HYBRID WIND AND SOLAR CHARGING CONTROLLER

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ABSTRACT

Environmental concern over the use of conventional sources has reached an alarming stage, thus alternatives sources is imminent. Renewable sources such as wind and solar has gain popularity and demand over the last decade. Power produced from these sources depends very much on the weather condition. Thus, combination of these sources had shown excellent potential as complementary option to generate power. This project will investigates the prototype combination of the solar and wind turbine charging system. The voltage generated from the PV and wind turbine will be recorded everyday and then is need to calculate the average power generated. The old data from the past experiment at Universiti Malaysia Pahang, Pekan will be use to make it as reference or comparison with new data. It is expected that new charging system is reliable and able to charge the battery at optimum power.

ABSTRAK

Kebimbangan alam sekitar ke atas penggunaan sumber konvensional telah mencapai tahap yang membimbangkan, maka alternatif sumber tidak dapat dielakkan. Sumber yang boleh diperbaharui seperti angin dan solar mempunyai populariti keuntungan dan permintaan ke atas dekad yang lalu. Kuasa yang dihasilkan daripada sumber-sumber ini banyak bergantung kepada keadaan cuaca. Oleh itu, kombinasi sumber-sumber ini telah menunjukkan potensi yang cemerlang sebagai pilihan pelengkap untuk menjana kuasa. Projek ini akan menyiasat kombinasi prototaip sistem turbin solar dan angin mengecas. Voltan yang dijana daripada PV dan turbin angin akan direkodkan setiap hari dan kemudian perlu untuk mengira kuasa purata yang dijana. Data yang lama daripada eksperimen yang lalu di Universiti Malaysia Pahang, Pekan akan gunakan untuk menjadikan ia sebagai rujukan atau perbandingan dengan data baru. Ia dijangka bahawa sistem pengecasan baru boleh dipercayai dan mampu mengecas bateri pada kuasa optimum.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Three decades ago, Malaysia energy policy has been focusing on oil, natural gas, hydro and coal. In millennium year 2000, renewable energy has been added into the energy policy as the fifth fuel. As of today, Malaysia government has introduced the National Green Technology Policy into the 10th Malaysia Plan to preserve the Malaysian environment and the future of the country power generation. Besides that, the government has introduced incentives to promote and encourage people in utilizing renewable energy at commercial level as well as residential. These benefits include providing investment allowance and exemption of tax. Recently, the country effort has taken a step closer in order to achieve its national objectives. Malaysia will be building its first carbon neutral city and also will invest in carbon mitigation projects under Kyoto Protocol's Clean Development Mechanism. This has further strengthened Malaysia need for renewable energy [1].

Among renewable energy, photovoltaic cells and wind turbines are indeed the most popular, both featuring no pollution and being advantaged by a large availability of an inexpensive primary energy. In China, this wind and solar hybrid power system is already practice while in Xcalak, Quintana Roo, Mexico has been implement since May

1992. The application of wind-solar hybrid generation systems can reduce the capacity of batteries and the total cost of the system compared with stand-alone PV or wind generation systems. The wind undoubtedly is the more affected by variability, although, also photovoltaic plants are heavily influenced by weather conditions, moreover featuring a limited period of operation over the day. Therefore, both photovoltaic arrays and wind turbines working alone cannot ensure the minimum level of power continuity required to supply in island mode a generic set of residential loads [2].

In this project, the controller for the combination of the wind turbine and solar PV array will be designed. The hybrid controller will collect the power from the both wind turbine and solar PV array and stored on to the battery. For this control charging system, the PIC (Peripheral Interfacing Connector) will be used to display the voltage during the charging process. The voltage generated from the PV and wind turbine will be recorded everyday and then is need to calculate the average power generated. The old data from the past experiment at Universiti Malaysia Pahang, Pekan will be use to make it as reference or comparison with new data. It is expected that new charging system is reliable and able to charge the battery at optimum power.

For example in Malaysia, this wind and solar hybrid power system is very suitable to be practice. This is because the condition of the Malaysia is on the equatorial line. So, Malaysia have same time of the night and daylight and suitable for installation of the solar power system. In addition, Malaysia has a long area of beach and many number of island. The condition of the beach and island that always windy are very suitable for installation of the wind turbine. So, renewable energy like wind and solar hybrid power system is exactly suitable in Malaysia.

1.1 Problem Statements

Raw materials such as natural gas and diesel that has been used to produce electricity is decreasing. For example today, mostly power plant use raw material such as natural gas to operate their power plant. And the world has already known that raw material is become decreasing every day. So, with this hybrid solar-wind can solve this problem.

The combination of wind turbine and solar PV array is more reliable and cheap if compare with stand-alone wind turbine or stand-alone PV array. The word reliable here means that if customers want the electricity at 2 a.m. for sure they can get it.

Output that generate from wind turbine and solar PV array is variable. For example wind turbine. The output from wind turbine based on the wind speed. High wind speed, more power will be generated. Same goes like solar PV array. The outputs depend on the concentration of the sun.

This hybrid solar and wind turbine has a good level in power continuity and very suitable to applied in Malaysia. This is because the weather at Malaysian and geographical location is on the equatorial line. So, Malaysian have a same time of night and daylight. In addition, Malaysian also have a long area of beach and the condition at beach that always windy are good for wind turbine installation. So, this combination of wind and solar is exactly suitable in Malaysian.

1.2 Research Objective

i. To design and develop the controller for the combination of the wind turbine and solar PV array.
ii. To select the suitable battery for the storage system.

1.3 Expected Result

The new charging circuit for hybrid wind turbine and solar PV array will be able to charge battery wherever there is a sufficient wind to move the wind turbine or sufficient sunlight for PV to generate the energy.

1.4 Scope of Research

i. Controller is designed based on wind turbine and solar PV array that available in FKEE.
ii. Use battery that available.

1.5 Thesis outline

The thesis is orderly organized into 5 chapter and they are outline as below.

Chapter one explains the objective of hybrid wind and solar charging controller, research objective, expected result, scope of research, and thesis outline.

Chapter two describe the architecture of the hybrid system, IC 555, stand-alone hybrid generation of wind turbine and solar, peripheral interface controller, lead acid battery, and charge controller of hybrid.

Chapter three describe the operation of the charging controller that will be used, solar panel, wind turbine, and the battery that will be used.

Chapter four shows the result and discussion from simulation and hardware.

Lastly, **chapter six** summarizes the overall conclusion for this thesis and a few recommendations for future development.

1.6 Conclusion

As a conclusion, in this chapter the research objective, project scope, expected result, thesis outline and scope of research has been state clearly. For the next chapter, literature review will be study to gain more knowledge.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In the previous chapter, the objective of this project was explained briefly. In this chapter, more literature review and journal will be read to gain more knowledge about this project.

A photovoltaic system (or PV system) is a system which uses one or more solar panels to convert sunlight into electricity or a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. It consists of multiple components, including the photovoltaic modules, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output. The performance of a solar PV array is powerfully relying on operating conditions, like the sun's geometric location, the ambient temperature and its irradiation levels of the sun Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Materials presently used for photovoltaic include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide.

A wind turbine is a device that converts kinetic energy from the wind into mechanical energy. If the mechanical energy is used to produce electricity, the device may be called a wind generator or wind charger. If the mechanical energy is used to drive machinery, such as for grinding grain or pumping water, the device is called a windmill or wind pump. Developed for over a millennium, today's wind turbines are manufactured in a range of vertical and horizontal axis types. The smallest turbines are used for applications such as battery charging or auxiliary power on sailing boats; while large grid-connected arrays of turbines are becoming an increasingly large source of commercial electric power.

Solar PV panels, wind turbine and batteries can be most effective when they work together in a hybrid power system. Wind and solar energy also have very strong complementarities. Wind turbine generator, solar cells and storage battery can raise power supply reliability and reduce the system cost. For hybrid wind turbine and solar PV array, batteries have functions of electrical energy storage and adjustment. If electrical energy is excess from wind turbine generator and photovoltaic array, the battery save energy. When the system generated energy is insufficient, and power consumption is increased, the loads is supplied for energy by the battery. The battery run in discharge state.

A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may prevent against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining ("deep discharging") a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. The terms "charge controller" or "charge regulator" may refer to either a stand-alone device, or to control circuitry integrated within a battery pack, battery-powered device, or battery recharger. A series charge controller or series regulator disables further current flow into batteries when they are full. A shunt charge controller or shunt regulator diverts excess electricity to an auxiliary or "shunt" load, such as an electric water heater, when batteries are full [3]. Charge controllers may also monitor battery temperature to prevent overheating. Some charge controller systems also display data, transmit data to remote displays, and data logging to track electric flow over time [4].

2.1 A stand-alone hybrid generation system combining solar photovoltaic and wind turbine with simple maximum power point tracking control

According to this journal by Nabil A. Ahmed and Masafumi Miyatake from Sophia University, Tokyo, Japan, the wind and PV are used as main energy sources, while the battery is used as back-up energy source. Two individual dc-dc boost converters are used to control the power flow to the load.

Refer to the figure 2.1, two energy sources are connected in parallel to a common dc bus line through their individual dc-dc converters. The diode D1 and D2 allow only unidirectional current flow from the source to the dc bus line, thus keeping each source from acting as a load on each other or on the battery. Therefore in the event of malfunctioning of any of the energy sources, the respective diode will automatically disconnected that source from the system [5].

A battery charger is used to keep the battery fully charged at a constant dc bus line voltage. All this things will be applied at hybrid panel at the FKEE lab.

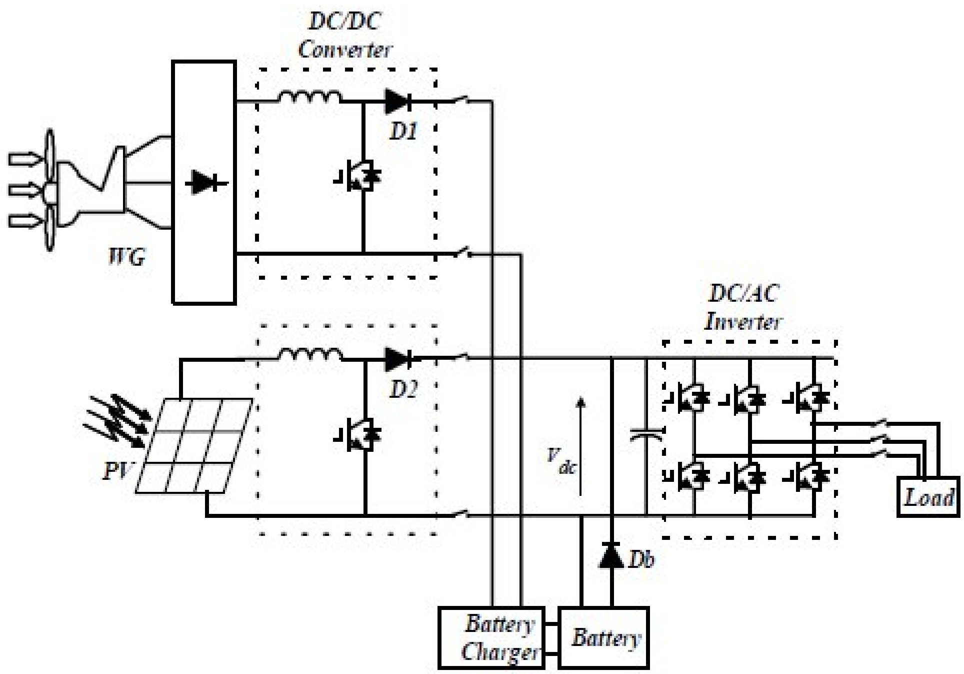

Figure 2.1: Diagram of the hybrid wind and solar.

2.1.1 Wind Turbine

Wind power is generated by capturing the kinetic energy of wind and converting it into electrical energy by a turbine. Wind turbine has two types, the first type is Vertical-axis wind turbine and the second type is Horizontal-axis wind turbine. Any wind turbine used has three essential function part that is rotor blades, shaft, and a generator. The rotor blades capture kinetic energy of the wind and transform it to shaft rotational energy. The shaft in turn channelizes the energy to the generator. Finally, the generator will produce the electricity.

The power output of a wind turbine is not steady. The voltage and current levels produced directly by the wind turbine vary with the speed of the wind driving it. Therefore, the wind turbine alone is not dependable as the primary source of power for most applications. In most residential applications, the output of the wind turbine is either used to charge a bank of storage batteries or it is applied to the commercial power grid to supplement the incoming to the residential.

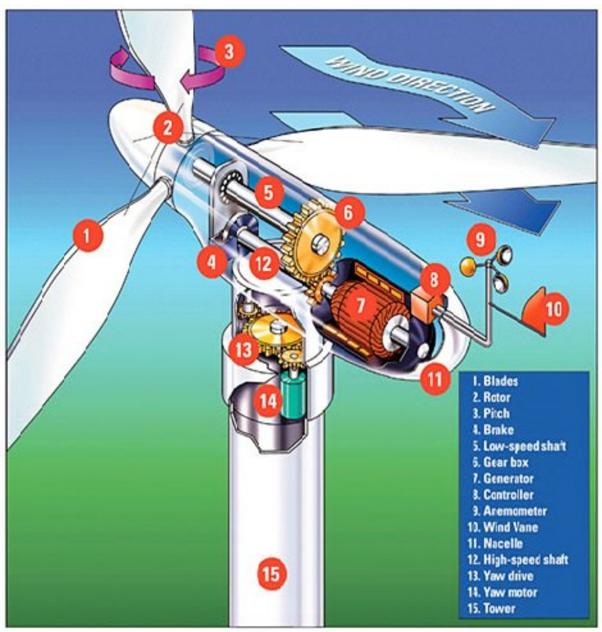

Figure 2.2: Diagram of the wind turbine.

2.1.2 Solar Photovoltaic

Photovoltaic (PV) power systems convert sunlight directly into electricity. A residential PV power system enables a homeowner to generate some or all of their daily electrical energy demand on their own roof, exchanging daytime excess power for future energy needs. The house remains connected to the electric utility at all times, so any power needed above what the solar system can produce is simply drawn from the utility. PV systems can also include battery backup or uninterruptible power supply (UPS) capability to operate selected circuits in the residence for hours or days during a utility outage.

Photovoltaic systems are solar energy systems that produce electricity directly from sunlight. PV systems provide clean, reliable energy without consuming fossil fuels. They are much safer and more environment friendly than conventional sources of energy production. The availability of solar energy varies because of the day night cycle and seasonally, because of the earth's orbit around the sun. Consequently, the energy collected when the sun is shining must be stored for use in periods when it is unavailable. Thus there is need for energy storage in a standalone off-grid PV system. As the energy storage device batteries are used, they play a major role in PV systems. System loads can be powered from the batteries during the day or night, continuously or intermittently, regardless of weather conditions.

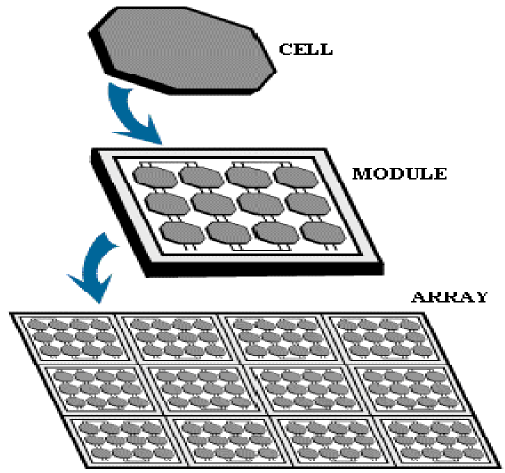

Figure 2.3: PV module.

2.2 Charge controller for hybrid wind turbine and solar PV array

The main part in this circuit is IC555. The 555 timer IC is an integrated circuit (chip) used in a variety of timer, pulse generation and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element [6]. The 555 timer is a device that allows you to provide a timing signal to a controlled circuit. You provide an RC or other type of tuneable circuit. Once triggered, the 555 will provide an output of a set duration. It uses a threshold pin that is typically connected to an RC circuit. Depending on how it is connected, it can operate in one shot mode (monostable), astable mode (retriggerable), or schmitt trigger mode. In its internal circuitry there are 3 resistors each valued 5 k ohm. Derivatives provide up to four timing circuits in one package.

Oscillation is the repetitive variation, typically in time, of some measure about a central value (often a point of equilibrium) or between two or more different states.

Familiar examples include a swinging pendulum and AC power. A flip-flop or latch is a circuit that has two stable states and can be used to store state information. The circuit can be made to change state by signals applied to one or more control inputs and will have one or two outputs. It is the basic storage element in sequential logic. Flip-flops and latches are a fundamental building block of digital electronics systems used in computers, communications, and many other types of systems.

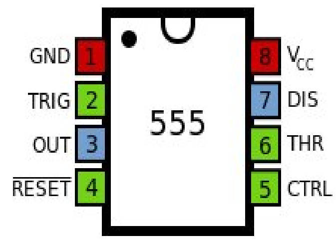

Figure 2.4: Integrated Circuit 555.

Table 2.1: Connection pin for IC 555.

Pin	Name	Purpose
1	GND	Ground, low level (0 V)
2	TRIG	OUT rises, and interval starts, when this input falls below 1/3 V_{CC}.
3	OUT	This output is driven to +V_{CC} or GND.
4	RESET	A timing interval may be interrupted by driving this input to GND.
5	CTRL	"Control" access to the internal voltage divider (by default, 2/3 V_{CC}).
6	THR	The interval ends when the voltage at THR is greater than at CTRL.
7	DIS	Open collector output; may discharge a capacitor between intervals
8	$V+$, V_{CC}	Positive supply voltage is usually between 3 and 15 V.

2.3 Pin definition of IC 555

Pin number one is ground**.** This pin is connected to the common (or negative pole of power supply). No need for further explanation.

Pin number eight is Vcc or power supple. On this pin the power supply for the operation of the 555 is connected. The power supply can be from 5V to 15V (4.5 - 16) and for some military designed packages could go up to 18V. There is not a big difference in timing operation of the 555 by changing the supply voltage, not more than 0.1% per volts which is considered to be stable enough. Actually, the only thing that significantly changes is the output supply capability in terms of voltage and current.

Pin number three is output. This is the primary output of the 555. It is able to provide up to 1.7V lower than Vcc, about 3.3Volts for 5Vcc and 13.3 for 15Vcc. The output saturation levels depends on the Vcc. Typically, at Vcc=5V the low state is 0.25V at 5mA and could sink up to 200mA when Vcc=15V and an output low voltage of 2V is allowable.

The output is comes from Darlington transistors, providing high state output voltages with good noise margin, able to interface directly with logic circuits. Rise and fall times are typically as fast as 100nSec.

Pin number two is trigger**.** This pin is the input to the lower comparator. It is used to control the latch that will set the output to high state. This triggering is done when the pin voltage is taken from above to below the one third (1/3) of the voltage level, that could be 1/2 of the voltage appeared at pin 5. A trigger could be accomplished from a slow ROC (rate of changing) waveform or even from pulses, due to the fact that the input is level sensitive. The allowable voltage range for triggering is between +V and ground. The current needed is typically 500nA. Two precautions should be taken in account. First, the period of the trigger input signal should not remain lower than 1/3 of the Vcc for longer than the time cycle. In this case, the timer will re-trigger upon termination of the first output pulse. In monostable mode, the input trigger should be effectively shortened by differention. The minimum allowable pulse with for triggering is somewhat dependent upon pulse level, but in general, greater than 1μSec is reliable. A second precaution that should be taken into account is the storage time in the lower comparator. This portion of the circuit can exhibit normal turn-off delays of several μSecs after triggering. The latch may still have a trigger input for this period of time after the trigger pulse. In this case, the minimum monostable output pulse width should be in the order of 10μSec to prevent possible re-triggering.

Pin number five is control voltage**.** By this pin someone can gain access to the 2/3 of the Vcc on the voltage-divider point. That is the reference point of the upper comparator, and an indirect access to the lower comparator reference. When this pin is connected to an external voltage, the 555 operates in voltage-controlled. When in this mode, the voltage control ranges from 1V bellow the Vcc down to 2Volts above ground. Voltages outside those limits can be safely applied but with not a reliable operation. This pin expands the uses of the chip. In monostable mode, When external power is connected, the timing of the device can be altered with no respect to the RC timing circuit, and the control voltage may vary from 45% to 90% of Vcc. In astable mode, applying voltage to that pin will make it act as a Frequency Modulator (FM). This pin in basic wiring is not needed to be connected, instead a capacitor around 10nF is connected from this pin to the ground to reduce any parasitic noise. The capacitor can be omitted but is highly recommended to avoid false triggers.