Controller for Stand Alone Room Lighting Powered by Wind Energy

Mat Nizam Bin Mahmud
Faculty of Electrical Engineering
Universiti Teknologi MARA Malaysia
40450 Shah Alam, Selangor, Malaysia
E-mail: mtnizam@yahoo.com

Abstract- **The primary focus in this project is to design the suitable charge controller for prototype of stand-alone room lighting powered by wind energy. This controller design will provide the protection to the battery during the charging and discharging activities. This is due to battery charger have it limiter for upper and lower voltage. In other way, the indicator Led and charging status display is design to convenience for costumer to checking the status of the system. Apart from that, the controller design also provide the protection from the over speeding of wind turbine that produce over voltage. All those characteristics of controller are design to produce high efficiency controller and compatible with the battery charger design and wind turbine design.**

Keywords-Controller,Room ligting,Wind energy

I. INTRODUCTION

Renewable energy sources such as wind and solar energy for electric power supply has received considerable attention in recent years due to global environmental concerns associated with conventional generation and potential worldwide energy shortages. Many countries throughout the world are supplied with electrical energy produced by diesel generators. In many of these communities, the cost of energy is largely determined by the landed cost of the diesel fuel. So the solution to reduce the cost of energy has led to the investigation of the use of renewable energy sources, such as the nature wind around us, to replace some or all of the fuel consumed. The small wind turbines in conjunction with battery storage, can replace the electrical energy produced by diesel generators in stand-alone applications [1].

Therefore, it is about time that we take concrete steps to save power. Apart from being conscious about the usage of power, people can employ pollution-free and cost-effective power solutions at homes. Solar power solutions and wind power solutions are the two of the most efficient solutions that can replace the conventional power solutions employed at our homes. These solutions will help people combat power outages, reduce electricity bills, and also help the environment.

Therefore, the stand alone room lighting powered by wind energy should be applied that can provide a better renewable energy and high efficiency of using energy. This prototype use the other fan (ceiling fan or stand alone fan) as it source of wind and collect it to rotate the blade. The concept is to collect the free wind energy from home fan and convert it to the electrical energy by generating the DC generator. The main purpose of the controller in this prototype is to provide the protection to the battery during charging and discharging activities. Besides that, it will provide information to the user the current condition of the whole system.

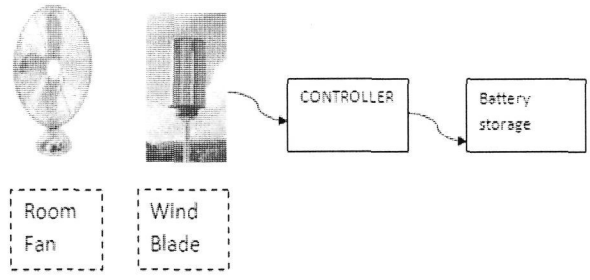

Figure 1. Flow stage of wind energy concept

The figure above shown the analogy of the stand alone room lighting powered by wind energy. The idea came by thinking to benefit the home fan and convert it to energy that can light up the lamp (LED lamp) in the room.

II. METHODOLOGY

This stand alone room lighting powered by the wind energy is divided into three main parts. These three parts consist of wind blade design with generator, controller, and battery energy storage. Each part should be design with suitable to the condition of home fan. Apart from that, it's also needs to be synchronizing and design with suitable to each other. This is very important to make sure there are matching to produce high efficiency and optimum power absorptions.

For the blade design the shape of Vertical axis wind turbine is chosen. Vertical axis wind turbine is a type of wind turbine that has its rotor shaft installed vertically and can therefore work even if the turbine is not directly

pointed to the wind. This ensures wind power even in areas where there is low wind speed. Vertical Axis Wind Turbines, more commonly referred to as VAWTs.

For the battery charger design Lead-acid batteries are chosen. Lead-acid batteries are in many cases the backbone behind alternative energy and related new technologies. For example, the lead-acid battery is a key component of solar energy, wind energy and hybrid cars. As storage batteries, lead-acid batteries are able to deliver a constant level of power to the electrical system. Without storage batteries an electrical system would be limited by the immediate output of the energy generators. So, wind-powered systems would be subject to constant power fluctuations as the wind speed increased, dropped or disappeared entirely [2].

Therefore, the energy made by the motion of the turning blades of a wind turbine can be stored in lead-acid batteries so that these wind systems can function consistently regardless of any changes in wind.

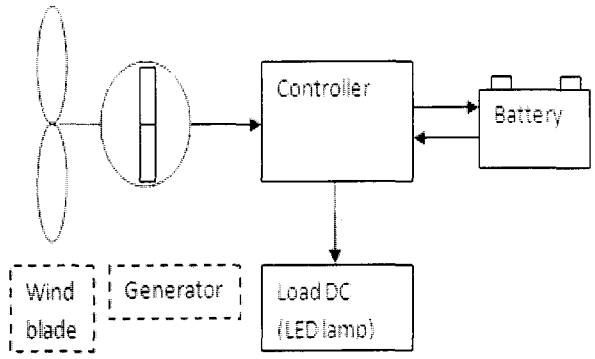

Figure 2. Basic blog diagram of Stand Alone Room Lighting

Finally, for this project purpose is the controller design that construct to constantly monitor the battery voltage. If that voltage approaches a set maximum (the *float voltage*) then the controller turns on an Alternative load or dummy load which dissipates excess power to prevent it from over-charging the batteries. Apart from that, the wind turbine controller must ensure that the wind turbine is constantly under load to prevent it from spinning out of control (*over speeding*) and being damaged in suddenly strong winds.

III. CONTROLLER SYSTEM

The controller system is very important in each generating system. To design the controller of the wind generator there are some condition should be consider before proceed with construction of the hardware. The problem should be consider is the wind blade will spinning at high speed that will generate a huge current spike, possibly destroying the controller and perhaps even the generator in the process [3]. The method that will solve with this main problem of wind generator will become the main method of construction the controller.

The ideal solution is to charge the batteries until they reach a full charge, then switch to an alternate load where the energy can be safely handled. The alternate load this energy should be used for some useful purpose, such as light bulbs or internal fan [4]. The condition to switch the alternate load is by using the voltage sensor (comparator) that connected directly to the battery that shown the status of the voltage left. After that, comparator is applied to decide whether to switch to an alternate load or charging.

Therefore, Controller system is very important to Wind turbine because it will provide the protection to the battery and will make the operation smooth. This controller design involved two parts which is software development and hardware construction. This controller is using the PIC16F877A microcontroller. A microcontroller (also microcomputer, MCU or μC) is a small computer on a single integrated circuit consisting internally of a relatively simple CPU, clock, timers, I/O ports, and memory [5]. The construction of hardware that using PIC was done on laboratory. Second part is involving of software design that is by developing the PIC programming using MPLAB software.

The concept of the voltage sensor is to compare analog input voltage to reference and output a digital result. When the analog input at Vin+ is greater than the analog input at Vin-, the output of the comparator Vout will be logic high. When Vin+ is less than Vin-, then Vout will be logic low [6].

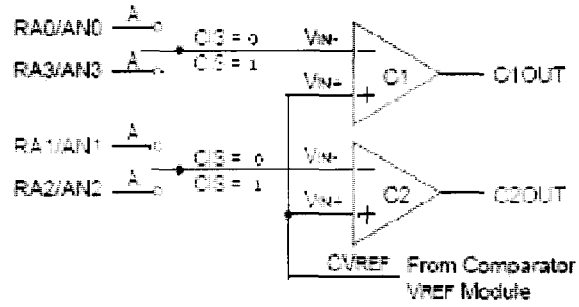

Figure 3. comparator

The figure above showed the two comparators in the microprocessor that available to read an analog value.

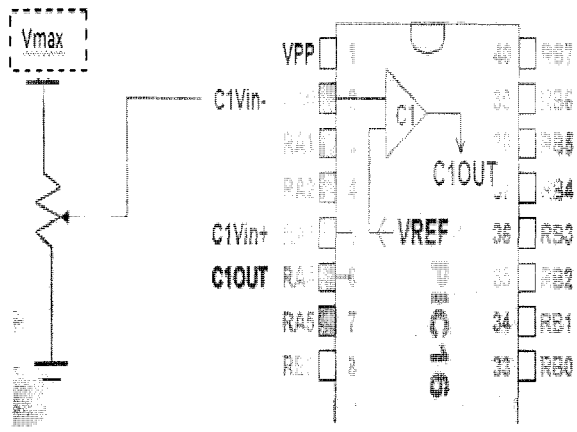

Figure 4. Potentiometer as the voltage sensor.

PIC16F877A microcontroller is provided two internal comparator that used as the voltage sensor for the controller. The two internal comparator is located at the RA0 and RA1. Both potentiometers are used on this controller. This is applied to detect two stage of voltage which is full charge and lower limit of the battery. The Indicators in the form of LED's is used in the three colours (red, Yellow and green).

The red colour is indicates that the battery level is lower and not enough to supply to the load. At this stage, the relay will cut out the supply from the battery to the load. This is to avoid the battery using the battery while it's in the lower condition. The green colour is indicates that the battery level is on charging and enough to supply to the load. The yellow colour is indicates that the battery level is full charge and enough to supply to the load. At this stage, the relay will switch from supply the source to the battery to the alternate load.

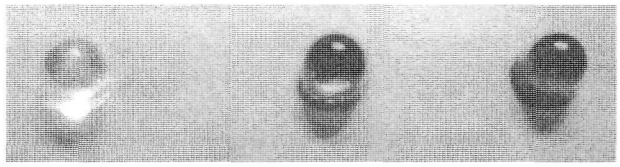

Figure 5. Figure of LED as indicator

This controller has provided an LCD display during it operation. This is for user information on the status of the battery. This LCD display will work same principle to the LED indictor. When the red LED light up the LCD will display 'LOWER VOLTAGE'. For green LED the LCD will display "ON CHARGING" and at Yellow led THE LCD will display "FULL CHARGE". This LCD will also display the voltage status of the battery. This will alert the user the condition of the whole system. The voltage value is setting to read at the port RA0 that directly read the value of the battery voltage.

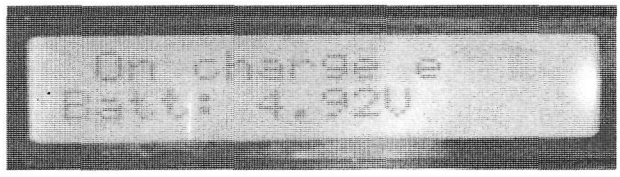

Figure 6. LCD display for system status

IV. PRINCIPLE OF OPERATION

The basic principle of the controller is shown in the figure 7. The potentiometer is set as the voltage sensor on this controller to read the voltage of the battery. Since, it read the battery voltage; it will determine the voltage level the battery is located. Then the PIC will send the signal that will inform the status of the whole system.

This controller is design that suitable for small application of the stored energy especially for this standalone room lighting powered by wind energy that protect the battery from overcharging and lower level of voltage. At the same time the controller will inform the user the status of system state.

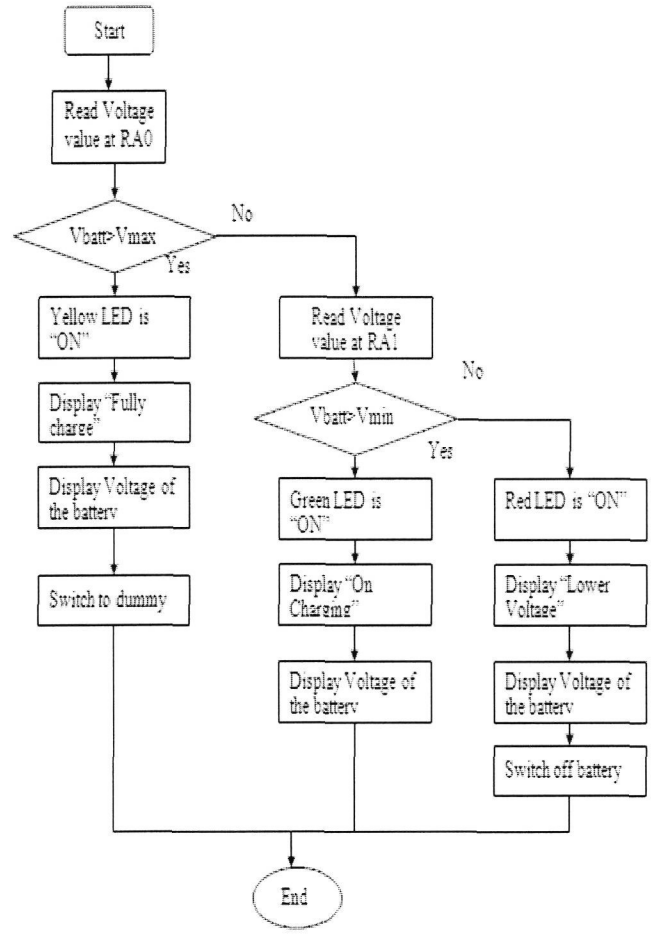

Figure 7. Operation system flow of the controller.

From above system both comparators is compare to each other, which is RA0 is setting as the maximum voltage value while RA1 is setting at the minimum voltage value. If the value read at RA0 is not satisfied then the microcontroller will read at the RA1. In other word if the battery is not fully charge yet, then the microcontroller will read at other level of voltage either level voltage on charging or in the lower state.

The switch in this controller is used relay to switch the flow of the wind energy supply. This switch is applied on the two conditions which is when the battery is fully charge and when the battery is in the lower state. The supply from the wind turbine will switch to alternative load when the state of the battery is fully charge and when there are overspending of the wind that produce higher voltage level that cannot be supported by the battery charging design. Besides that, when the battery not received any supply energy and deceasing in the level of voltage the relay that install at the load line will be disconnected to prevent the battery from being very low and will affect the performance of the battery. The function of a Led indicator is to alert the user the state of the system that can will give a signal to user what step should be taken in that state. The LCD also helps the user to take an action that gives the system information.

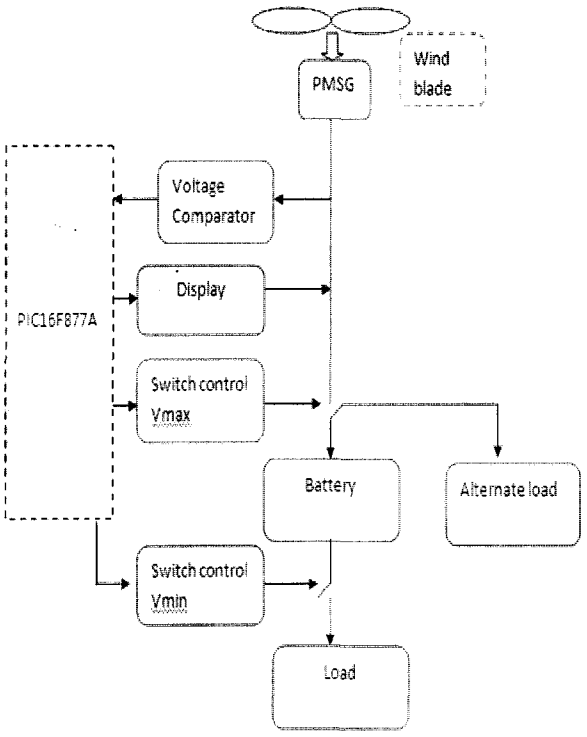

Figure 8. Controller blog diagram.

Figure 7 shown the blog diagram of the controller which is become a medium of from the supply to charge the battery. The microcontroller PIC16877A become a main center to make a decision of the charging and discharging activities of the battery that monitor the relay switch that connect the supply and the load.

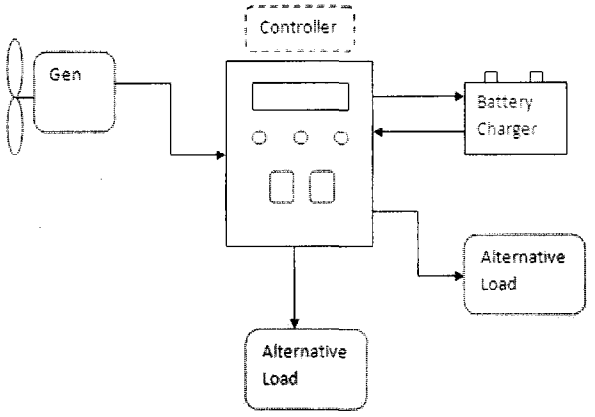

Figure 9. The integration of prototype

Finally, All part need to be integrate together to complete the system of the prototype. The system need to be setup correctly that refers to the planning of each part to make the prototype is synchronizing to each other while there in running blade. Wrong setup will cause the system will be collapse and not functioning well. From above figure it's clear that the controller becomes a medium to connect the generator and the battery storage to monitoring the system flow.

VI. RESULT AND DISCUSSION

After all the required part including hardware and software were completed, further testing was carried out. Then the hardware construction needs to integrate each other part. All the setting procedure must be done to make sure the system is smoothly operate.

First of all, The voltage reference of the controller is setting for maximum voltage and the minimum voltage limit depend on the battery used by adjusting the potentiometer and software programming to make sure the voltage sensor are operate as desire to the system as below:

a) Potentiometer1 (P1) is set at maximum= 6.37V

b) Potentiometer2 (P2) is set at minimum = 5.50V

The maximum setting point is because the maximum voltage of the battery can store (full charge is about 6% of the battery). Then minimum point is setting based on load design and the SOC (state of charge) of the battery and the load used (LED lamp). This setting value will be change accordingly to the desire condition. The battery use in the experiment is 6V Lead acid with eight blade Vertical axis wind turbine with the variation of speed of wind and gear ratio of 1:1.5.

The first step to testing the prototype is by choosing a two random stand alone fan that usually using in the room and choosing the different size of the room to conduct the experiment. The stand alone fan is chosen that will produce wind speed in the range of 5.5 m/s to 6.5m/s that will produce voltage in the range of approximately 5.4V to 6.4V. All the battery reading is taken directly from the controller LCD's display that provides overall system status.

Condition setting of the Controller

TABLE I. CONTROLLER SETTING

Voltage level setting	LED colour	Condition	Status
0- 5.5 V	RED	Lower battery level	Lower voltage state and supply to the load is disconnected
5.5 - 6.37V	GREEN	Stable battery condition	On charging state and is in the range stable to supply
6.37 V and above	YELLOW	Full charge	Fully charge and the supply from generator switch is turn to the alternative load

From the above table it shown that the level of the voltage sensor and it action taken by the controller to prevent the battery from overcharging and the condition of extremely discharge the battery energy. The controller also prevents the battery from sudden over speeding of the wind that produce voltage over the maximum voltage setting by cutting off the main supply to the alternating load that indicating by the yellow LED.

A. Experiment on room 1

For the first experiment one room is chosen with two difference type of room fan. This will produce six measurement of the wind variation. The room size chosen is 12'x6'x8'. The position of the wind turbine is set near to the room fan testing. The distance is about 0.5 meter. This experiment is conduct to find out the variation of difference wind speed produce by difference types of room fan.

Room Size : 12'x6'x8'
Blade : 8 blades (Vertical)
Position : 0.5 Meter
Battery type : Rechargeable battery Lead acid 6V

From the both type of the room fan testing, it can be simplified in one table within increase sequence in the speed of the wind. This purpose is to analyze the difference of the voltage produce by the variation of the wind produce.

TABLE II. ROOM FAN TESTING

Variation	Speed of Fan (m/s)	Output Voltage (V)	Output Voltage (V)
1	3.78	108.5	3.85
2	4.01	118.5	4.05
3	5.14	167.8	5.16
4	5.20	175.5	5.28
5	6.20	198.0	6.28
6	6.30	210.0	6.40

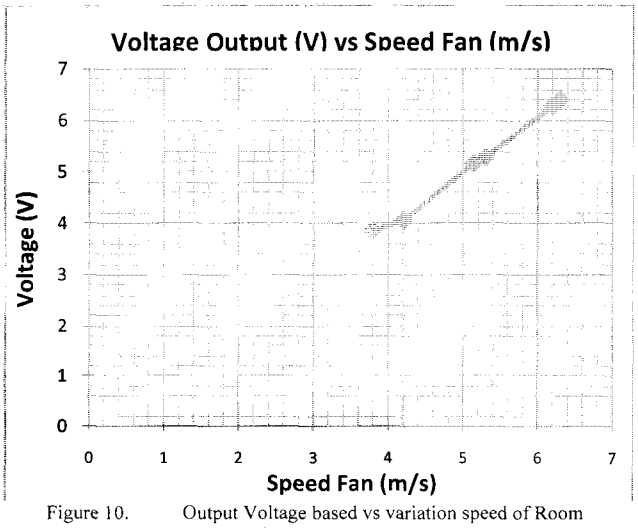

Figure 10. Output Voltage based vs variation speed of Room Fan selected.

The figure 10 above it shown that, if the speed of the room fan is increase, the voltage output will also increase. The speed of the room fan is directly proportional to the Voltage output of the generator. Then the experiment is proceeding with the choosing the higher speed of the speed to test the prototype. The condition chosen is with speed regulation produce 6.3 m/s and output voltage of 6.4V (maximum value). The voltage supply will be assumed supplying constant to measure how long it take time to charging. The purpose is to test the real room environment to get the real wind flow of the room fan. The starting charging battery voltage is 5.37V (20%)

TABLE III. EXPERIMENT ON SPEED REGULATION OF 6.3 m/s.

Time (Hr)	Generator Output Voltage (V)	Battery voltage (V)	Controller Status (LED Indicator)		
			Red	*Green*	*yellow*
0	6.40	5.37	1	0	0
0.5	6.40	5.54	1	0	0
1.0	6.40	5.66	0	1	0
1.5	6.40	5.81	0	1	0
2.0	6.40	5.94	0	1	0
2.5	6.40	6.10	0	1	0
3.0	6.40	6.24	0	1	0
3.5	6.40	6.37	0	0	1
4.0	6.40	6.37	0	0	1

The table is shown the testing the speed of 6.30 m/s produce by room fan to generate the energy. It takes approximately 3.5 hour to reach the maximum output voltage 6.37V. After that value the battery is not charging more. This is because the maximum voltage of the battery is set to 6.37V and can't be reaching to 6.4V. This level is maximum limit of the voltage that can be reaching. At the same time the Led indicator will display the status of the battery and system. The symbol '1' is signal as high and the LED is ON and '0' is low which is OFF state.

The red LED will turn on if battery voltage below 5.5V and green LED will turn on above 5.5V until reach 6.37V. For the above 6.37V the yellow LED will turn ON that signal the battery is in the full charge condition. The 6.37V is setting because this is safety limit of the voltage supply can charge the battery.

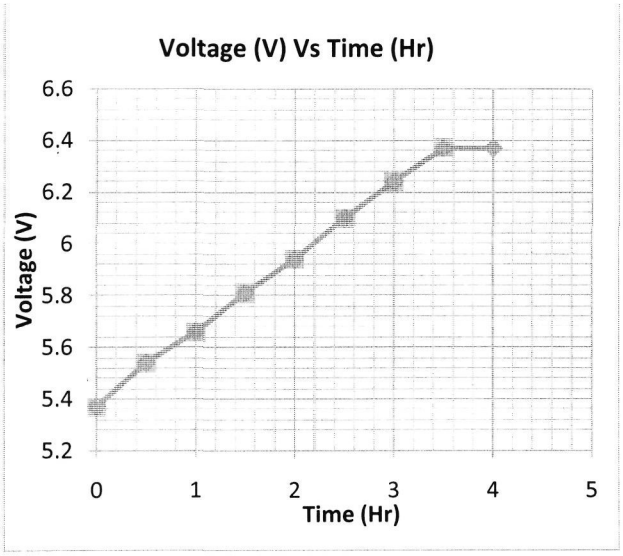

Figure 11. Output Voltage (V) Vs Time (Hr)

From the above figure the supply from the generator can reach for only approximately 6.37V and the battery charging will only can reach 6.37Vand after that start to saturate although the supply is still on. The flow will change to the dummy load due to full charge condition reach.

B. Experiment on room 2

For the second experiment the room size chosen is 20'x10'x8' with same type of the room fan type used in experiment A. The room sizes choose is bigger than the first experiment. The position of the wind turbine is set near to the room fan testing. The distance is about 0.5 meter.

Room Size : 20'x10'x8'
Blade : 8 blades (Vertical)
Position : 0.5 Meter
Battery type : Rechargeable battery Lead acid 6V

From the both type of the room fan testing, it can be simplified in one table within increase sequence in the speed of the wind. This purpose is to analyze the difference of the voltage produce by the generator to charge the battery.

TABLE IV. ROOM FAN TESTING

Variation	Speed of Fan (m/s)	Generator speed(rpm)	Output Voltage (V)
1	3.70	106.0	3.81
2	3.98	114.5	4.01
3	5.05	163.2	5.10
4	5.18	170.5	5.21
5	6.12	189.4	6.20
6	6.25	208.0	6.32

Table above shown the variation of the wind speed is compiling in the increase sequence of the speed variation.

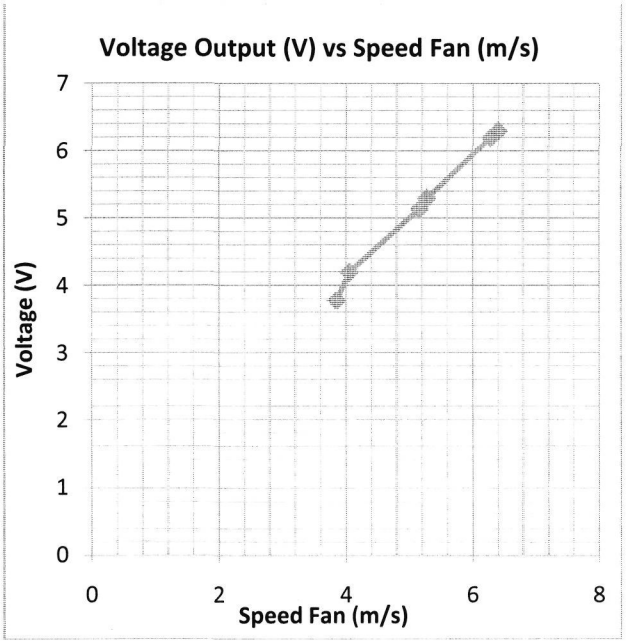

Figure 12. Output Voltage based on variation of Room Fan speed.

The figure 12 above it shown that, if the speed of the room fan is increase, the voltage output will also increase. The speed of the room fan is directly proportional to the Voltage output of the generator. From the table 4 all measurement of speed of fan, generator speed and output voltage are decreasing when the experiment are conducting in the second room which is bigger than first room. This is maybe due to the scattered of the wind. Besides that, in the small room the wind flow will be more converged compare to the bigger room. This condition lead to the all reading little bit change effected by the area of the room.

Then the experiment is proceeding with the choosing the higher speed of the fan speed to test the prototype as same as conduct in the experiment 1.the highest is speed regulation that produce 6.25 m/s and output voltage of 6.32V.

TABLE V. EXPERIMENT ON SPEED REGULATION OF 6.25m/s.

Time (Hr)	Generator Output Voltage (V)	Battery voltage (V)	Controller Status (LED Indicator)		
			Red	*Green*	*yellow*
0	6.32	5.38	1	0	0
0.5	6.32	5.50	0	1	0
1.0	6.32	5.62	0	1	0
1.5	6.32	5.74	0	1	0
2.0	6.32	5.86	0	1	0
2.5	6.32	5.98	0	1	0
3.0	6.32	6.10	0	1	0
3.5	6.32	6.28	0	1	0
4.0	6.32	6.36	0	1	0
4.5	6.32	6.37	0	0	1
5.0	6.32	6.37	0	0	1

The table is shown the testing the speed of 6.25 m/s produce by room fan to generate the energy. It takes approximately 4 hour to reach the maximum output voltage 6.37V (fully charge). This happen because the supply only reach 6.32V, above this rating the charging is become slow and take a time to fully charge.

From the table V, the red Led will turn on if battery voltage below 5.5V. When the Red LED is ON, automatically the battery supply to load is disconnect. Besides that, green LED will turn ON above 5.5V until reach 6.37V.This range of the battery supply is connected to the load. For the above 6.37V the yellow LED will turn ON that signal the battery is in the full charge condition. When the yellow LED is ON, automatically the supply is switch to the alternative load.

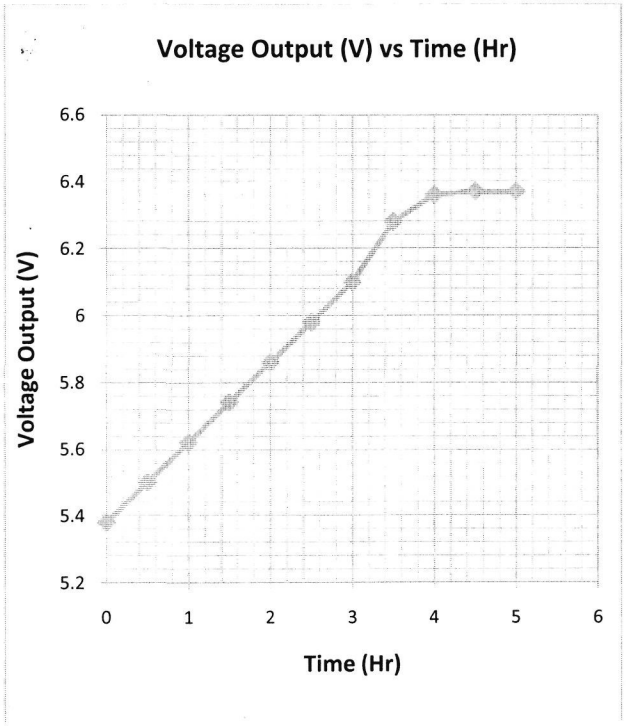

Figure 13. Output Voltage (V) Vs Time (Hr)

From the above figure the battery charging only can reach 6.37Vand after that start to saturate although the supply is still on. That take just take a delay time to fully charge compare to the first room voltage. This is happen because after voltage level reach 6.32V the charging activities is going slow due to level voltage charging must be above the battery voltage. If lower than the battery voltage the current charging going slow. The flow will switch to the dummy load after full charge condition reach.

From the both experiment conduct above, the cutting point of the full charge for this controller is at 6.37V and the wind speed is around 6.30 m/s. above this range the battery will not charge. So, if the over voltage due to the over speeding produce by the source fan or environment as suddenly happen the controller will switch off the supply from the charging activities. This is the safety purpose to make sure the battery is not damage due to the over voltage charging.

VII. CONCLUSION

In many areas of the country, renewable resources provide an opportunity to boost the local economy significantly. This prototype of the Room Lighting Powered by Wind Energy is one of the renewable resources that create to use the energy around us fully. This is one solution of efficiency of use the nature energy that converted into the electrical energy that supply to our home lighting.

By collecting the room stand alone fan wind of our house, this actually directly will save our bill and will use energy as free by use this prototype. This controller fulfil the requirement of this prototype by display the status of whole system and protect the battery from being damage and blow up by overs peeding wind and full charge state.This controller is very significant to provide the battery protection and it have done it work by make the lead acid battery battery to be long life and avoid from something bad during the charging and discharging activities.

Apart from that, the conditon of the environment should be consider for installation of the prototype. The size of room and the fan used is directly effect the prformnce of the energy capture by the wind blade.

VIII. RECOMMENDATION

There a lot of controller method that will be used to control the charging and discharging activities of the wind turbine generator. But the basic method of controlling the wind energy with variation speed is still the same. The other method that that can provide the fully use of energy whether it's over speeding wind is by controlling the level of supply voltage so that the voltage is still in the condition of charging [7]. This type of controller is constant voltage charging that control the input voltage produce by wind generator and stabilize the voltage for charging activities. This directly increases the efficiency of capture the energy.

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