power has a limited capacity so that it is not enough to meet the needs of power for several days. A portable power generation is needed to generate electricity using available natural resources such as running water or wind. The objective of this research is to develop a portable power generation system to meet the needs of electrical energy during outdoor activities. The portable power generation system consists of a small turbine, a small generator, and a battery charger. The prototype was tested in the laboratory and in the field. Tests showed the DC generator generated a voltage of 0.7 - 11.1 V when rotated at a speed of 117 - 1434 rpm. The step up converter produces a voltage of 2.2 - 15.74 V when the input voltage is 1.5 - 12 V. The boost module produces a voltage of 3.19 - 4.38 V when the input voltage is 3 - 12 V. The portable power generation system will generate electricity if the minimum speed of the running water is 4.8 m/s. When tested using wind power with speeds between 4.0 - 10.3 m/s, the portable power generation system produces a voltage of 1.4 - 9.3 V.

1. Introduction
Many people do outdoor activities such as camping, research, mountaineering, tourism, outbound, and so on. This activity sometimes takes several days. An emergency power is often needed to recharge the batteries of mobile phones, handy talkies, emergency lights, and other equipment. The emergency power usually used by the people is a power bank with limited capacity. The power bank won’t be sufficient if the outdoor activities were carried out for several days. Therefore, a small-scale power plant is needed to meet the needs of electrical energy. The power plant can use the existing resources such as water or wind.

Energy is classified into the main needs of the Indonesian people. Indonesia has several problems in the energy sector, including increasing energy consumption, high dependence on fossil energy, and low electrification ratio. A portable hydropower system needs to be developed in remote areas to meet the needs of electrical energy. The power plant can utilize the energy stored in the running water which is known as a nano-hydro power plant. The power plant can operate using slow-flowing rivers [1]. The kinetic energy stored in the flowing water can also be used to generate electricity. The changing seasons will cause fluctuations in river water discharge so that the energy produced will fluctuate. The development of portable nano-hydro power generators by the community will encourage the use of natural resources more effectively and efficiently [2]. The variation of turbine speed will occur in a stand alone hydropower plant.
due to variations in the connected load [3]. It will change the generator voltage so that a control equipment is needed to regulate the voltage. The river flow turbine will start working when water enters the turbine. The water is directed by the guiding angle towards the runner and exits through a draft tube. The runner will rotate due to the kinetic energy of the water so that the turbine shaft will rotate [4]. The generator coupled to the turbine will generate voltage at the output terminal. This type of water turbine is suitable for application in flat rivers and irrigation channels [5].

Several studies related to hydroelectric power have been carried out. Sudhakar and Saxena conducted research on portable generators using low speed wind energy [6]. Saikumar et al developed a portable wind generator used to charge electronic equipment [7]. Singh implemented a wind generator to generate electricity in a two-wheeled vehicle 12 V battery charging system [8]. In this study, a portable power generation system was designed to charge the battery of electronic equipment during outdoor activities. The prototype was designed with a small size so it is suitable for traveling. The implementation of this system is expected to encourage the use of environmentally friendly renewable energy sources.

2. Research Methods

The tools and materials used in this research include: a small DC generator, a small turbine, a step up converter, a battery charger module, lithium batteries, USB cable, jumper cables, protective pipe, tachometer, multimeter and laptop as shown in Figure 1.

![Figure 1: The tools and materials used in the research (a) small DC generator, (b) small turbine, (c) step up converters, (d) battery charger module, (e) lithium batteries, (f) protective pipe](image)

The prototype of a portable power generation system is designed to have a small turbine on the outside. This turbine will be used to convert the energy stored in water or wind into kinetic energy. The turbine is coupled to a small DC generator. When the turbine has been rotated due to the flow of water or wind, the generator will rotate so that the voltage will be generated. The output voltage of the generator is increased with a step up converter so that the voltage meets the specifications required by the battery charger module. The entire block diagram of a portable power generation system is shown in Figure 2. This research consists of several stages
starting from literature study, design and testing of portable power generation systems, and data analysis. Various literatures in the form of proceedings, journals, and reference books were studied at an early stage. The next stage is the design of portable power plants starting from the turbines, small generators, and voltage regulators. All components are put in a waterproof container which is specially designed so that it is safe when put into water. The portable power generation system is designed to generate qualified power so that it is safe when used to charge electronic equipment batteries. The portable power generation system is tested in the laboratory and in the field. The laboratory testing is carried out to observe the generator output voltage when rotated at different speeds. It will produce the optimal rotational speed required by the generator to generate a voltage in accordance with the battery charger module specifications. The field testing is carried out by bringing the portable power generation system into a place that has sufficient wind or water speed to turn the generator. The resulting data, such as rotational speed, voltage, and current are recorded, graphed and analyzed for further conclusions.

3. Results and discussion
The tested portable power generation system is shown in Figure 3.

3.1. No-load test of DC generator
The results of the DC generator test at no-load condition are shown in Figure 4. When the generator is rotated at a speed of 117 rpm, the generator produces a voltage of 0.7 V. When the rotational speed of the generator is increased to 245 rpm, the generator produces a voltage of 1.6 V. When the rotational speed of the generator has increased from 389 - 1434 rpm, the generator produces a voltage of 3 - 11.1 V. This test indicates the higher the rotational speed of the generator, the higher the voltage generated by the generator. In other words, the generator voltage is directly proportional to the rotational speed. This is in accordance with the theory so that the tested DC generator can be used in a portable power generation system.

3.2. The XL6009 DC-DC boost step up converter test
Figure 5 shows the results of the XL6009 DC-DC boost step up converter test. The step up converter produces an output voltage of 2.2 V when the input voltage is 1.5 V and the LED
indicator is off. When the input voltage varies from 3 - 12 V, an output voltage of 4.2 - 15.74 V is produced and the LED indicator is on. Based on these results it can be concluded that the greater the input voltage of the step up converter, the greater the output voltage. Thus the step up converter can be used to increase the output voltage of the DC generator. The test results show that the LED indicator will light up when the input voltage is 3 - 12 V. This is in accordance with the step up converter specification, which requires a minimum voltage of 3 V to work properly.

### 3.3. The DC step up boost module test

Figure 6 shows the results of the DC step up boost module test. When the input voltage of DC step up boost module is 1.5 V, it will not produce a voltage at the output so the LED indicator is off. When the input voltage is increased to 3 - 12 V, an output voltage of 3.19 - 4.38 V is produced and the LED indicator is on. Based on these results, it can be concluded that the output of DC step up boost module will remain stable although the input voltage varies. Thus, this device can be used as a battery charger module which regulates the DC generator output voltage to meet the specifications required by electronic equipment batteries such as smartphones. When the generator output voltage is too high, this device will reduce it to around 4.3 volts so it is safe to recharge smartphone batteries with a nominal voltage of 3.7 V.
Figure 6: The results of the DC step up boost module test

3.4. The portable power generation system test

Figure 7 shows the results of the portable power generation system test. When the rotational speed of the generator is 108 rpm, the generator will generate a voltage of 0.6 V. The step up converter will increase it to 1.2 V. It does not meet the minimum value required by the boost module so that the output voltage is zero and the indicator turns off. When the rotational speed of the generator is increased to 214 rpm, the generator will produce a voltage of 1.4 V. The step up converter will increase it to 2.2 V. It still does not meet the minimum value required by the boost module so that the output voltage remains zero and the indicator remains off. When the rotational speed of the generator varies from 382 - 1405 rpm, the generator will produce a voltage of 2.9 - 10.4 V. The step up converter will increase it to 4.9 - 14.7 V. It has met the specifications and the boost module will work properly. The boost module will stabilize the high voltage of step up converter to 3.5 - 5.3 V so that it is safe to recharge the batteries of electronic equipment such as smartphones. Smartphone batteries have a nominal voltage of 3.7 V and are usually charged with a 5 V charger.

Figure 7: The results of a portable power generation system test

3.5. The portable power generation system test in rivers

Figure 8 shows the results of the portable power generation system field test in rivers at different speeds. When the water flow on the turbine, it will rotate the generator and generate voltage. The portable power generation system is tied with a rope to keep it from drifting. When the portable power generation system is immersed in water at a speed of 2.2 - 3.4 m/s, the output voltage is still zero so the LED indicator is off. This shows that the speed of the water is
not sufficient to rotate the generator to generate the minimum voltage required by the step up converter and the boost module to work properly. When the prototype is moved to other places with faster speed, i.e. 4.8 and 5.9 m/s, a voltage of 3.2 V and 3.4 V will be generated and make the LED indicator lights up. This indicates that the portable power generation system will generate sufficient voltage to recharge the battery if immersed in water with a minimum speed of 4.8 m/s.

3.6. The portable power generation system test by using the wind

Figure 9 shows the results of the portable power generation system test utilizing wind power. A wind speed of 4.0 m/s will rotate the generator at 203 rpm and generate a voltage of 1.4 V. The step up converter will increase it to 2.2 V. It has not met the minimum value required by the boost module to work properly so that the output voltage is still zero and the indicator is off. When the prototype was tested with a wind speed of 6.2 m/s, the rotational speed of the generator increased to 404 rpm and generate a voltage of 3 V. The step up converter will increase it to 4.9 V so it meets the minimum value required by the boost module to work properly and turns on the indicator. The boost module will reduce it to 3.6 V. When the prototype is tested with a wind speed of 7.8 - 10.3 m/s, the rotational speed of the generator varies from 681 - 1334 rpm and the voltage vary from 4.2 - 9.3 V. The step up converter will increase it to 6.4 - 10.8 V. This high voltage will be stabilized in 4.4 - 5.1 V by using the boost module. It can be concluded that the portable power generation system can produce voltage to recharge the battery if it is in an area with a minimum wind speed of 6.2 m/s.
4. Conclusion
Based on the results and discussion, it can be concluded: The DC generator can generate a voltage of 0.7 - 11.1 V when rotated at a speed of 117 - 1434 rpm. The higher the rotational speed of the generator, the higher the voltage generated. The step up converter with an input voltage of 1.5 - 12 V produces an output voltage of 2.2 - 15.74 V. This equipment will increase the voltage so that the output voltage is around 1.3 times the input voltage. The boost module with an input voltage of 3 - 12 V produces an output voltage of 3.19 - 4.38 V. This equipment will stabilize the fluctuation of the input voltage so it is safe to recharge the battery. The portable power generation system test on rivers with a speed of 2.2 - 5.9 m/s will generate a voltage when the minimum speed is 4.8 m/s. The portable power generation system test using wind power with a speed of 4.0 - 10.3 m/s can generate a voltage of 1.4 - 9.3 V.

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