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JEVA

http://publisher.uthm.edu.my/ojs/index.php/jeva
e-ISSN : 2716-6074

Journal of Electronic Voltage and Application

Development of Double Mini Windmill with Smart Monitoring System

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DOI: https://doi.org/10.30880/jeva.2022.03.02.006
Received 13 July 2022; Accepted 23 October 2022; Available online 29 December 2022

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 development of double mini windmill with smart monitoring system. Thus, the project addresses the development 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 data logging shield board was used to allow the data collection system save in the micro-SD card. Data logger is a platform used to represent the data collection into Microsoft excel. Double mini windmill energy data collection was conducted to assess the wind energy performance through reading the data from the LCD of the monitoring system. The maximum power generated is 3.632W with 6.0m/s wind speed while the minimum power generated is 0.362W with 2.4m/s wind speed. The project was tested at Pantai Punggor, Batu Pahat, Johor on 9 June 2022 and 10 June 2022 while at the residential area Taman Universiti, Parit Raja, Batu Pahat, Johor the project implemented on 11 June 2022.

Keywords: Arduino UNO, data logging shield, micro-sd card

1. Introduction

Renewable energy has been an important part in order to replace existing system. The difference between renewable and non-renewable energy are the availability of the system. The common renewable energy that widely used in Malaysia nowadays is wind energy. A Renewable energy is energy produced from sources that do not diminish or can be replaced within a human's life time. The renewable energy resource that available in Malaysia include wind, solar, geothermal, biomass, and hydropower. A Renewable energy is friendly energy source thus it has exceedingly potential to develop wind turbine and therefore the generation of electricity turn out to be desired [1].

Wind energy is unlimited, environmentally friendly, and almost available at any place in this atmosphere [2]. Besides, a wind energy is one of the cleanest forms of energy production currently available. Today, the Information and Technology (IT) now represents about 10 percent of the world's electricity generation [3]. Furthermore, most of our standard electronic equipment, such as the television, refrigerator, washing machine, and cell phone, rely on energy to operate. In other words, as computerization, industrialization, and electronic industries advance, so does power consumption. Malaysia's power usage has risen drastically from 9,090 GWh in 1980 to 116,937 GWh in year 2010. [4]. An increase in energy demand has a direct impact on power generation. Statistically, minimum average wind speed at

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Malaysia is 5.14 m/s and it is good enough to develop a mini windmill energy due to its geographical structure [5]. The mechanical output power of a wind turbine is determined by the wind speed, which is unpredictable, intermittent, and fluctuates unpredictably. [6]. Thus, the aim of this study was to establish double mini windmill with smart monitoring system.

2. Mini Wind Energy

This part will explain the theory of wind energy. Renewable Energy Sources are those vitality sources which are not decimated when their vitality is bridled. Human utilization of renewable energy sources requires advancements that outfit common phenomena, such as sunlight, wind, waves, water stream, and organic procedures, such as anaerobic processing, biological hydrogen creation, and geothermal heat. Among the previously mentioned wellsprings of vitality, there has been a great deal of advancement in the innovation for saddling vitality from the wind [5].

Wind energy is the one part or utilization of wind to give mechanical power through wind turbine to turn to electric energy and supply to some specialist device or customarily to accomplish other work, such as milling or pumping. Wind power is a reasonable and sustainable power source and has a lot of littler effects on nature compared with consuming non-renewable energy sources such as burning fossil fuels. A wind turbine is a fan with two or three blades that revolve due to wind, with the axis of rotation aligned with the direction of the wind as shown in Fig. 1. Kinetic energy is the movement or motion of gear and object. A gearbox is a high-precision mechanical system that is used to convert energy from one device to another by employing a mechanical approach.

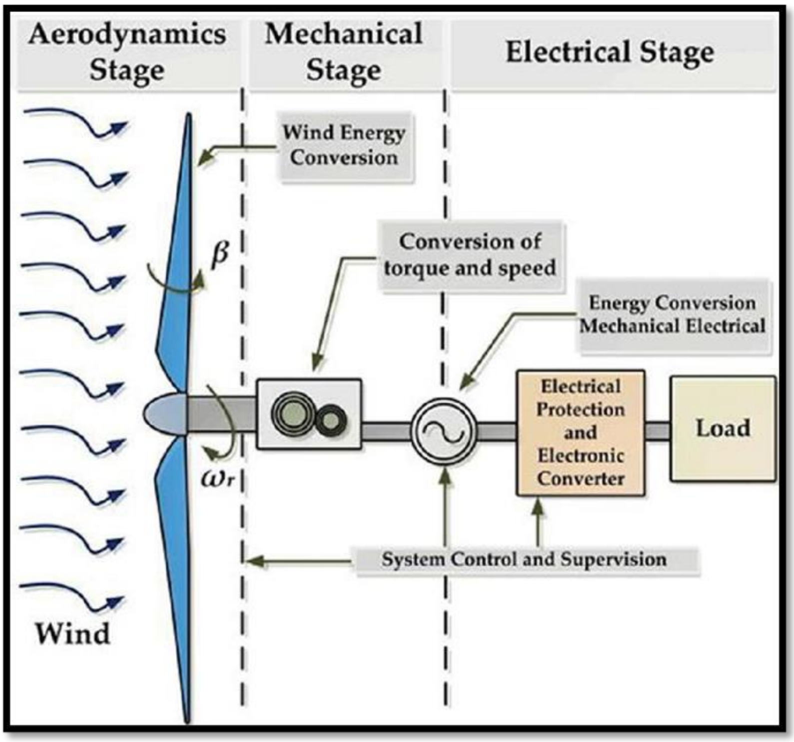

Fig. 1 - Energy conversion process for a wind turbine

2.1 Hardware Development with Monitoring System

For development of the project, voltage sensor and current sensor used to monitor the performance of the double mini windmill system. Fig. 2 shows the flow chart of smart monitoring of double mini windmill system using data logger.

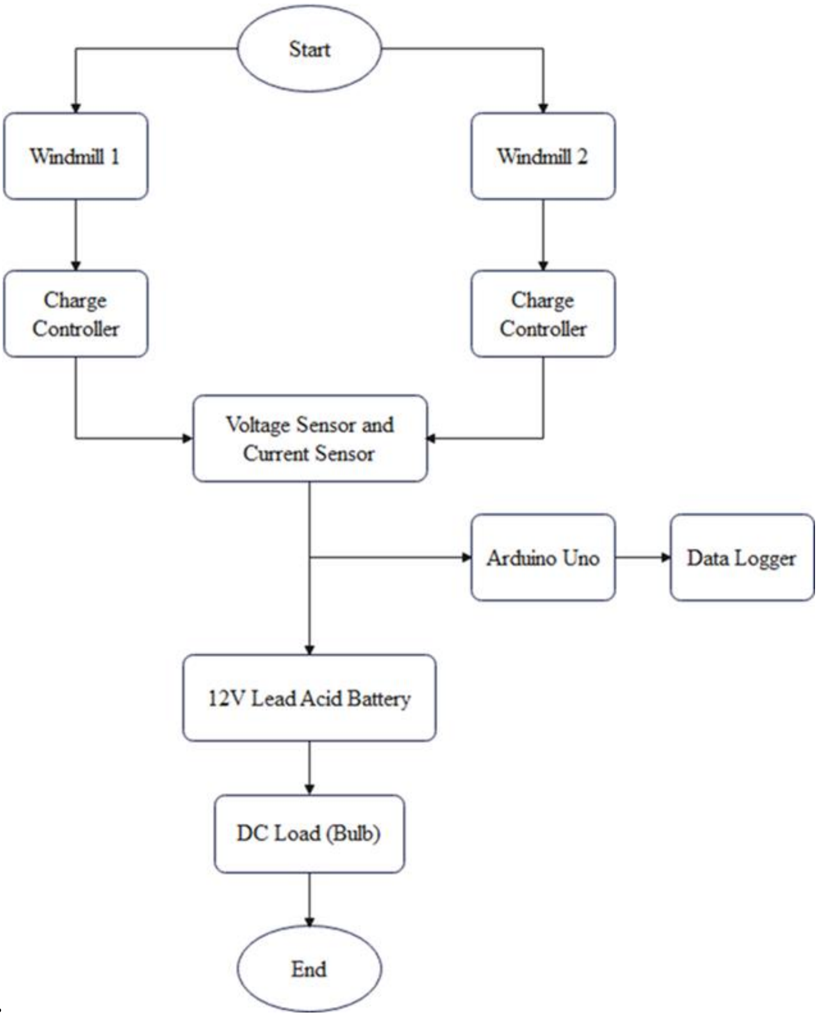

Fig. 2 - Flowchart of hardware development

2.2 Materials

This part will explain the main component that use to build it. The main components of the project are double mini windmill turbine, charge controller, an Arduino UNO board, LCD, SD card, and 12V battery.

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

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

c. Data Logging Shield
   - To allow communication between Arduino and Data logger
   - Operating Voltage 5V

d. Battery
   - Nominal Voltage 12V
   - Charging Current 7Ah

e. DC Bulb
   - Voltage Rating 12V
   - Power Rating 3W

3. Result and Discussion

3.1 Hardware Development

The hardware component of the project is shown in Fig. 3. Several critical components were used to construct the hardware for this project's hardware. To begin, the Arduino UNO board is the system's most important component. It is used for the first time when trailing. The Arduino UNO board handles all of the coding. The second component of the sensor is a current sensor and a voltage sensor, which are used to measure current and voltage. In testing, the sensors are linked to an analogue pin on the Arduino Uno board. Finally, as a monitoring system, the data logging shield that is connected to an SD card will save all of the data to the Micro-SD card.

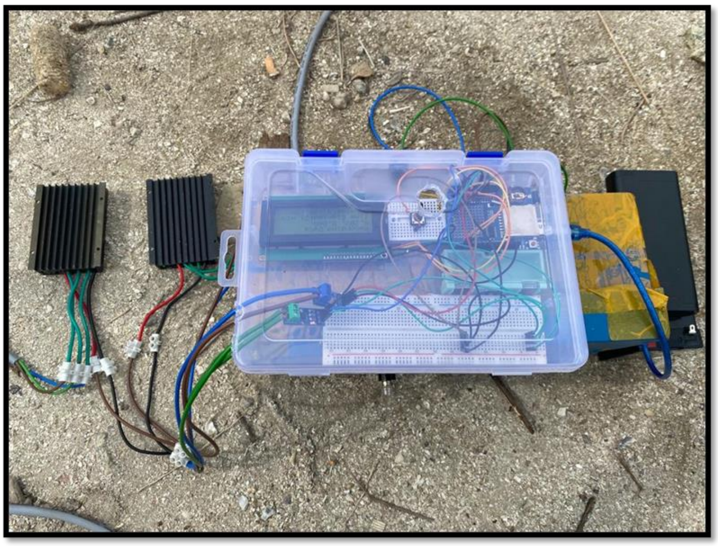

Fig. 3 - Hardware prototype with battery charging

Fig. 4 shows the completed design of the double mini windmill with smart monitoring system. The circuit for testing the charging of 12V battery. The wind turbine is connected to each charge controller, and the charge controller output is directly connected to the battery. The reading data is displayed on the LCD screen.

Fig. 4 - Setup for the testing project

3.2 The Current Charging of Battery

Table 1 shows that the result for average wind speed is 4.92 m/s. The maximum wind speed recorded is 6.0 m/s and the double mini windmill system can generate a voltage of 12.97V with 0.28A current and the power of 3.632W. The result shows that on 17.00 p.m. the wind speed is 3.0 m/s and current show 0.03A cause low wind speed which is not enough to maintain the charging current from double mini windmill and the output of power generated is 0.365W.

Table 1 - Readings on 9th June 2022

Time (p.m.)	Wind Speed (m/s)	Voltage (V)	Current (A)	Power (W)
1300	6	12.97	0.28	3.632
1330	5.5	12.88	0.17	2.190
1400	5	12.84	0.15	1.926
1430	4.7	12.84	0.05	0.642
1500	4.8	12.82	0.05	0.641
1530	5.5	12.88	0.16	2.061
1600	5.3	12.86	0.14	1.800
1630	4.5	12.19	0.04	0.488
1700	3	12.17	0.03	0.365

Table 2 shows the average wind speed is 3.97 m/s. The maximum voltage can generate 12.86V while current produce 0.18A and can generate 2.315W. In the afternoon, the wind speed is 5.3 m/s because the wind is roughly strong by seaside. The lowest result show on 17. 00p.m. which is can generate 12.08V. The wind speed is 2.4 m/s and current produce 0.03A because at that time the wind speed in the evening not enough to start up and maintain the output. The power generated is 0.362W.

Table 2 - Readings on 10th June 2022

Time (p.m.)	Wind Speed (m/s)	Voltage (V)	Current (A)	Power (W)
1300	5.3	12.86	0.18	2.315
1330	3.5	12.84	0.12	1.541
1400	4.5	12.65	0.13	1.645
1430	4	12.6	0.07	0.882
1500	4.2	12.46	0.07	0.872
1530	5.1	12.85	0.17	2.185
1600	3.5	12.74	0.12	1.529
1630	3.2	12.71	0.07	0.890
1700	2.4	12.08	0.03	0.362

Table 3 shows the average wind speed is 4.53 m/s. The maximum wind speed recorded is 5.5m/s that can generate a voltage 12.69V with 0.26A current and the power of 3.2994W. It is because the wind flow that given from fan is stable to generate the voltage and current. The result shows the lowest wind speed in the reading is 3.5m/s that generate the 12.54V with 0.13A current that can generate 1.6302W. The double mini windmill can produce a stable current charging to the battery and load when using the wind fan as the support to get the wind flow.

Table 3 - Readings at residential area by wind fan on 11th June 2022

Time (p.m.)	Wind Speed (m/s)	Voltage (V)	Current (A)	Power (W)
1300	4.5	12.42	0.17	2.1114
1330	4.8	12.61	0.24	3.0264
1400	5.5	12.69	0.26	3.2994
1430	4.5	12.55	0.18	2.2590
1500	3.8	12.12	0.16	1.9392
1530	3.5	12.54	0.13	1.6302
1600	4.3	12.64	0.18	2.2752
1630	5.1	12.19	0.2	2.4380
1700	4.8	12.56	0.19	2.3864

Figure 5 shows the graft of the charging current on 9 June 2022, 10 June 2022 and 11 June 2022 show that the current charging by the seaside is increase at around 13.00 p.m. and 15.30 p.m. because the weather is quite hot and windy. It starts to decrease at around 17.00 p.m. because at that time, the wind is low to generate the current and voltage. The reading data by the seaside depends on the weather condition while the reading data around residential area is support using a wind fan. So, the current charging is more stable due to constant wind flow to produce the voltage and current.

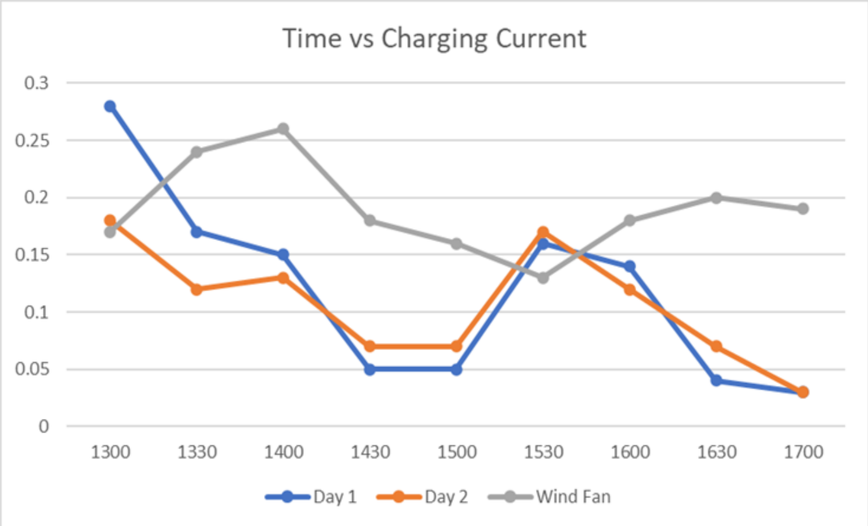

Fig. 5 - Charging current graph in different day and area

3.3 Output DC Load Test

Table 4 shows the DC load test without battery for the testing based on direct current load is into 12V 3W light bulb. For testing on 12V 3W light bulb, the bulb is direct connected to double mini windmill system output and the smart monitoring system. The data are recorded based on the wind speed, voltage and current that have related with wind flow. The wind speed is recorded using anemometer and for the power generated is calculated by using power law equation.

The direct current load test result based on 12V 3W bulb at Pantai Punggor, Batu Pahat, Johor on 10 June 2022. The data is recorded every 30 minutes, starting from 13.00 p.m. until 17.00 p.m. The result shows that the average wind speed is 4.03 m/s, and the average power from the result is 0.951W. The maximum wind speed recorded is 5.3m/s that can generate a voltage of 10.69V with 0.18A current and the power of 1.924W.

Table 4 - DC load test without battery

Time	Wind Speed (m/s)	Voltage (V)	Current (A)	Power (W)
1300	5.1	10.22	0.17	1.737
1330	3.5	7.15	0.12	0.858
1400	4.5	9.45	0.13	1.229
1430	4	8.58	0.07	0.601
1500	4.2	8.87	0.07	0.621
1530	5.3	10.69	0.18	1.924
1600	3.5	7.24	0.12	0.869
1630	3.2	7.13	0.07	0.499
1700	3	5.58	0.04	0.223

Figure 6 shows that the graph of the Wind Speed and Power Output comparison on 10 June 2022. The graph shows that the higher the wind speed, the higher the power output produce to the DC load test. It will increase proportional or decrease proportional due to the wind speed of the double mini windmill.

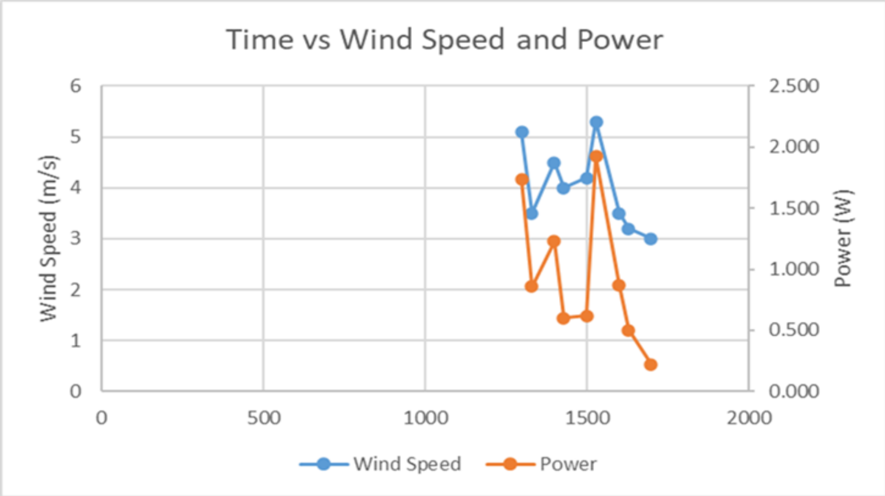

Fig. 6 - Graph between wind speed and power output DC load test

3.4 Comparison Output Voltage Generated from Number of Turbines

Table 5 shows the output reading for the number of wind turbine used. This part discusses the comparison output between the number of wind turbines and voltage generate. The correct way to install 2 wind turbine is by installing the input which is 2 wind turbine motor are connected to each charge controller and the output from the charge controller will connected to series circuit. Then, the voltage output directly connected to the 12V DC battery. The data recorded using data logger at residential area Taman Universiti, Batu Pahat, Johor from 8.00 p.m. until 12.00 a.m. The wind turbine rotates with the help of wind fan as the residential area did not have enough wind flow which is 1.8m/s minimum to start up the wind turbine. The data are recorded based on the number of wind turbine used and battery voltage generated.

Table 5 - Output reading for the number of wind turbines

Time	Wind Speed (m/s)	Voltage Output from 1 unit of turbine (V)	Voltage Output from 2 units of turbine (V)
8.00 pm	5.1	5.61	10.22
8.30 pm	3.5	3.075	7.15
9.00 pm	4.5	5.225	9.45
9.30 pm	4	3.79	8.58
10.00 pm	4.2	4.935	8.87
10.30 pm	5.3	4.845	10.69
11.00 pm	3.5	4.12	7.24
11.30 pm	3.2	3.065	7.13
12.00 am	3	3.29	5.58

The number of wind turbine will generate more voltage when the circuit wiring is connected in series. The highest voltage generated from 1-unit wind turbine is 5.61V while for 2 units wind turbine is 10.69V. The lowest voltage generated from 1-unit wind turbine is 3.065V while for 2 units wind turbine is 5.58V as shown in Figure 7.

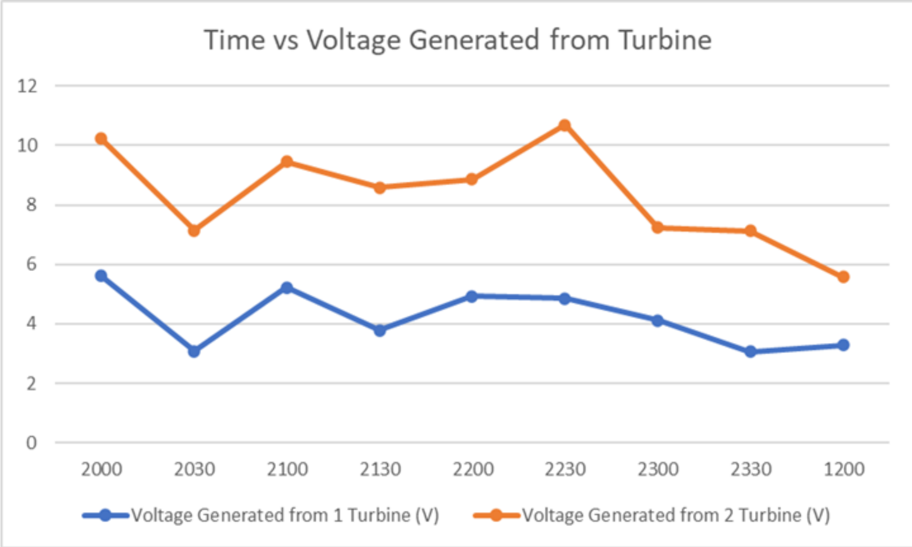

Fig. 7 - Comparison graph for voltage generated from number of turbine

4. Conclusion

In conclusion, the development of Double Mini Windmill with Smart Monitoring System using data logger are success. The objective of the project is successfully achieved by developing Double Mini Windmill with Smart Monitoring System that can save the data recorded in the Micro SD card and transfer the data into the PC or laptop. Output test and reading is generated on Double Mini Windmill System at Pantai Punggor, Batu Pahat and at residential area Taman Universiti, Batu Pahat. For the first objective, to design the double mini wind energy for generate the voltage and current are successful. For the second objective, to test and evaluate the effectiveness of the double mini windmill for energy generation. The effectiveness is truly accepted due to current charging to the battery and DC load test. The third objective, to develop a smart monitoring system for monitoring the current and voltage of the output. The monitoring system declare the system worked successfully. The average wind speed by the seaside quite good but the wind flow is not stable due to the change of weather.

Acknowledgement

The Author would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for the facilities that has been provided and for its support.

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