CHAPTER 1

INTRODUCTION

1.1 Background Study

In the middle age of time, wind energy has been exploited by human for a thousand years as a source of ship navigation, wind mill and other. Wind turbine is a machine that converts wind power into electricity form. The wind energy is renewable energy because it uses the renewable source. It is also called as green energy or non-polluting energy because it does not produce any green house effect gasses. The effect of burning that fossil fuel has caused people search for alternatives. Wind also one of potential energy to be used since wind exists everywhere on the earth. This kind of electricity generation can be used if we find a new way to use the wind. As electricity generator, wind turbine is connected to some electrical network [1]. These network include battery charging, residential scale power system isolated or island network and large utility grid [1].

1.2 Problem Statement

Electricity is actually a secondary source which is conversion of other sources such as coal, nuclear or fuel. These are called primary source. The primary source that is used to make electricity can be renewable or non-renewable. However, electricity itself is either renewable or non renewable. In power generation industries, most of the industries use these types of primary sources to generate electricity. High electricity consumption has realizes the people especially in the matter of increasing electricity bill per year. Therefore, this project aims to reduce the electricity consumption by using the renewable sources at home.

1.3 Objectives

The following are objective of this project:

- To study how the operation of small wind turbine system model using MATLAB Simulink.
- To analyze the effect of the power and current output when the radius of the blade is variable.
- To analyze the inverter circuit so that the output power can support the electrical appliance demand.
- To fabricate actual inverter circuit of input 12DC volt to 220AC volt.
- To analyze the output of the inverter circuit.

1.4 Scope of the Project

The scope of study will involve the power analysis where it is related to the power generation and distribution. The system is preferred to install at house and rural area rather than urban environment. It also involve the knowledge of Wind Energy Technology such as understanding the principle of the amount of energy that can be captured from the wind is exponentially proportional to the speed of the wind. This project also needs the knowledge of power electronic where very important to create the inverter circuit.

1.4.1 Relevancy of the project

The purpose of this project is to design the prototype of Small Wind Turbine experiment. Since this technology is still zero development in Malaysia, this project will prove whether the small wind turbine system efficiently can be used in our country. So, the system is used to help people in reducing their electricity bill.

1.4.2 Feasibility of the Project within the scope and time frame

This project starts by collecting the reading material such as the books, journals, related website, discussion with supervisor and discussion with laboratory technician. During the range time for Final Year Project (FYP) 1, this project target's is to setup the prototype of inverter circuit and start to collect the initial important data of the experiments. During the FYP 2 period, the target is to get more data and analysis for different condition of situation.

CHAPTER 2

LITERATURE REVIEW

2.1 WIND BASIC

2.1.1. Energy from moving air

Wind can be defined as air in motion. There are two main cause of the wind. The first one is that the earth is turning around its own axis. The second cause is circulation of hot air or wind cycle. Global wind are caused by pressure difference across the earth's surface [1] due to the uneven heating of earth surface has caused this phenomenon. This is because the earth has different kind of geographical surface where the earth will absorb the heat from the sun at different rate. The equator part of earth's surface is tending to absorbed more solar radiation compare to the poles parts. In a simple word, we can say that the wind arises at the equator and will end up at the poles. The circulation of the atmosphere that results from uneven heating is greatly influence by the effect of the rotation of the earth [1].

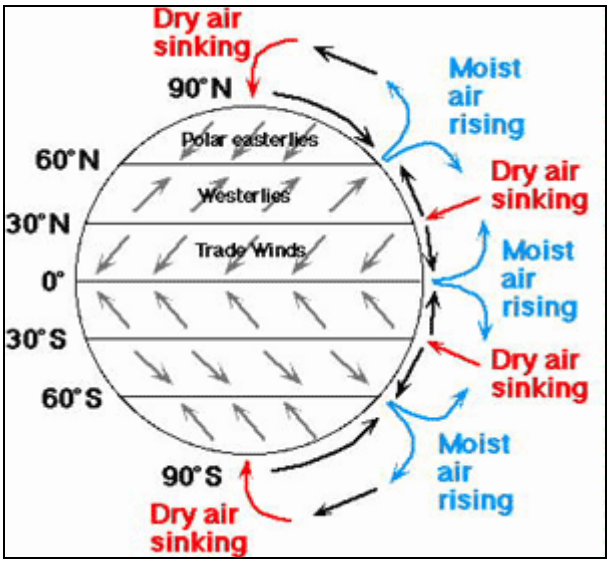


Figure 1: Surface wind of worldwide circulation

2.1.2. Daily wind cycle

During the day, the air at the land heats up faster than the air at the water. Therefore, the warm air at the land will expand and rises and also heavier. The cooler air tends to rush in to take place when the warm air expands and result the wind. At night, the situation is reversed where the cool air more rapidly at land rather than at the water.

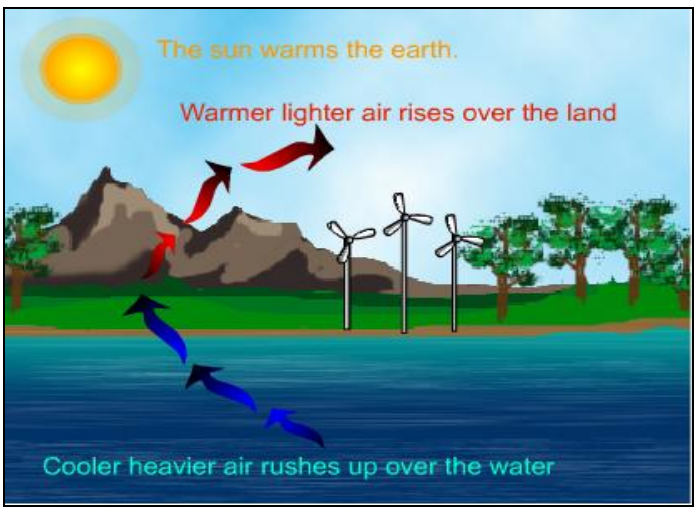


Figure 2: Wind Cycle

2.1.3. Wind Speed Different in Each Country.

In each country, the wind speed is different because of a few factors. Wind speed is affected by pressure gradient, Rossby wave and local weather condition. Other than that, the heat transfer at earth's atmosphere will cause variation of atmospheric pressure field which is caused the air move from high to low pressure.

Pressure gradient is the difference in air pressure between two points in the atmosphere or on the surface of the earth. The greater the difference in pressure, the faster the wind flows to balance out the variation. The pressure gradient force in the vertical direction is usually cancelled by the downward gravitational force [1]. Thus, the wind blow predominately in the horizontal plane, responding to horizontal pressure gradient [1].When it combines with the Coriolis Effect and friction; it will cause the wind direction.

Rossby waves are the strong winds in the upper troposphere. The waves are different wind speed from what we experience in the lower troposphere.

Local weather condition effect the wind speed for example the formation of hurricanes, monsoons and cyclones as freak weather which is can change the speed of wind.

The figure 3 in the next page shows the latest wind speed activity in Malaysia:

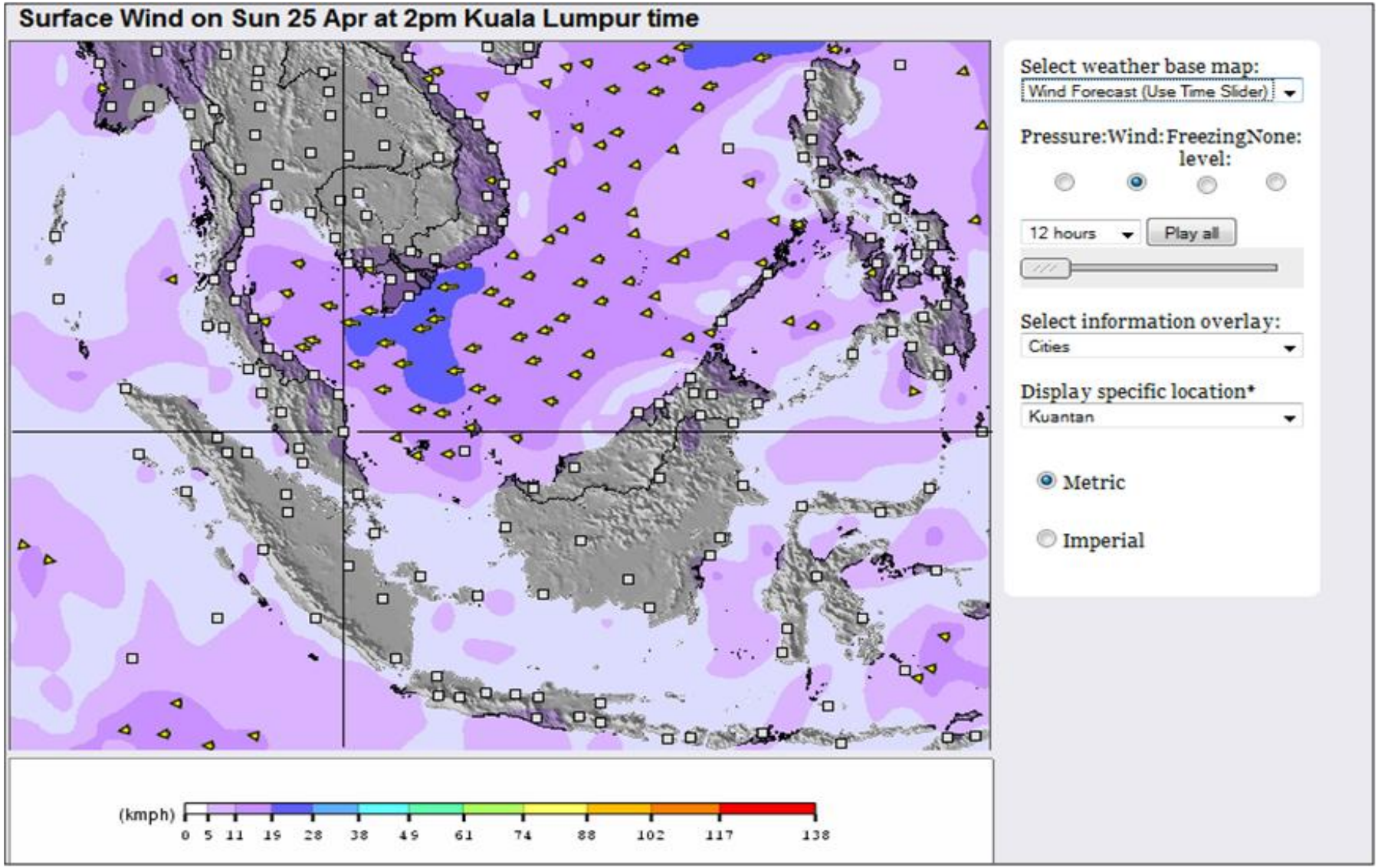


Figure 3: Wind Speed Activity

2.2 Residential Wind Turbine

Residential wind turbines are quickly becoming one of the most popular alternative green energy on this day. Actually, this residential wind turbine is not a new thing since many years ago people have been using the windmills to pump water and grind grain. But today, these kinds of wind turbines are now being use at the cities in past few years to generate electricity for their home and also another purpose. In United States, 2007, this kind of alternative energy has been installed 5.2 gigawatts of new wind energy and also other countries such as China (3.4 GW) and Spain (3.5 GW). The people are interested in this kind of alternative energy because it is stand-alone energy. Therefore, the people are using the residential wind turbine in order to reduce electricity bills, reduce the greenhouse effect and become individually energy independent. Generally, residential wind turbines are come in two type of different axis wind turbine.

In figure 4, it shows the picture of horizontal wind turbine which is the most common. The residential wind turbines with using the horizontal axis usually will be placed either on a rooftop or in the yard and also mounted on the top of the tower. Figure 5 and Figure 6 shows the picture of where the residential wind turbine is placed.

Figure 4: HAWT

Figure 5: Rooftop

Figure 6: Yard

In different location, when the wind turbine is far from the ground, the wind speed will be higher and the faster the wind turbine will turn. Other than that, the rooftop mounted wind turbine also can provide enough energy which is cheaper and need less maintenance than using the wind turbine that required the tower.

In Figure 7, the figure shows the vertical axis wind turbine which is the fastest growing segment. The residential wind turbine usually mounted much closer to the ground or also can be mounted on the rooftop. This type of wind turbine cannot generate maximum electricity when the wind direction changes. However, this design is more suitable where the place have lower wind speed where it has more pleasing aesthetics design than other models.

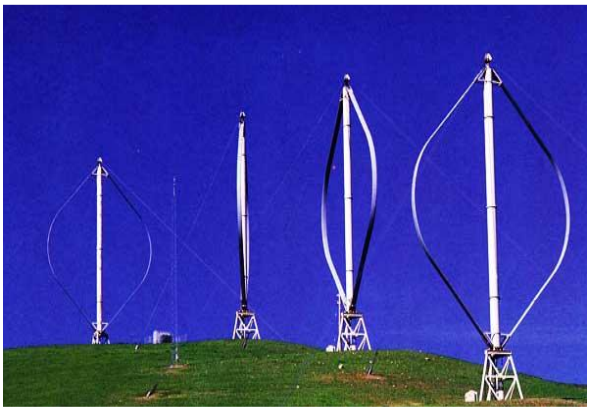


Figure 7: VAWT

2.3 Magnetic Wind Turbines

The MagLev wind turbine is the turbines that can generate electricity in slower winds, have less resistance and last longer due to less damage from continuous use. The MagLev wind turbine usually is built in vertical axis that is suspended with magnets above the base. This means that it has no or less damage from continuous use as there would be non-magnetized model. The material that implement in the MagLev is neodymium. The neodymium is a rare material that can work without electricity and the system is equipped with electromagnets. Figure 8 below shows the magnet that has magnetic levitation.

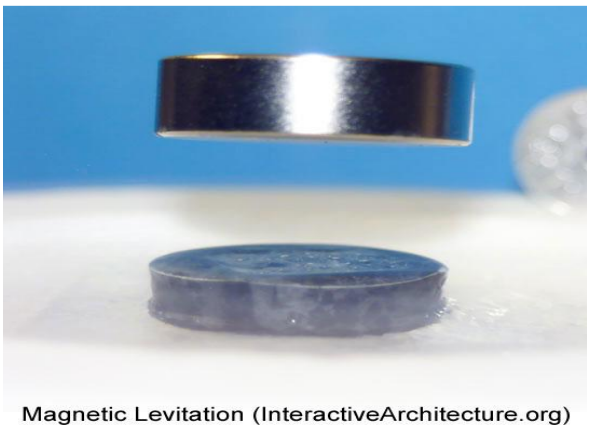


Figure 8: Magnetic Levitation

The most important is that this advantage of magnetic wind is that it produces little energy loss due to friction. This material is not touching but is repel each other. This means that the wind turbine can turning or work in very low speed of wind (3mph). Other that than, this turbine also can work very well in higher speed of wind at over 80mph. Different to the other turbines, those turbines will automatically shutdown to avoid the damage. The Zhongke Hengyuan Thecnology in central China also has begun building the world's largest utility scale magnetic wind turbine in November 2007. Since the design is vertical axis, cone shaped and low resistance, this type of wind turbine can be placed at the lower to the ground. However, this magnetic wind turbine idea not only can be used for utility but also applicable at our home. This kind of wind turbine has been used by Jay Leno. He has a 5kW magnetic wind turbine on the world famous Jay Leno's Garage. Figure 9 show the idea to build the MagLev wind turbine while Figure 10 shows the Jay Leno's magnetic wind turbine.

Figure 9: MagLev

Figure 10: Jay Leno's wind turbine

2.4 Solar Wind Turbine

Nowadays, a lot of manufacturing try to develop renewable technologies especially in wind and solar field. Therefore, there are a few companies that try to combine these two types of energy in one function. They have invented the solar wind turbine which makes use of both photovoltaic and wind energy. They also claim that this turbine can generate electricity even the wind speed is low about 4mph and operate in a silent which is not affect the surrounding. During the summer, the wind may be not as strong as during other seasons. Therefore, the solar cell will be used in generating the electricity especially in hot which is sunny climates. During the night, the solar sell won't work so this wind turbine will replace the solar cell to generate the electricity. This solar wind turbine can give double benefit when both the wind is blowing and the sun is shining. Another benefits also can we have from this because the rotation of the wind turbine will act as a cooling on the photovoltaic cells. As a conclusion, we can conclude that the combination of the two types of energies would increase the efficiency. The seasonal effect may affect the collection of energy where during the winter where there would not be a lot of sunlight and during summer wind may not be strong. The solar wind turbine would suitable for the country that sunny and windy such as Malaysia. Figure 11 below shows the construction of the solar wind turbine.

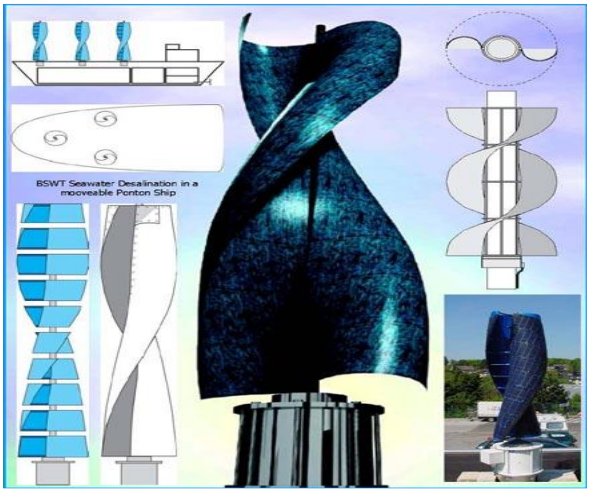


Figure 11: Solar Wind Turbine

2.5 The UPS System

The UPS is an uninterruptible power supply or battery backup. In the electrical system, the UPS system provides emergency power to a load when the input power source fails. The UPS is differs from an auxiliary power system or standby generator. This is because the UPS system will provide instantaneous protection from input power interruption. This system can only support for low power users. The on-battery runtime of most uninterruptable power source cannot be extend for a long time but sufficient to allow time to bring an auxiliary power source online or properly shutdown the protected equipment. The UPS is typically used to protect computers; data center and others electrical equipment that unexpected power failure could cause injuries, fatalities and data loss.

2.5.1 The Double Conversion On-Line UPS

The online UPS as Figure 12 (double conversion UPS) technology operates by taking the incoming utility alternating current (AC) and converts is it to direct current (DC) which charges the batteries. The DC is converted back to the AC which is supplied to the protected load. Since the inverter is always connected to the output of the UPS, the double-conversion technology produces clean sine waves and also reduces harmonics.

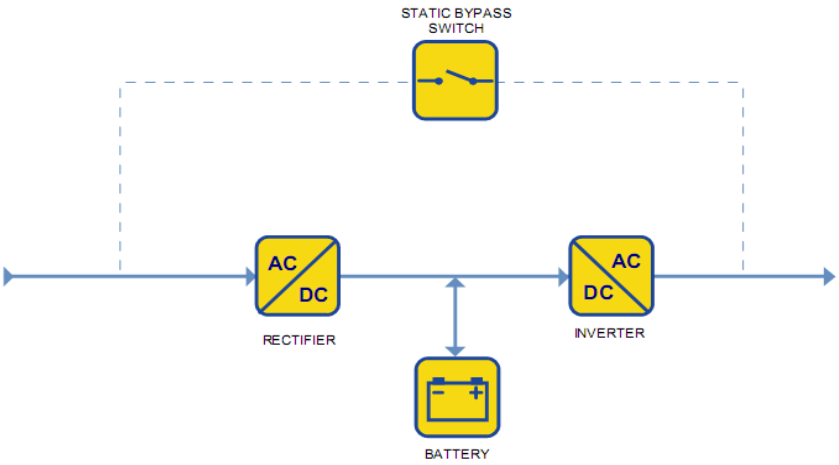


Figure 12: Double Conversion On-Line UPS

The advantage of this sytem is there is no transfer time. This is because dropping the incoming voltage does not cause activation of the transfer switch because the input AC is not the primary source which is it is the backup power sources. Therefore, an input power failure does not cause a transfer function.

CHAPTER 3

METHODOLOGY

3.1. Procedure Identification

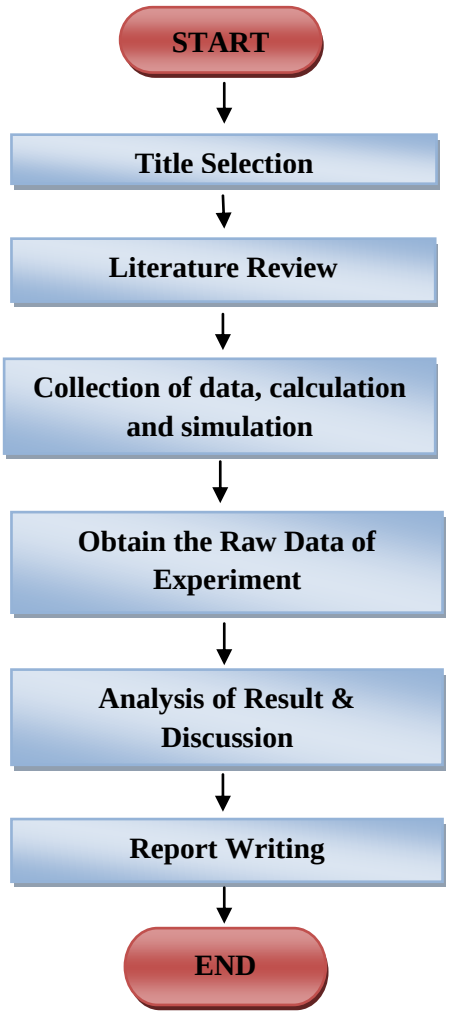


Figure 13: Flow chart

The research methodology for the final year project is meant to be conducted in two semesters. In the first semester, the projects start with literature review and simulation on small wind turbine system using matlab simulink software. The fabrication for small wind turbine prototype is conducted in both semesters.

3.2. Tools Required

This project required several tools which consist of software and hardware. Matlab simulink is the software used in order to simulate the small wind turbine system. All the data gained will be gathered and analyzed for the results.

3.2.1 Matlab Simulink

Matlab Simulink is a tool use to model, analyze and simulate dynamic system using block diagrams. Analyzing the project by using this tool is east and fast to learn and flexible. It provides an interactive graphical environment and customizable set of block libraries that let you design, simulate, implement and test a variety of system. A matlab/ simulink tool box for wind turbine application has been developed during the project. This tool box contains models for the main components from a wind turbine system. Wind turbine block set v2.0 is the latest toolbox for modeling wind system.

3.2.2 Hardwares

All the hardware as mentioned in the Table 1 is used to construct the circuit for the small wind turbine prototype. DC generator power supply is used to inject the voltage and current to the circuit.

Table 1: Table of tool and equipment

Hardware
1. Multimeter 2. Project board 3. Transformer: 12V-0-12V @ 3A/36VA 230V-115V-0 4. Transistor 5. Integrated Circuit (IC) 6. Wire 7. Long nose plier 8. 12V lead acid battery 9. Soldering Gun 10. Lead 11. DC generator

CHAPTER 4

RESULT & DISCUSSION

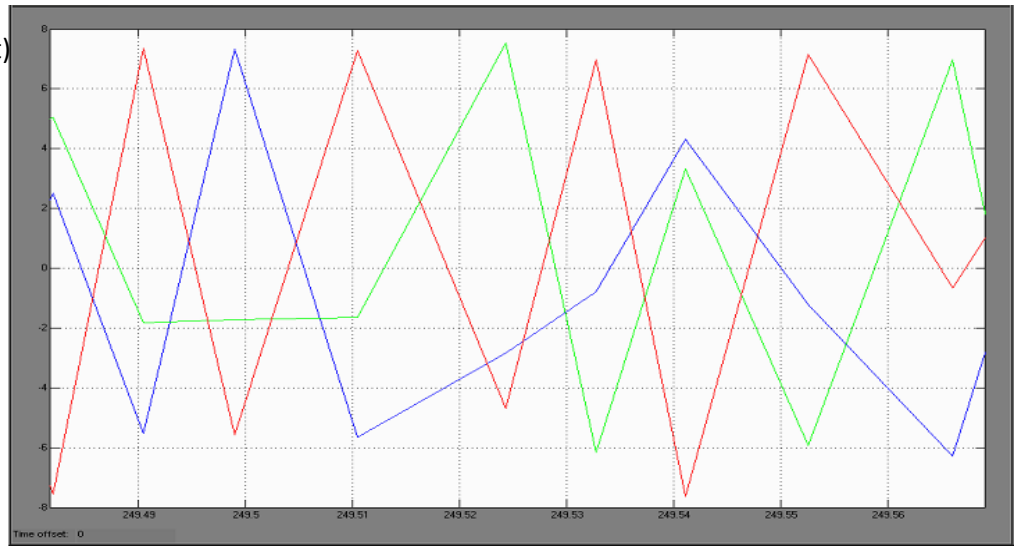
4.1 Matlab Simulation

In this project, the power output from this wind turbine system is analyzed based on the variable of radius blade and the variable wind speed data for the different place in Malaysia. The radius blade of 5 meter, 10 meter and 15 meter are used to analyze the output power.

The experiment is analyzed using the constant wind speed and the variable of radius blade. The values of the radius are 5 meter, 10 meter and 15 meter. The main purpose is to observe the effect of the different of radius blade to the output power. Figure below show the output current and output power for each radius.

a) Radius: 5 meter

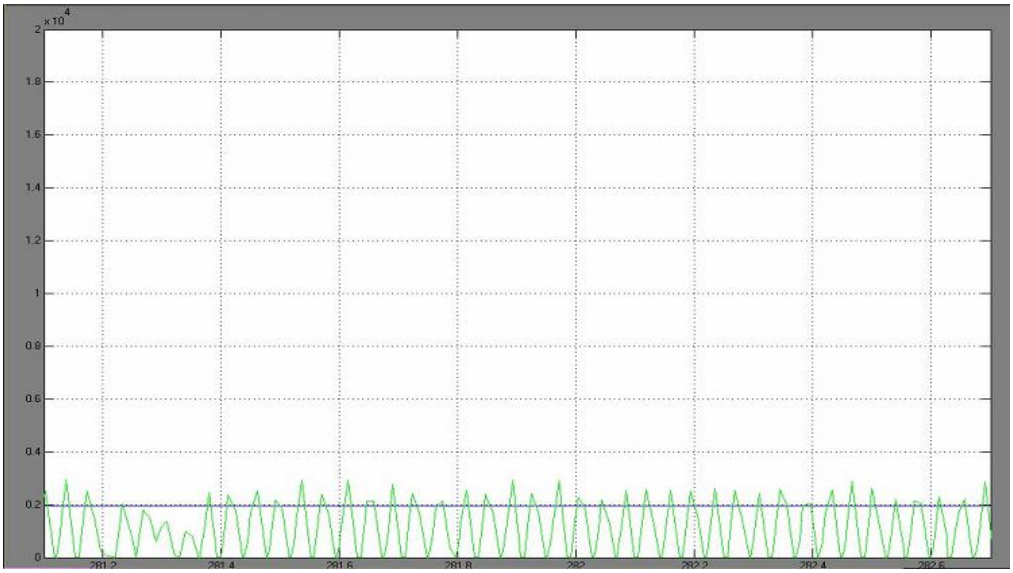
(Current)



(Time)

Figure 14: Output current for 5 meter radius

(Power)



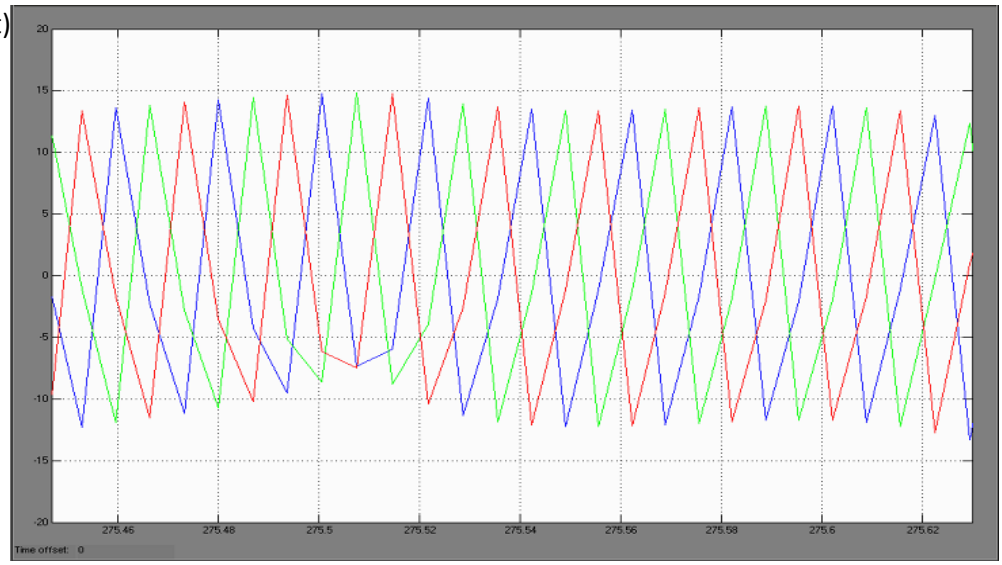
(Time)

Figure 15: Output power for 5 meter radius blades

Based on the output current result in Figure 14, the maximum current produced is about 7amp and the minimum current produced is about 2amp. The output power result in Figure 15 shows that the power produced is 2kW by using the radius of blade 5 meter.

b) Radius: 10 meter

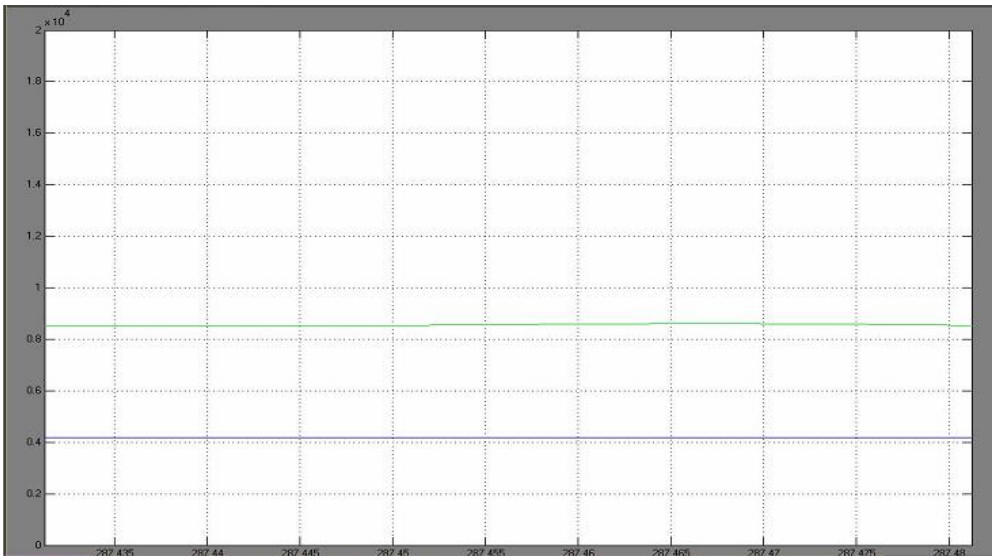
(Current)



(Time)

Figure 16: Output current for 10 meter radius

(Power)



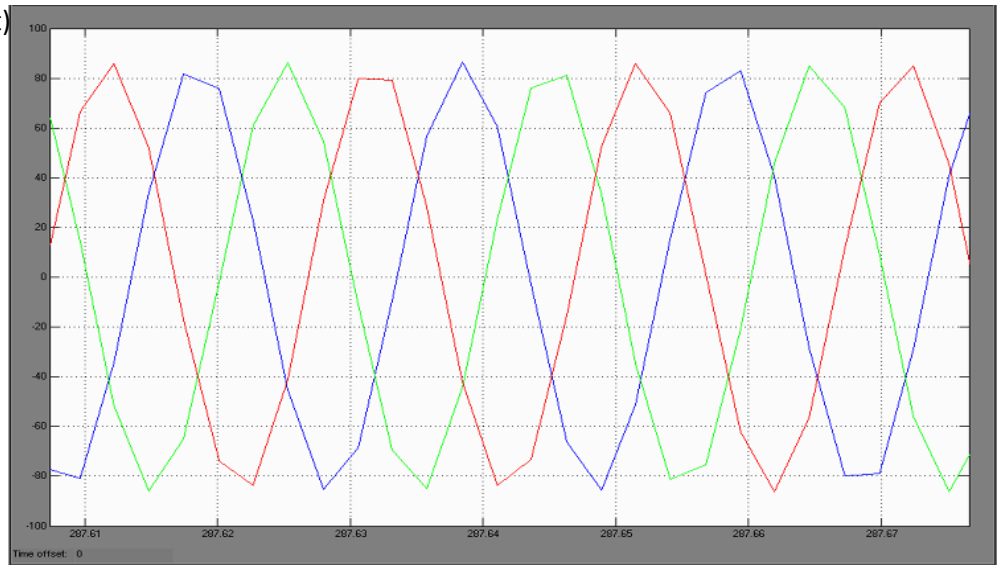
(Time)

Figure 17: Output power for 10 meter radius blades

Based on the output result, for the current output in Figure 16, the current that is produced by using the radius of blade 10 meter, the maximum output current is about 15amp and the minimum is about 12amp. The output power result in Figure 17 shows that the output power is about 4kW.

c) Radius: 15 meter

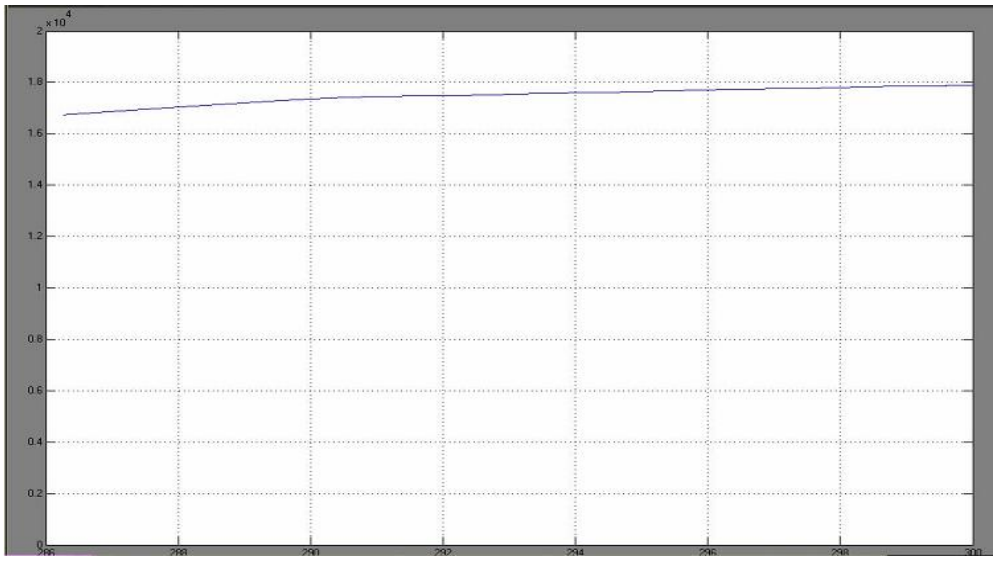
(Current)



(Time)

Figure 18: Output current for 15 meter radius

(Power)



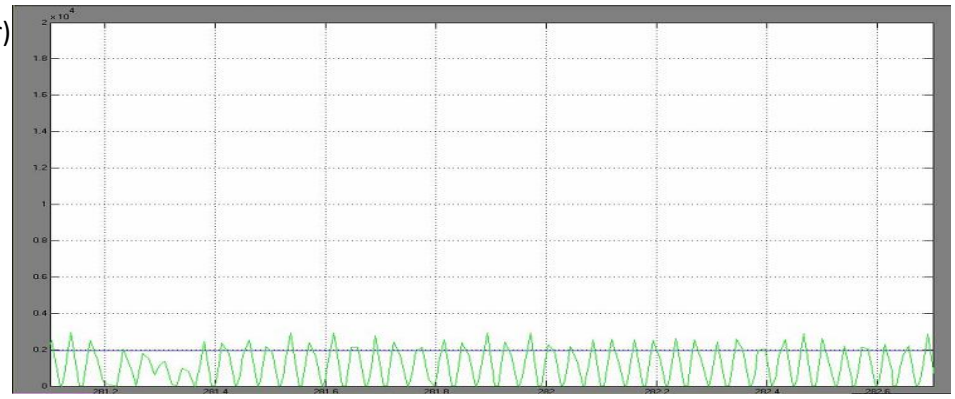
(Time)

Figure 19: Output power for 15 meter radius blades

Based on the output current result in Figure 18, the maximum current produced is about 84amp and the minimum current produced is about 80amp. The output power result in Figure 19 shows that the power produced is 17kW and increasing until 20kW by using the radius of blade 15 meter.

d) Comparison of output power

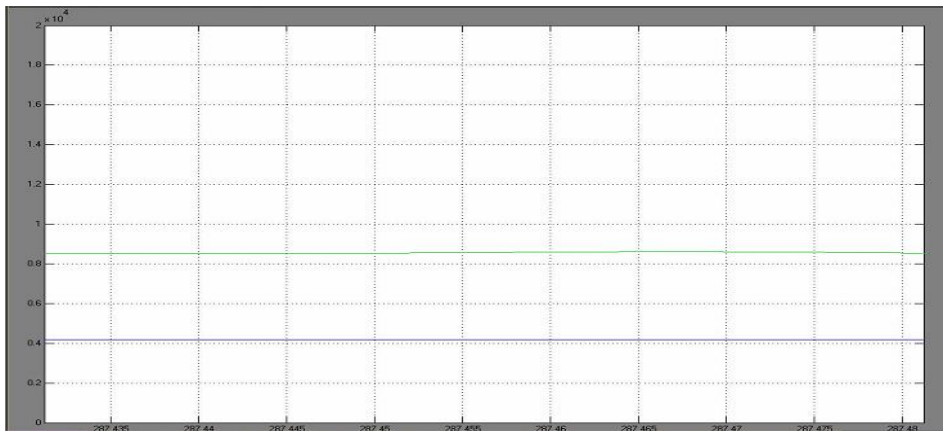
(Power)



(Time)

Figure 20: Output power for 5 meter radius blades

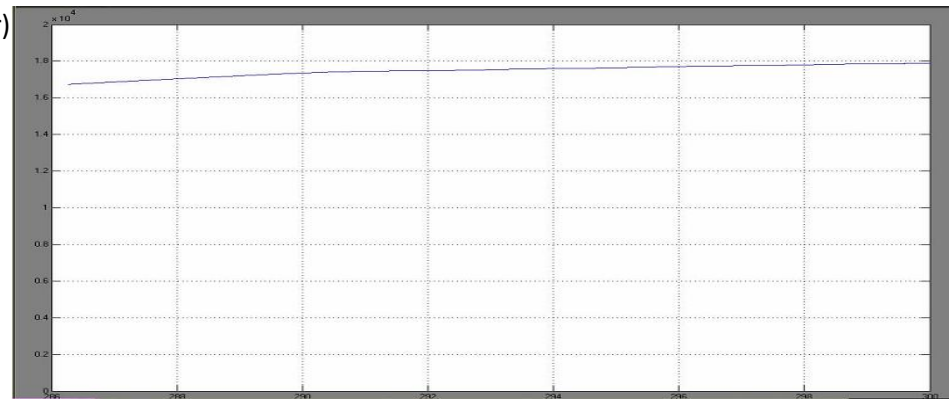
(Power)



(Time)

Figure 21: Output power for 10 meter radius blades

(Power)



(Time)

Figure 22: Output power for 15 meter radius blades

Based on the comparison result, the output power for 5 meter radius blade in Figure 20 is 2kW. For the 10 meter radius blade, the output power in Figure 21 is 4kW and for 15 meter radius blade, the output power in Figure 22 is increasing until 20kW. From this analysis, when the radius of the blade increases, the output current and output power also will increase.

4.2 Suitable Places

The data for the wind forecast has been taken on Sunday, 25 April 2010 which is the latest wind forecast on that day. The map below shows pressure isobars and current weather conditions for Malaysia. The control is used to customize the map to display the various forecasts and current weather conditions available Based on the wind forecast we can se that the wind always blow from the east cost.

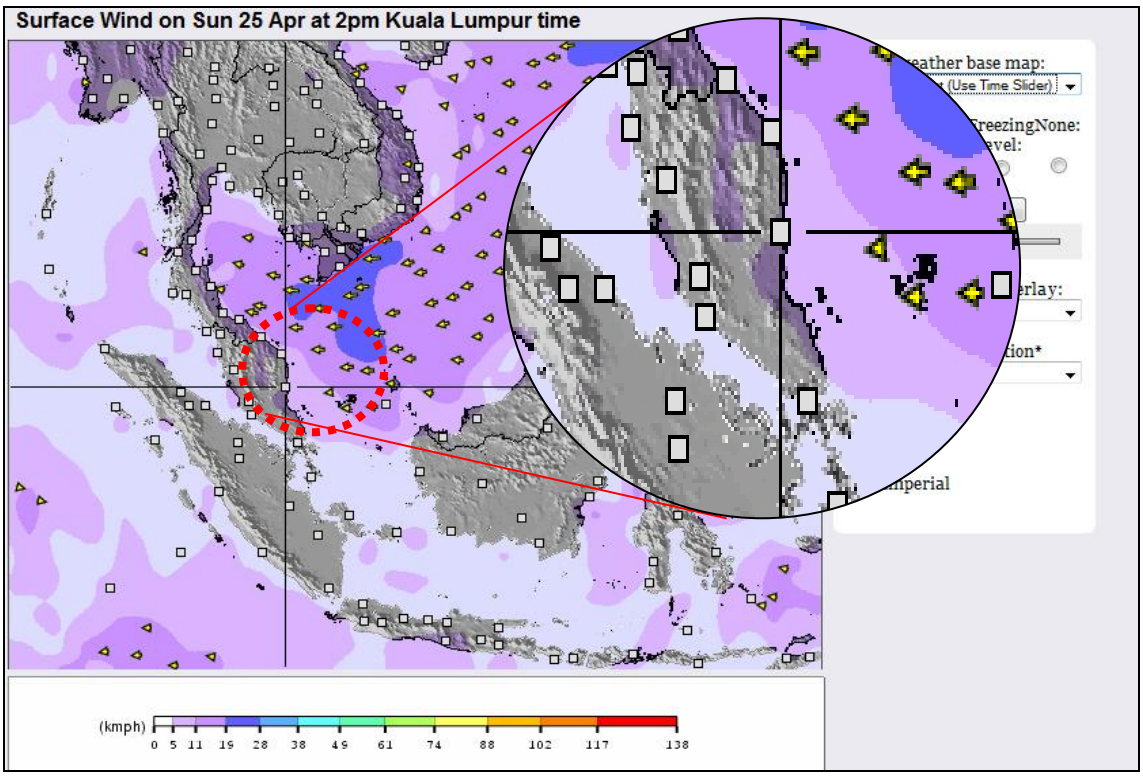


Figure 23: Wind speed map and contour colour

The contour color on the wind forecast maps show that different color of contour indicates different types of wind speed. The white color indicates that the wind speed is the slowest speed of the wind compare to the other color. While the red colors indicate that the wind speed is the fastest speed of wind.

The figure below show that the indicators of wind speed:

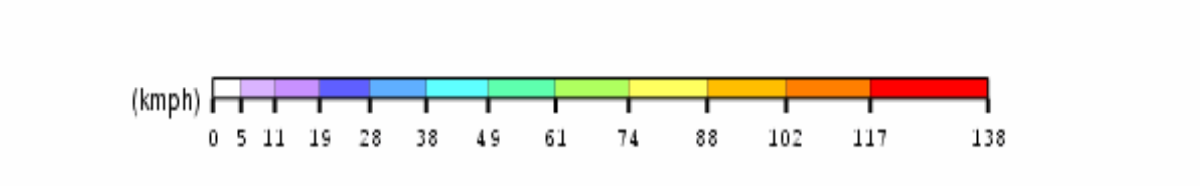


Figure 24: Color Indicator

When we refer to the wind speed map and the indicator, we can see that the wind speed at east cost of Malaysia is in range of 5 kmph until 11 kmph which is the light purple color. Therefore, we can say that the place which is situated at area of east cost is the most suitable place to implement this system.

4.3 Wind Statistic

After done the study case of the suitable places, wind statistic in certain places is very important. This is because based on the wind statistic result; we can observe the pattern of wind blow and the average speed so that we can use it to determine how much the electricity can be generated. In this case, we take three different cities in Malaysia which are Kuantan, Kota Bahru, and Sitiawan. The places are chosen based on geographical. Kuantan and Kota Bahru part of east coast area Malaysia while Sitiawan is part of west coast area. These stats are taken based on observation between in month of January 2008 until May 2010, daily from 7 am to 7 pm.

a) Kuantan

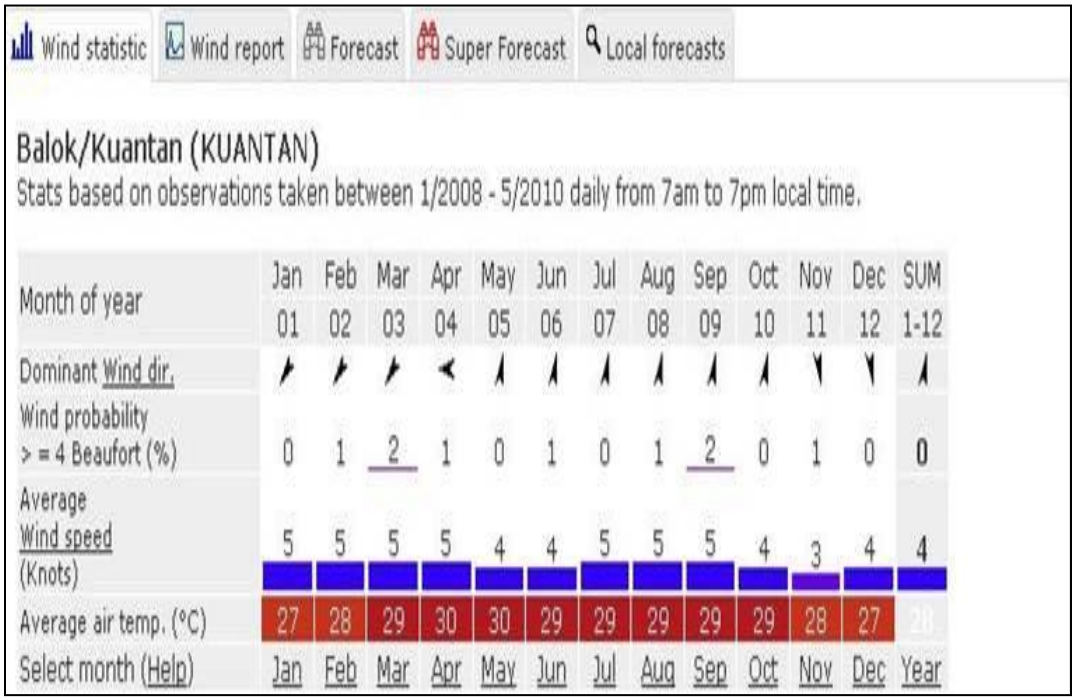


Figure 25: Average Wind Speed at Kuantan

b) Kota Bahru

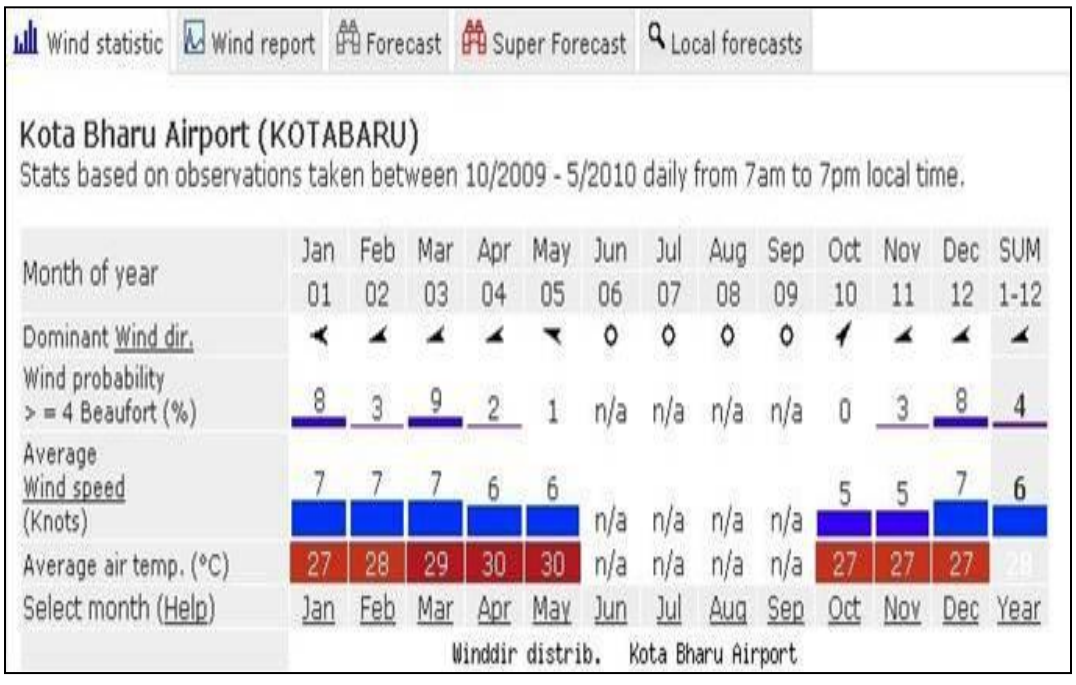


Figure 26: Average Wind Speed at Kota Bahru

c) Sitiawan

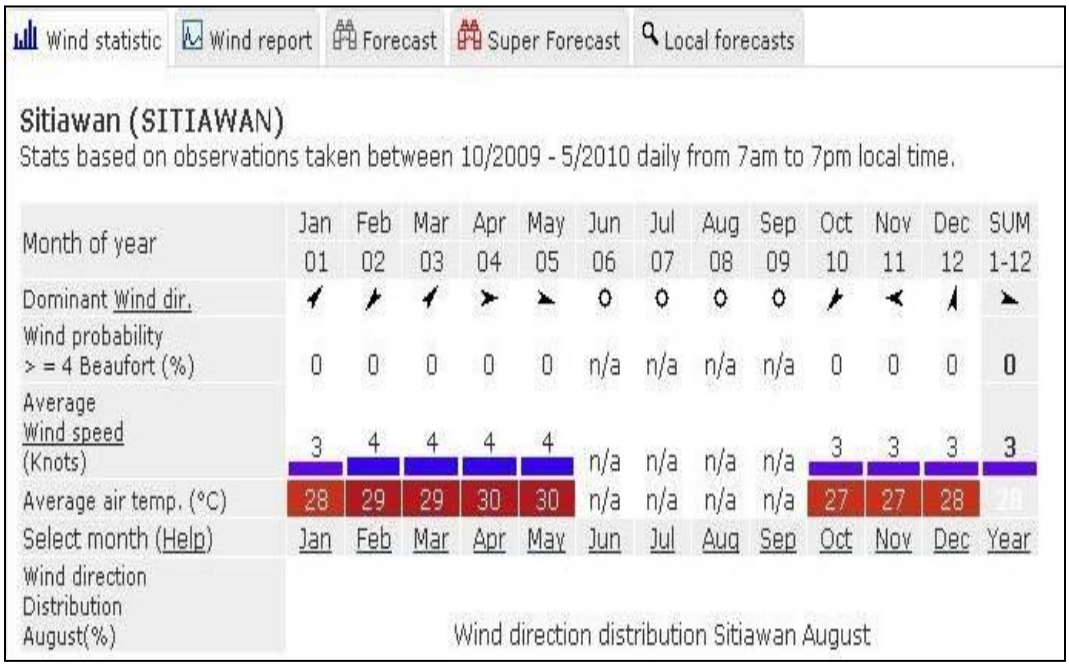


Figure 27: Average Wind Speed at Sitiawan

Based on these three wind statistic table, the average of wind speed at Kuantan city in Figure 25 is about 5 knots. In Kota Bahru city, the average of wind speed is about 7 knots based on Figure 26 while the average of wind speed in Sitiawan city is 4 knot based on Figure 27. The average of wind speed of each city is taken based on the highest wind speed from month of January until month of December. The average of wind speed will be used in the calculation of how much power can be produced.

Before do the calculation, the unit of wind speed must be converted from knots to meter per second. This is because, in the power calculation we used meter as a unit. Therefore:

Knot to meter/second unit conversion:-

- 1knots = 1.15 mile per hour
- (1mi/h) x (1hour/ 3600sec) x (1.61km/1mile) x (1000m/1km) = 0.45 m/s

Example:

10 knot x 1.15 mph = 11.5 mph

11.5 mph x 0.45 m/s = 5.175 m/s

4.4 Power

After done the conversion unit of wind speed, we will use the formula to calculate the wind speed which is from slowest to the highest speed. The range of the wind speed data can be used from 1 knot until 10 knot.

Kinetic energy per unit time or power:

$$P = (1/2)\ (\rho)\ (U^3)$$

ρ = density of air, 1.225 kg/m^3

U = air velocity

A = rotor disk of area, πr^2

The Table 2 below shows that all the result after calculation has been done. This calculation show how much power can be generated from different value of wind speed.

Table 2: Power Generated

$$P = (1/2)\,(\rho)\,(U^3)$$

Knot	Air velocity (m/s)	Power (W)
1	0.5144	1.6369
2	1.0289	13.0995
3	1.5433	44.2066
4	2.0577	104.7809
5	2.5722	204.6681
6	3.0866	353.6527
7	3.6011	561.6186
8	4.1155	838.3084
9	4.6300	1193.6554
10	5.1444	1637.3449

4.5 Inverter Output

In the electrical system, the inverter circuit is used to convert direct current (DC) at input to the alternating current (AC) at output. After done the fabrication of inverter circuit at project board, the circuit is tested and the output and input result is measured by using the multimeter. Since the dc generator still not fabricate yet, the input source is supplied by using the 12 volt battery lead acid as in Figure 28 to replace the dc generator.

Figure 28: 12V battery lead acid

Figure 29: Input Voltage

Since the battery has been used several times, the input not exceed 12 volt (see Figure 29). However, the circuit can still be run. Then the output voltage is also measured by using the multimeter at the transformer output (see Figure 30).

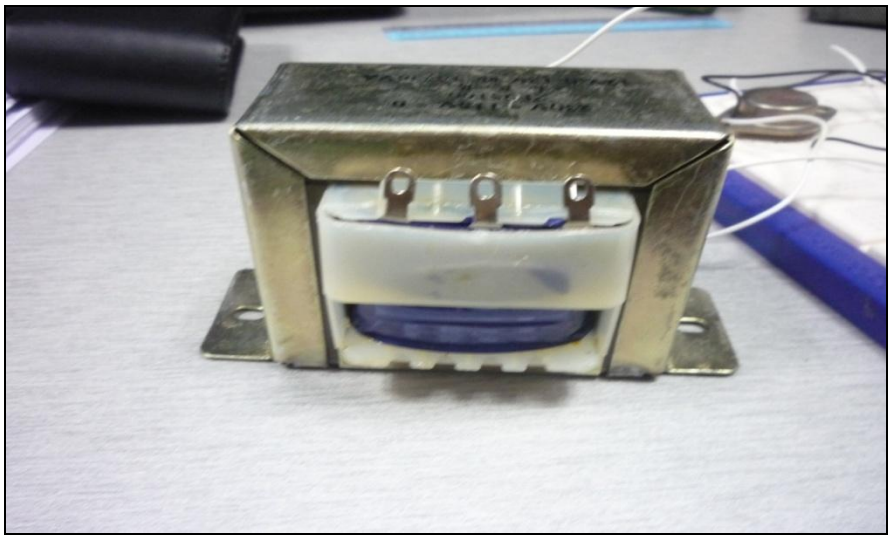


Figure 30: Transformer

At the output of transformer, the value of the output voltage is about 150 volt only (see Figure 31). Based on the theory of this circuit, the output voltage should be 220 volt. Therefore the values not exceed the value that we target. However, if we connected to the load, this value should support or can be used to switch on the electrical appliance such as lighting.

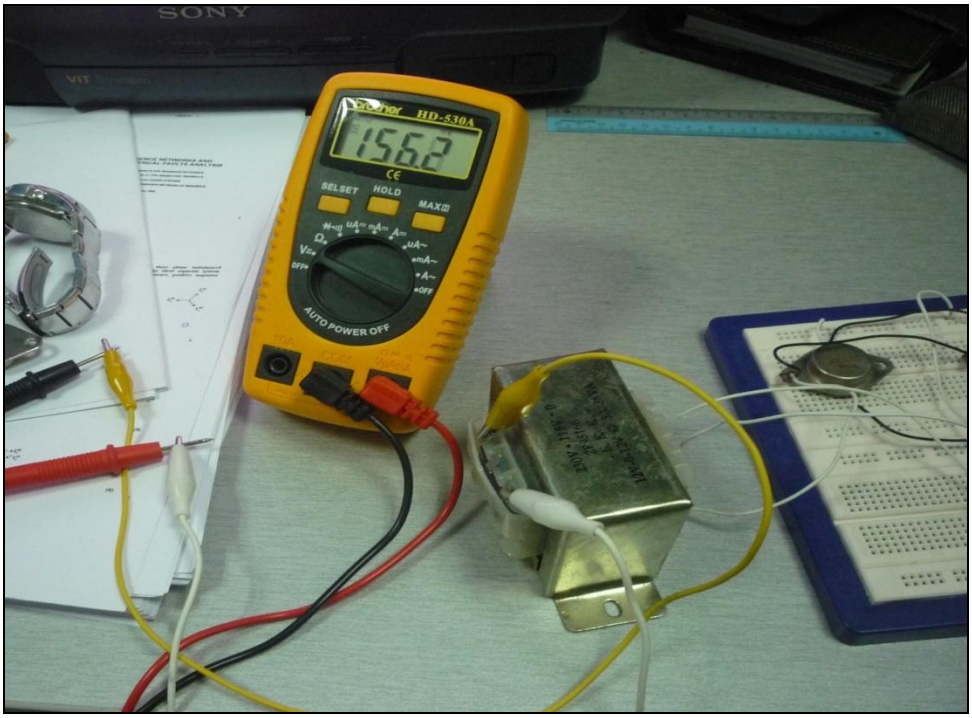


Figure 31: Output Voltage

4.6 12V Lead Acid Battery Monitor

The LM3914 is one of the integrated circuit which is built to sense analog voltage levels and also drives 10 LEDs. This integrated circuit providing linear analog display. This integrated circuit operates by a single pin change the display from the moving dot to a bar graph. The current that drive the LEDs in the integrated circuit is regulated and programmable which is eliminating the need for resistor. Figure 32 shows the configuration of the LM3914.

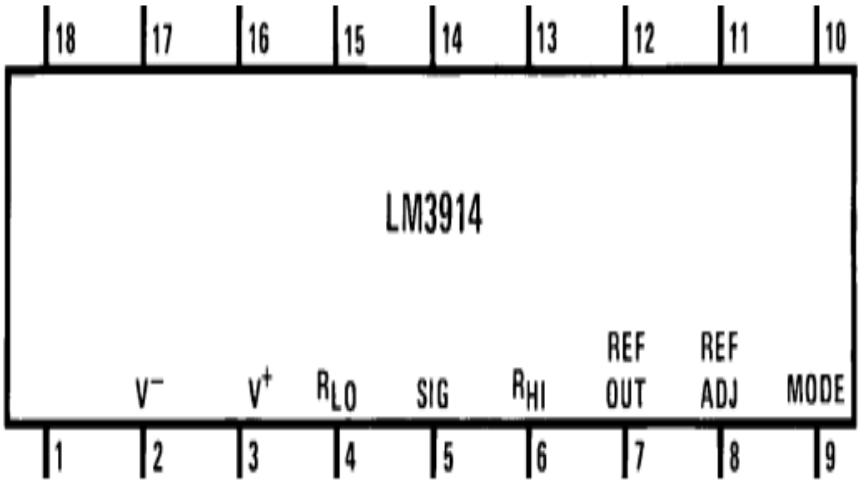


Figure 32: LM3194 configuration

Since the circuit need to be set first, the input of 12 volt is supplied form the DC generator as the source to replace the battery. Figure 33 show the DC generator that is used to test the circuit which the input is set to 12 volt.

Figure 33: DC generator with input 12 volt

The input voltage of 12 volt is connected to the positive and negative terminal. Figure 34 show the configuration of the circuit. Then, the 10K trimmer potentiometer need to be adjusted until Led 10 lights up. Figure 35 show the 10K trimmer that need to be adjusted to set the Led 10 light up. At this point, the circuit has been set when the battery is fully charged at 12 volt. The Led 10 wills lights up to show that the battery is fully charged. Figure 36 show the condition of the Led 10(green LED light up).In other cases when the voltage is lower, all other Led's lights up in sequence showing that the battery is discharging.

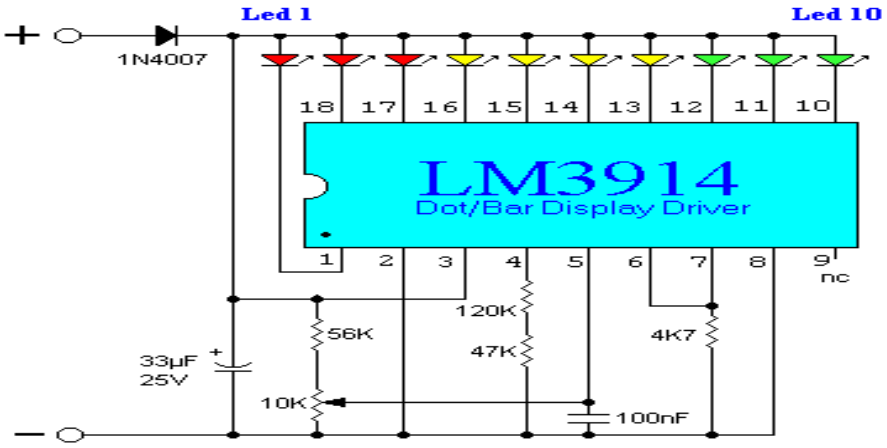


Figure 34: Battery monitor circuit

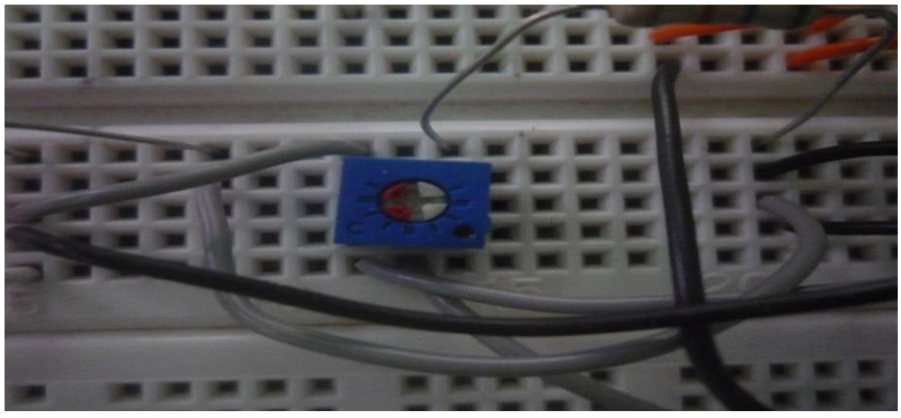


Figure 35: 10K trimmers

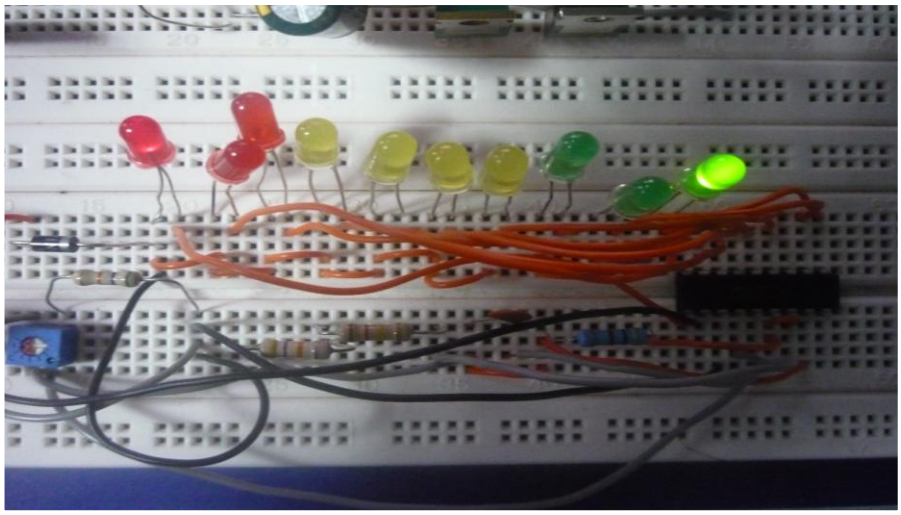


Figure 36: Led 10

Based on the circuit, the battery capacity can be divided into three parts. The green Led's indicates that the battery capacity is more than 50%. The second part is the yellow Led's show that the battery capacity is between ranges of 30% until 50%. Lastly the third part is the red Led's indicates that the battery capacity less than 30%. Since the circuit is set for DOT mode, only one Led at a time will be lit.

The LEDs will lights up based on the voltage of the battery. Meaning that at each LED the value of the voltage is different. The Led 10 only lights up when the battery capacity is 12 volt. When the battery capacity is below 10.6 volt, the battery capacity is considered empty and the battery needs to be charged. Table 3 below indicates the voltage at each Led have different level of voltage.

Table 3: Voltage at each LED

LED	Voltage
1(Red)	10.6
2(Red)	10.6
3(Red)	10.7
4(Yellow)	10.8
5(Yellow)	10.8
6(Yellow)	10.9
7(Yellow)	11.0
8(Green)	11.1
9(Green)	11.2
10(Green)	12.1

In the circuit, the diode 1N4007 is including at the positive of the terminal input. The function of the diode is to protect the circuit form a wrong polarity connection.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The purpose of small wind turbine is to bed use as an alternative to reduce our electricity bill. Nowadays, electricity bill always increases every year due to increasing cost fossil-fuel. From the project, the wind turbine that have radius blade of 5 meter can produce 1kW power. This power is potential to supply low power equipment at home such as lighting, radio equipment and others. Other than that, based on the wind speed map, we can conclude that the best place for implement this system is at the east coast area. A lot of experiment had been made to ensure that this system is stable and safe to be used. However, the inverter circuit shows a good result at the output part but it still not reached out target value. The calculation of power shows a good value of power generation. However this also depend the rating of the dc generator and the speed of wind. Hopefully, this invention can give new approach to solve problem in electricity usage.

5.2 Recommendation

The real input of wind turbine system can be obtained by using dc generator. Due to high cost of dc generator, the dc generator can be replaced by dc motor. The PVC pipe will be used as the blades for the wind turbine. The inverter circuits need to be adjusted to get higher output by changing other transformer with different rating or replace the resistor. In the 12 volt lead-acid battery monitor circuit, the LED brightness can be adjusted up and down by changing a different value for the 4.7K

ohm resistor that is connected at pin 6/7. Lastly, the charge controller will be added to the system.

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