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Monitoring System for Portable Mini Wind Energy with DC Water Pump Application

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Abstract: Nowadays, renewable energy is becoming the most reliable way to generate electricity in exchange with non-renewable energy which commonly comes from coals and gases. This project is about the monitoring system of mini wind energy with DC water pump application harvested from seaside area. Thus, the project addresses the development of prototype of mini wind energy with monitoring system by using Arduino UNO as main microcontroller. For the project development, the voltage and current sensors are used to monitor the mini wind energy system's performance. The NodeMCU ESP8266 board was used to allow communication between system and device through the Blynk application. Blynk is a platform used to include the Internet of Things (IoT) for this project. A mini wind energy data collection was conducted to assess the wind energy performance through manually reading the data from the LCD of the monitoring system and through the Blynk application. The project was done at Pantai Punggor, Batu Pahat, Johor. The project was conducted to observe the capability of Mini Wind Energy to supply power to the 12V DC water pump as well as the monitoring system of the prototype. Based on the result, the load is observed to be working in a voltage of 13.22V, current at 0.19A and a power output of 2.51W with the average wind speed of 5.8 m/s.

Keywords: Arduino, IoT, NodeMCU ESP8266, Blynk

1. Introduction

The need for exploring and discovering new energy resources is essential due to the global warming issue caused by greenhouse gases (GHG) emission and the increment of the energy demand [1]. As a result of rising costs and environmental issues associated with fossil fuel-based power generation, electricity generation is currently switching to renewable energy sources. Therefore, this project focuses on production of mini wind energy. Mini wind energy is a portable yet useful source of energy that can be used to supply electrical appliances, in this case a DC water pump, in much environmental-friendly way. Wind energy is one of the most promising solutions as the alternative resource for power generation which to reduce the greenhouse gases emission [2]. Although the wind in Malaysia is generally weak and the direction is changing, there are periodic changes in the wind patterns. Based on this change, four seasons can be identified which is the northeast monsoon, the southwest monsoon and two shorter monsoon transitions [3]. According to the World Wildlife Fund (WWF), the global warming and the greenhouse gases emission are mainly caused by human activities [4]. The burning of fossil fuels for the generation of electricity has worsened the scenario. Greenhouse gases is any gas that absorbs the heat from the earth's surface and traps in the atmosphere [5]. Therefore, this research aims to reduce the greenhouse effects and introduce a mini horizontal wind turbine that can be use in low wind speed areas and monitor the power generated by the mini wind turbine.

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2. Theory of Wind Energy

Basically, wind energy is one of the renewable energy sources. A wind energy describes the process by which the wind is used to generate mechanical power or electricity. A wind turbine converts the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks such as grinding grain or pumping water or can be converted into electricity by a generator [6][7]. A wind power is a reasonable and sustainable power source and has much less effects on nature compared with using non-renewable energy sources such as burning fossil fuels. The kinetic energy within the wind is often generate into each mechanical and electrical energy using windmill. Kinetic energy is the movement or motion of gears and object. A contemporary sort of windmill that uses the kinetic energy of the wind to supply an electrical energy output is called a wind turbine [7]. Fig. 1 shows the principle of operation wind energy.

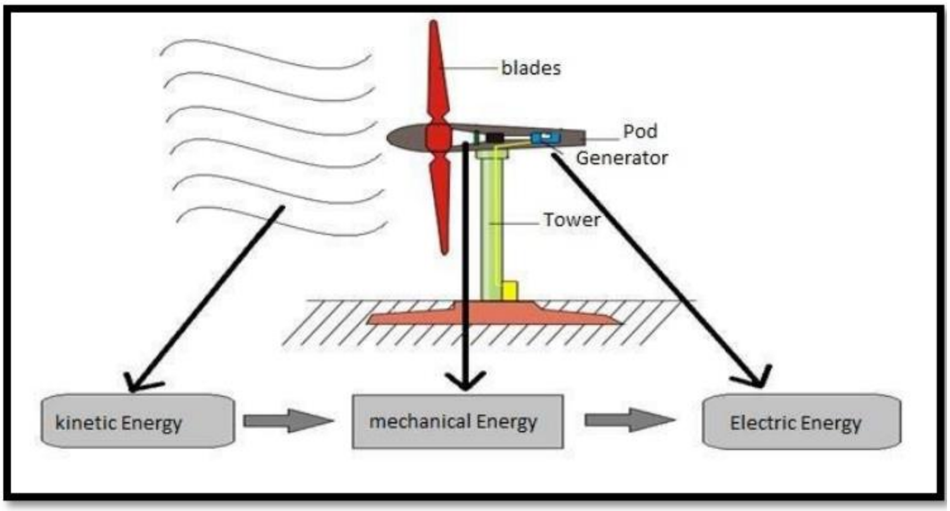


Fig. 1 - The principle of operation wind energy [6][7]

There are two types of wind turbine that are commonly used are: Horizontal axis wind turbine (HAWT) and Vertical axis wind turbine (VAWT). The Horizontal axis wind turbine (HAWT) A horizontal axis wind turbine is a turbine with a blade designed to be in parallel to the wind direction [8]. This type of turbine is commonly used in the wind farm as it is suitable to be used either in high or low wind velocity if it has a consistent and low turbulence wind. Next, a Vertical axis wind turbine (VAWT) rotates perpendicularly to the ground and around the vertical axis. Basically, there are two designs of VAWT and both designs work on different principles. The first design is Savonius which works by using drag forces to work. Its design is like the water wheel. Another design is called Darrieus which uses aerodynamic blade to produce lift and turn the turbine. VAWT has the potential to be used in the field of domestic application. It is because they are more effective in areas with slow and more turbulent wind environment because it can start produce power at low wind speed [9]. Plus, it can also be used omni-directionally compared to HAWT which needs to face the direction of the wind. The operating principle in the Darrieus rotor is that it rotates around a mid-axis because of the raise created by the rotating aero foils, however, in the case of Savonius, the rotor rotates because of the drag formed by its blades. For the Darrieus rotor, it can be subdivided into three categories which are (a)Savonius, (b)D – type, (c)H – type, and (d)helix type.

A mini wind energy is a term used to describe a low wind speed conditions or a small wind turbine. For small wind turbine, it usually has multiple rotor blades to help in supporting its low starting torque which a common issue in small turbines. The small starting torque of small wind turbines is small because of its small rotor size hence it is insufficient to start at low speed [10]. Therefore, the increased number of rotor blades helps in quick start the rotor and gives the turbine to operate in much smaller wind speed area [11].

3. Material and Method

This part is discussed of the materials and method of this project.

3.1 Materials

This part explains the concept of using Arduino Uno, ESP8266 and Blynk in the monitoring system and list of materials that were used in completion of this project.

a. Horizontal Axis Wind Turbine (HAWT) [12]
   - Rated Power 600W
   - 12V

- Blade Material: Nylon Fiber

b. Arduino Uno [13]
  - Act as the brain for the monitoring system
  - Operating Voltage 5V

c. NodeMCU ESP8266 [14]
  - To allow communication between Arduino and Blynk
  - Operating Voltage 3.3V

d. Lead Acid Rechargeable Battery [15]
  - Nominal Voltage 12V
  - Charging Current 7Ah

e. DC Water Pump [16]
  - Voltage Rating 12V
  - Current Rating 0.2A-0.7A
  - Power Rating 2.4W.

3.2 Method

This phase focuses on the development of its monitoring system by using Arduino UNO and NodeMCU ESP8266 which are used to monitor the output voltage and current generated from the mini wind energy prototype. The required values were displayed on the LCD and Blynk platform. The block diagram for the hardware and simulation development is as shown in Fig. 2.**Error! Reference source not found.**

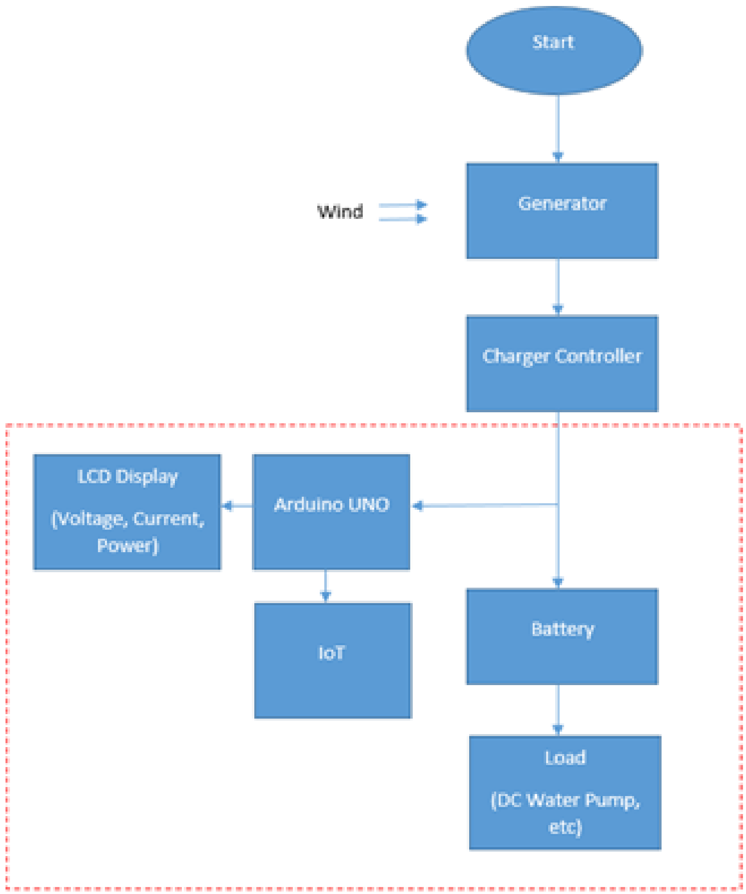


Fig. 2 - Block diagram of the project

4. Result and Discussion

This part is discussed the development of hardware, results for battery charging condition, $12V_{DC}$ Water Pump load condition and output Blink Application.

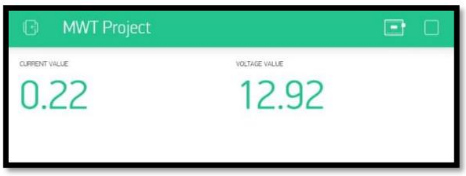
4.1 Hardware Development

The actual implementation of mini wind turbine and its monitoring system is shown in Fig. 3. The wind turbine was installed on the beach at Pantai Punggor, Batu Pahat, Johor.

Fig. 3 - Mini wind turbine with monitoring system

Next, Fig. 4 (a) show the prototype of monitoring system from Blink Application with consists of a LCD display, Blink interphase running on a tablet. The result from the LCD Display of the Arduino Uno board will be presented at the Blynk application that links to the project via the serial connection to the Arduino. It may be installed on a variety of devices including smartphones, tablets, and computers. To send and receive data from the monitoring system, the Blynk Application requires a NodeMcu ESP8266 and an Internet connection. Data also can be taken by using Blynk application, but it will function when it connects continuously to an internet connection. The data obtained from the monitoring system of mini wind turbine output is shown in Fig. 4(b).

(a) Prototype of monitoring system by IoT



(b) Blynk user interface

Fig. 4 - Blynk application monitoring system

Fig. 5 show the prototype of mini wind energy with battery charging and water pump load condition, respectively. The 12V battery and 12V DC water pump are the primary components to keep a check on while building a mini wind turbine. The charging configuration for a 12V battery is shown in Fig. 5(a). The charger controller's power output is connected to the terminals of the 12V battery to charge the battery. The configuration for the direct current load 12V DC water pump is shown in Figure 4.13. The 12V DC water pump is connected to the charger controller by connecting the pump's terminals directly to the charger controller. This is to test the pump's ability to perform as a load with the wind turbine's supply.

(a) Battery charging 12V condition **(b) 12V$_{DC}$ water pump load**

Fig. 5 - Prototype of mini wind energy with charging and water pump load condition

4.2 Battery Charging

The output mini wind turbine to charge 12V battery data are recorded from 9th and 10th June 2022 at Pantai Punggor, Johor. From 9.00 am to 1.00 pm, the results are recorded every 30 minutes. The average wind speed was 4.81 m/s on June 9th, 2022. The greatest wind speed measured was 6 m/s, resulting in a voltage of 12.903V, a current of 0.171A, and a power of 2.21W. The result reveals that the wind speed is lowest between 9.30 and 10.00 a.m., at 3.3 m/s, compared to previous data. This is due to the sunny weather, which creates lesser wind speed. However, the energy to turn on the mini wind turbine is still sufficient to produce the power. The average wind speed is 3.94 m/s which was calculated on June 10th, 2022. The greatest wind speed measured was 5.8 m/s, resulting in a voltage of 13.222V, 0.174A current, and 2.30W power. The result reveals that the wind speed between 10 am and 11 am is about 1 to 2 m/s, which is due to clear sky weather conditions that generate low wind speed, resulting in voltages less than 12 volts with ranges from 1 to 4 volts. The graphs of the charging current on 9th and 10th June 2022 are shown in Fig. 6. The graphs demonstrate that the current drops between 9 am and 10 am and then begins to rise around 11 am. This occurred because of the clear sky and the relatively low wind speed.

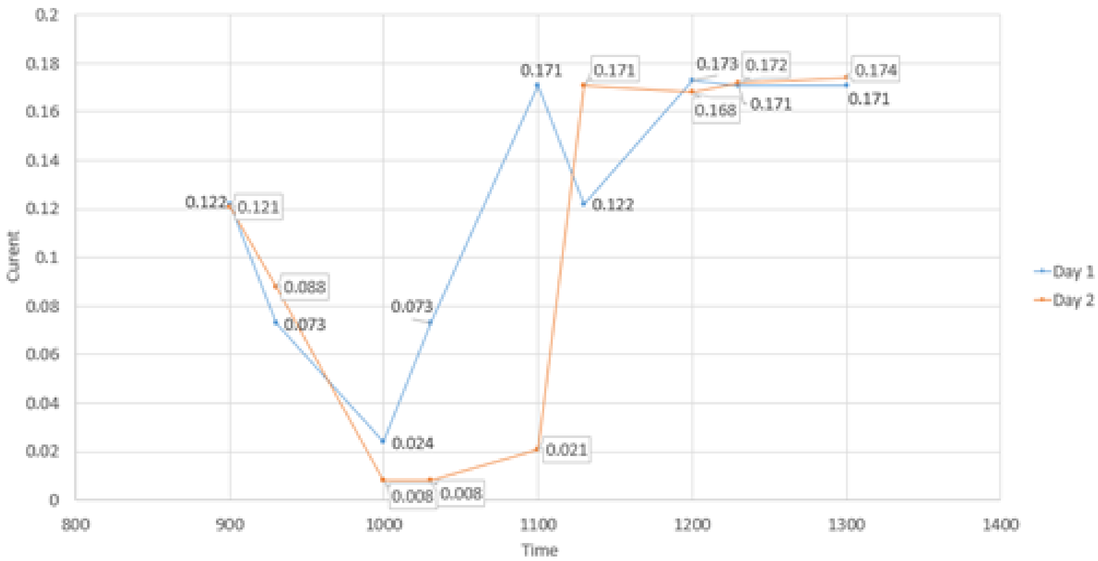


Fig. 6 - Charging current on 9th and 10th June 2022

4.3 12V$_{DC}$ Water Pump Load

A direct current load which is a 12V DC motor is applied for testing. The motor is connected directly to the mini wind turbine's output and the monitoring system. The data is collected using the parameters of wind speed, voltage, and current. An anemometer is used to measure the wind speed, and the power generated is calculated manually. On the 10th June 2022 in Pantai Punggor, Batu Pahat, Johor, the direct current load test results based on a 12V DC water pump were reported. The reading is recorded every 30 minutes from 9am. to 1pm. For this test, a 12V DC motor is utilized as the load. According to the data, the average wind speed is 3.94 m/s and the average power is 1.54 watts. The greatest wind speed recorded was 5.8 m/s, resulting in a voltage of 13.22V, a current of 0.19A, and a power output of 2.51W.

From Fig. 7, it displays the curve of power and current production vs wind speed from a 12V DC water pump. From 9.30 am to 10 am, it is observed that during the increase in wind speed, the power and current output also increases. When there is a decrease in speed, it can be due to the condition of the weather in which it is clear sky during the reading measurement. The maximum wind speed is rated at 5.8 m/s at 13.222V, 0.19A, and 2.512W.

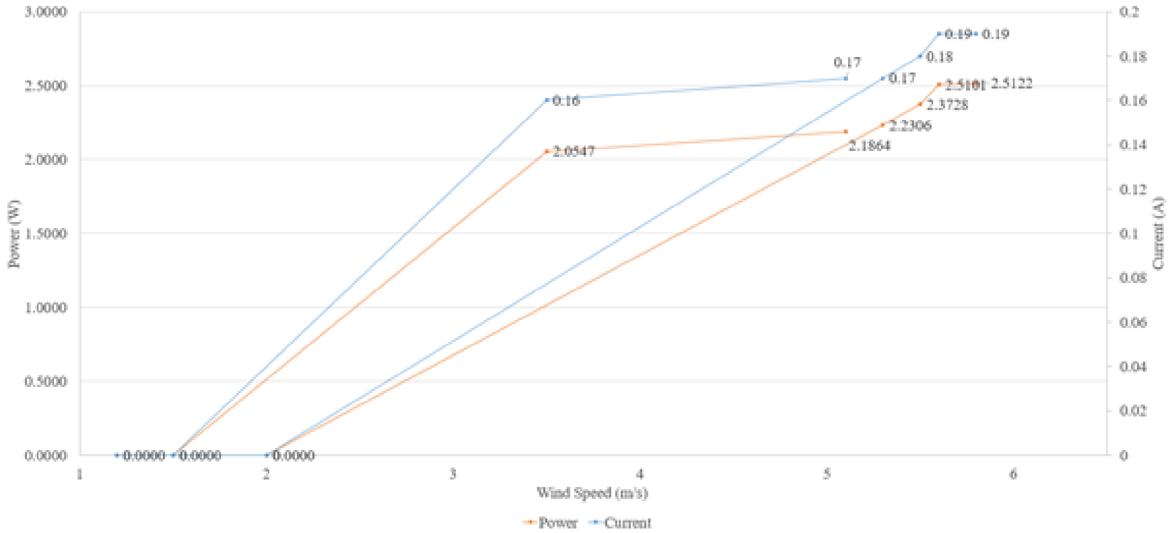


Fig. 7 - Power and current output vs wind speed of 12V DC water pump on 10th June 2022

4.3 Results from Blynk Application

This section displays the results of monitoring a mini wind energy system using the Blynk application. The result was obtained by charging a 12V battery on the 9th and 10th of June 2022 at Pantai Punggor, Batu Pahat, Johor. The result is recorded every 30 minutes from 9.00 am to 1.00 pm. The data is retrieved using the Blynk interface. On the 9th and 10th of June 2022, the results for output mini wind turbine using Blynk application to charge 12V battery at Pantai Punggor, Batu Pahat, Johor. The result shown is taken from 9.00 am until 1.00 pm, the result is observed every 30 minutes. Fig. 8 displays the charging current graph on June 9th and June 10th, 2022. The graph shows that the current decreases at 9.30 am and rises at 10.00 am.

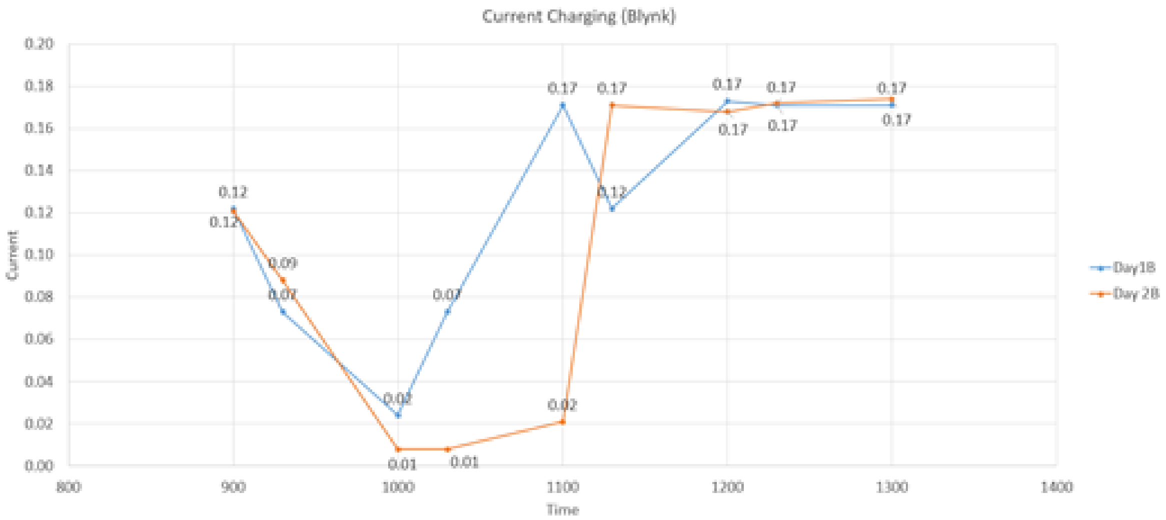


Fig. 8 - Charging current on 9th and 10th June 2022 using Blynk

4.4 Comparison of Results Mini Wind Turbine Monitoring System

This part discusses the Mini Wind Turbine Monitoring System comparison between the manual reading and Blynk Application at Pantai Punggor, Johor on 9th June 2022. The results were recorded every 30 minutes, starting from 9.00 am until 1.00 pm. The data were recorded based on wind speed, voltage and current. From the observation at 10.00 am on 9th June 2022, the highest percentage error is calculated which is 0.2% based on the current reading. Based on voltage reading, the percentage error is 0.2% and for the power is 0.7%.

On the 9th June 2022, the graph of voltage vs time is shown in Figure 9. A graph of the current vs the time on June 9th, 2022, as shown in Figure 10. Both the figures are demonstrated have a close similarity between manual reading and Blynk reading. Nevertheless, there is a small difference between the manual reading and the Blynk reading involving the decimal points. From that, it can be observed that the simulation and the actual implementation worked functionally. However, there are several errors in the results finding which is due to the latency in data transmission from the system to the Blynk application, as well as due to the number of decimal places that were specified by the Arduino code. In addition, the inaccuracy might have been caused by human error as well as instrument error, which occurs when a person takes an improper reading.

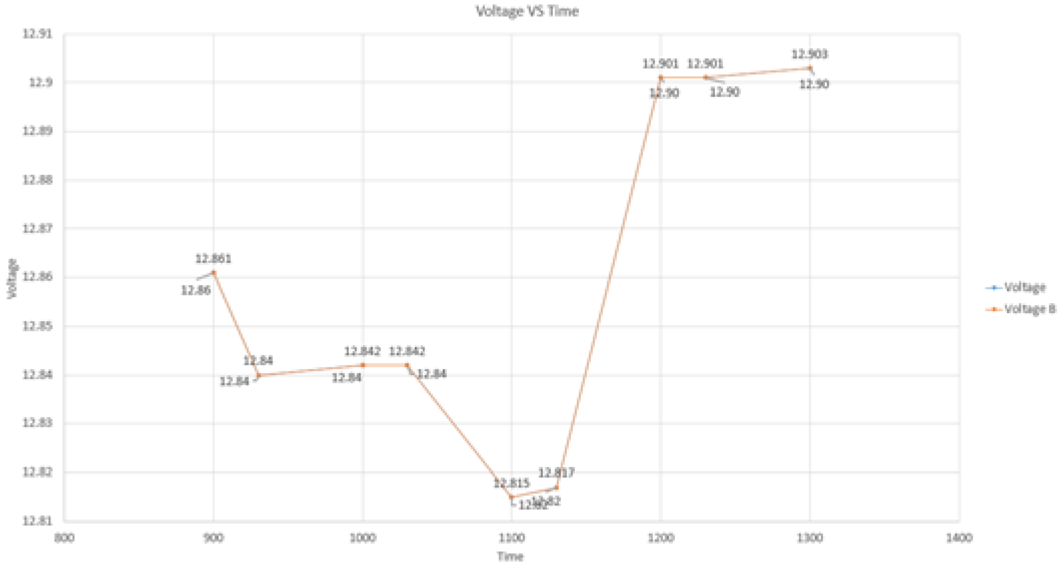


Fig. 9 - Graph of voltage vs time on 9th June 2022

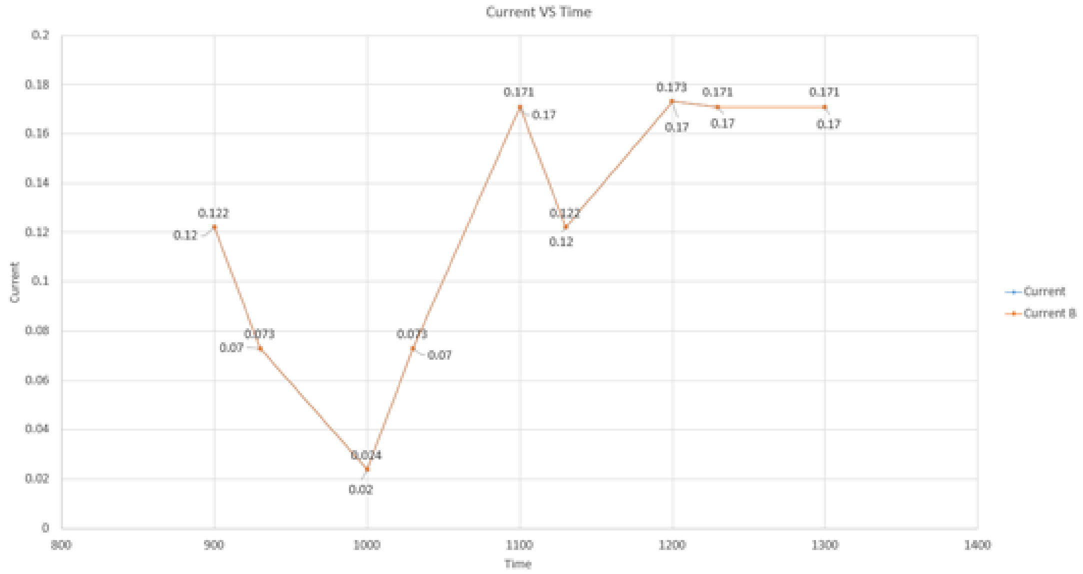


Fig. 10 - Graph of current vs time on 9th June 2022

5. Conclusion

In conclusion, the development of the prototype of mini wind energy monitoring system for the 12V DC water pump were succeeded. This project's objective is successfully achieved, developing a mini wind turbine monitoring system for 12V DC water pump that can monitor through an LCD display of the monitoring system and Blynk interface. The value of current and voltage has been displayed correctly on the LCD display and Blynk interface. Tests for the power output generated by the mini wind turbine has been done using table fan and wind by seaside at Pantai Punggor, Johor. For the first objective, the mini wind energy monitoring system using Arduino boards has been developed, using an Arduino UNO and NodeMcu Esp8266. The monitoring system worked successfully. For the second objective, monitoring the value of the current and voltage output of the mini wind system is successfully fulfilled. The third objective of testing mini wind energy potential based on charging the 12V battery and the direct current (DC) load test is also done successfully. The data collections were done to measure the mini wind turbine's output at Pantai Punggor, Johor. The data collection is a bit difficult to measure as the wind speed changes in time. From the tests had been done, the average charging current obtained is 0.12A with wind speed of 3.9 m/s. The average voltage is 12.86V and the average power is 1.57W. For the 12V DC water pump load, the average power is 1.54W with the average wind speed of 3.94 m/s.

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