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Solar Powered Boat

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Abstract

After decades of human growth and activities, the earth's natural resources began to deplete. Fishermen in urban area sometimes have trouble with the increasing cost of fuel. The route and course for fishing boats are set before they went out to the sea. However, the boats have their limits. They have their extra diesel fuel in storage for an unexpected journey but still the fuel will run out. In this paper, the solar powered boat is developed by considering the solar panel to harvest the solar energy and converted into electrical energy to power up motors and stored in a battery. Moreover, the solar powered boat also implies the usage of sun tracking system which is used to maximize the solar harvesting process. This solar powered boat system sole purpose is to reduce the pollution that is caused by the usage of internal combustion engines such as the diesel engine and petrol engine. The system uses Arduino UNO as a microcontroller to control the system and the movement of servo motor for the sun tracking system. Furthermore, the boat also can be used for night activity such as the squid jigging. The squid jigging process uses power from the storage from the battery and saves energy because the power consumption is reduced with low speed motor for squid jigging. At the end of the study the solar powered boat system is successfully developed and the 0.9 W solar panel is able to generate 3.7 V in 2.5 hours under the direct sunlight which is sufficient for this prototype to be operated. Other than that, the cost of fuel consumption also reduced by the application of solar energy system.

Keywords: *Solar panel, solar boat, sun tracking system, renewable energy, light dependent resistor.*

1. Introduction

Solar power is one of the great solutions to save the fuel cost [1] and has less effect on the environmental health [2]. A boat that is powered by solar energy requires a lot of aspects to be covered such as the speed and torque of the electric motor used, the energy efficiency, energy consumption, the capacity of energy stored and also the design of the boat.

In addition, the electric boat also concedes the environmental health because of their low emission and high efficiency which is stated by Han *et al*. in 2014 [3]. The solar boat system also plays an important role in reducing energy waste and maximizing the energy output. It can be

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done with the system working together with a few devices that can monitor the ambient light intensity for maximum solar energy harvest process. The solar power is harvested through the solar panel and then being stored in a battery that can occupy large capacity of electricity for long period of usage and for perhaps replacing the diesel-based engine. The invention of the light intensity sensor or Light Dependent Resistor (LDR) or photoresist or also contributes to the ease of human activity. The LDR will be able to send signal and provide protection for the solar panel against harmful and harsh environment by allocating the solar panel in the storage compartment on the boat with the help of motors. The rotation of the solar panel is actuated by the light intensity sensor.

Other than that, the boat is also available for night activity and used for night fishing such as squid jigging because of the additional electrical energy from the battery. At night, the LDR will detect low light intensity and initiate the squid jigging process by turning up the Light-Emitting Diode (LED) which attracts squids [4] and restrict the speed of motor for increasing the efficiency of energy consumption.

2. Experimental Set Up

The whole process is described in Fig 1. It is started by switching ON the main system. Then, the system will be on standby mode. The first step describes that the LDR 1 detects the presence of light in the surrounding. If there is no light detected, the system will stay in standby mode. If the LDR 1 detects light, the solar panel will be rotated. Then, the solar panel will start the charging process and stored via the battery. The next step involves the sun tracking process. The actuators for this process are the LDR 1 and LDR 2. The LDRs detects light and will have low resistance when light falls on it. The rotation and tilting of the solar panels depend on which LDR have the lower resistance and thus, it will keep in track of the source of the light. If both LDRs do not have any difference in resistance, the solar panel will stay stationary. When the LDR 1 and LDR 2 do not detect any light present in the surrounding, the Liquid Crystal Display (LCD) will print out night mode as a sign of night-time. As the readings on the both LDRS are low, the LED will light up to attract squids for squid jigging process.

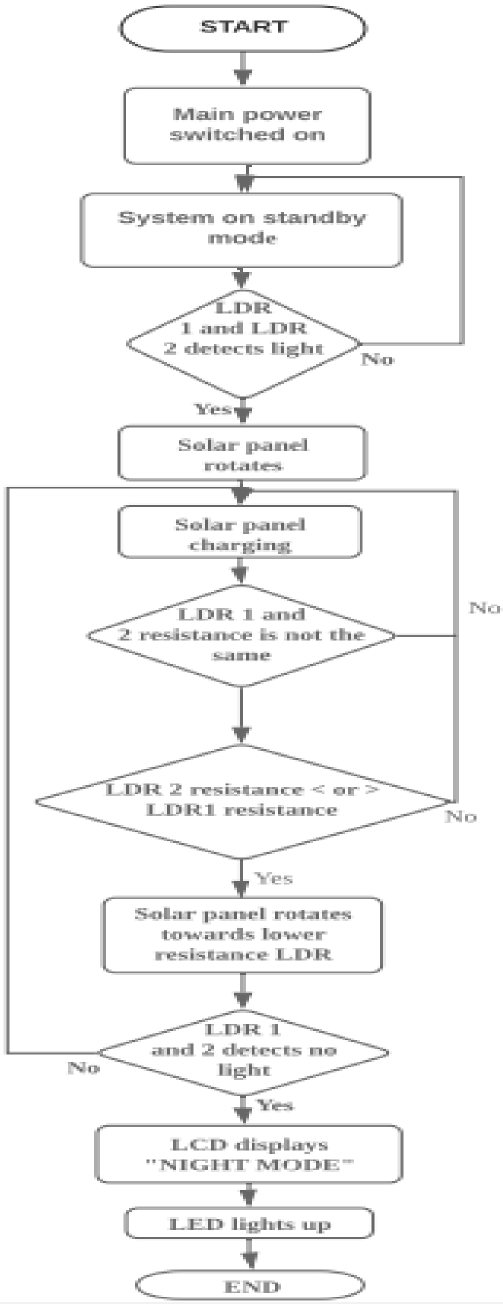

Figure 1: Process flowchart of Solar Powered Boat

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Mechanical Implementation

This project emphasizes on charging system from the solar power harvested by the solar panel though a few components. Fig 2 exhibits the concept of solar powered boat working principle.

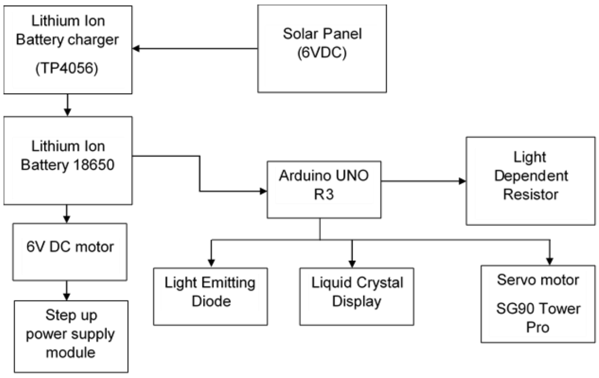

Figure 2: Concept and working design of Solar Power Boat system

The main supply of the system is the 0.9 W of solar panel which has the ability to generate total 6V DC and the energy will be stored into a Lithium-ion 18650 battery. The charging of the battery is supported with the presence of Lithium battery charger module (TP 4056) with a few other electrical components such as resistors, transistors and diodes to protect circuit from overflow of voltage. The status of the battery is presented by the LCD battery status. Then, the power from the solar panel is also channeled to the Arduino UNO as the main brain of the system. The Arduino then controls the circuit and other devices such as the motors and LEDs along with the user interface system. However, the charging system is not controlled by the Arduino UNO. The operation of motor is aided by the Arduino Motor Drive Shield (L293D) that controls the propulsion system and also sun tracking system.

The rotation of solar panel is actuated by two LDR which is LDR 2 and LDR 3. The low resistance of one of the LDR will actuates the direction of the rotation.

Electrical Implementation

The project is running on two controllers which are the Arduino UNO and the Arduino motor driver shield L293D. Arduino UNO runs with the supply of 5 V while the motor driver shield unit runs at 4.5 V. SIM1 acts as the main processing controller and all the other components are connected through it. Meanwhile, the L293D motor driver shield aids the operation of motor in the system which is the driver for motor for propulsion purpose and tilting and rotating of solar panel. Other components besides L293D motor driver shield that connects to the Arduino board are LCD, LED, transistor, LDR and resistor. The data logging process is also done through the Arduino which involves the connection between time and voltage. The data is obtained through time taken to charge the battery which is measured in voltage and seconds.

Light Dependent Resistor

A component that has a variable of resistance that changes with the light intensity that falls upon it is the LDR. With this feature, it allows LDR to be used in light sensing circuits. The most general type of LDR has a resistance that falls with an increase in the light intensity falling on the device. Typically, the LDR has resistance of certain values for night and day light intensity. The sun tracking application is been used for this project because of the ability of the LDR to detect presence of light which is then commenced by the movement of the solar panel.

LED and LCD

Light is created from LED which uses semiconductor and electroluminescence. The light emitting diodes are divided into two major kinds which are LED and OLED. The semiconductor crystal with reflectors and other parts are used to make light brighter and focused for LED. Typical LED applications include indication lights on devices, small and large lamps, large video screens and signs. In this

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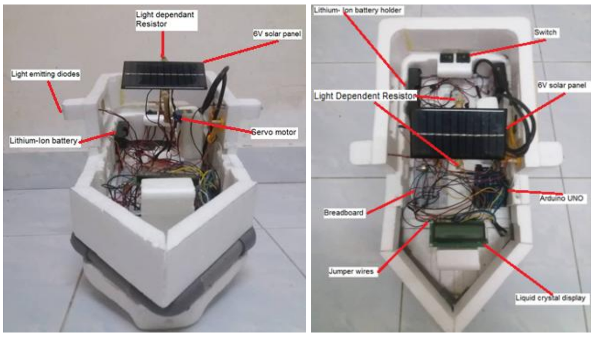
project, the LED is used to simulate light to attract squid for squid jigging process.

3. Results And Discussions

The objective of developing the solar prototype boat system has been achieved as illustrated in Figs. 3. All the functions and system embedded to the prototype has been tested for data analysis purpose.



(a) (b)

Figure 3: The prototype of solar powered boat (a) front view and (b) top view

The components that are visible from the front view (a) are the front structure of the boat, solar panel, LDR, servo motor SG90 and Lithium-Ion batteries. The solar panel will harvest the solar energy from the sun to convert it into electrical energy and then stored in the Lithium-Ion battery. It can also be seen that there are pillars that are connected to the solar panel and the servo motor which is embedded to the solar tracking system. The source of the solar energy which is light is tracked by the Light Dependent Resistor. The LDR will absorb light and then calculated by the microprocessor for the value which sends signal to the servo motor for the rotation. The servo motor plays an important role in the sun tracking system for the solar panel is rotated by it. The rotation depends on the value that is given from the microprocessor originated by the LDR readings. Other than that, the Lithium-Ion Batteries acts as a power supply and also for the storage of electrical energy converted by the solar panel from the solar energy.

From the top view (b), it can be seen that there are other components such as Arduino UNO board, LCD, breadboard, resistors, jumper wires, switches, charging port and batteries for the system. The system requires a microcontroller to manage and control every functions of the system on the structure. All the input and outputs for the system is processed within this controller. The inputs include LDR readings, LCD readings and communication ports. Other than that, the LCD works as an indicator to the system mode and also the indicator of the system supply. Meanwhile, the breadboard connects all the electronics components in the system including power supply and groundings. Switches, charging port and batteries are connected for the supply and charging purpose. The switch acts as the main power switch for the system while the charging port allows the batteries' power to be replenished by the power gained from the solar system.

Other than that, the ambient light intensity has been measured respectively for the system. The system uses the predetermined value of light intensity to efficiently harvest the energy from the solar power to convert to electrical energy for the system of the boat. In addition, the application of sun tracking system which controls the rotation of solar panel using the LDR as sensor and servo motor as its actuator have been successfully conducted.

Ambient Light Intensity

Fig 4 shows the data acquired from monitoring of ambient light intensity for the solar powered boat system. The values obtained by using the LDRs as a sensor and they are connected to the Arduino for data analysis. When connected to VCC 5 volts of Arduino, the LDRs give out an analog voltage which varies in magnitude in direct proportion to the received light intensity. The readings are greater when the greater the light intensity from the LDR. The LDRs are connected to the analog input pin of the Arduino

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since the LDRs give out analog voltages. With Arduino's built-in analog-to-digital converter (ADC), the analog voltage from 0 to 5 volts is then converted into digital values in the range of 0-1023. From the figure below, the highest value acquired from the LDR during bright sunny day is 994 (digital values) from the Arduino itself. The lowest value is achieved at night which is 0 values.

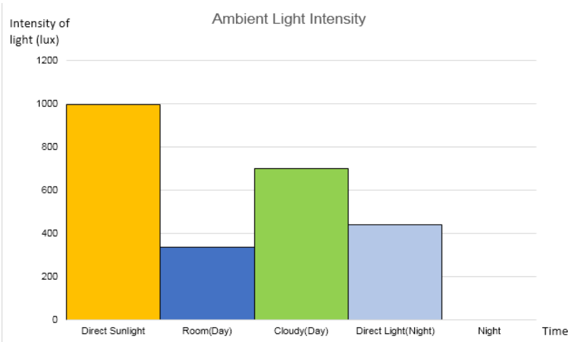

Figure 4: The graph of ambient light intensity

Resistance Vs Intensity of Light

The measurement of resistance versus intensity is a process to determine the respond of resistance towards light from the sensors which are the LDRs. Table 1 shows the calculated value for LDR measurement. The data obtained from the calculation then is plotted into a graph for data analysis.

Table 1: The calculated value for the LDR measurement

Intensity of light (lux)	Resistance	Average value of resistance
100	996	994
	994	
	994	
	996	
	990	
500	786	786.2
	784	
	787	
	786	
	788	
5000	590	590.6
	588	
	592	
	594	
	589	
7000	333	336.4
	339	
	334	
	341	
	335	
10000	275	277.8
	281	
	277	
	278	
	278	

The calculated value is then recorded and measured repeatedly. This is to ensure the precision and accuracy of data acquired. The measurement of the calculated value is taken for 5 consecutive times and the average of the values is calculated.

Fig. 5 shows the graph of resistance vs lux for the solar powered boat system. The resistance is measured by the LDR and also 10 kΩ resistor. Meanwhile, the light intensity is measured in unit lux. Clearly, when the light intensity at its highest, the value of the resistance acquired from the LDR used decreases. The resistance continues to increase as the light intensity decreases. It can be concluded that the highest resistance value can be obtain when the light intensity is the lowest while the lowest resistance value can be obtained from the highest amount of light intensity.

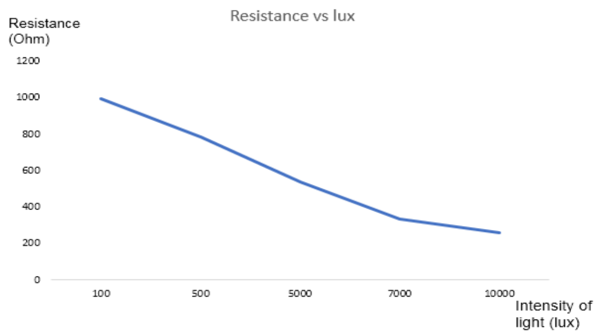

Figure 5: The graph of resistance against lux

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Voltage vs time

Fig. 6 shows the graph of voltage vs time for the solar powered boat system. To make electric charges move, voltage is needed. Voltage is the cause of charges to move and it pushes charges to move in a wire or other electrical conductor. However, voltage is not a force. The voltage is gained from the solar power which is harvested from the solar energy by the solar panel for the solar powered boat system. Based on the analyzed data, the voltage is measured from the lithium-ion battery 18650 3.7 volts which is used to store the energy obtained from the solar panel. The graph displays the increment of voltage in the lithium-ion battery when the time increases. However, the voltage stopped increases as the voltage reaches a steady state which supplies constant amount of voltage throughout the experiment. The lithium-ion battery took around 3 hours to be fully charged during a bright and sunny day.

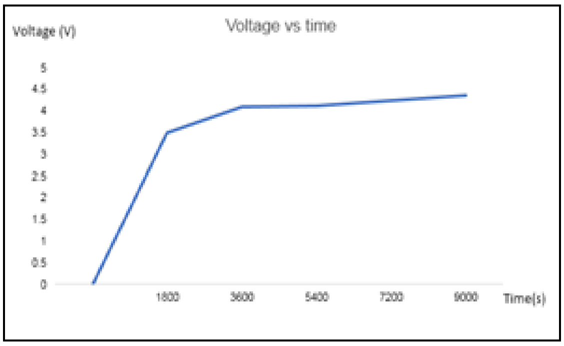

Figure 6: Graph of voltage against time

Analysis of Solar Tracking System

The observation and analysis of the solar tracking system which is embedded to the solar powered boat prototype are highlighted. The angle of the rotation of solar panel is observed and recorded.

The solar tracking system involves the movement and rotation of the solar panel with the help of servo motor. Table 2 shows the movement pattern of the solar panel respectively to the time and position of the sun. The data was taken at coordinate 1°130'29.4" N 103°52'54.6"E where there is no sun light source interference from shadows of building or trees.

Table 2: The movement pattern of solar panel

Time	Mechanism	Description
8.00 AM		At 8.00 AM, the sun light source is angled at between 15° to 30°. The solar panel rotated from initial position which is 90° to 20° tracking the sun light source.
10.00 AM		By 10.00 AM the position of the sun slightly changed to between 20° to 30°. The solar panel reacted to the change of the sun position and rotated to 30°.
12.00 PM		The sun changed its position again from 30° to 90°. The solar panel rotated from 30° to 88° at the time of 12.00 PM.
2.00 PM		In the afternoon, at 2.00 PM, the rotation of the solar panel slightly changed from the angle of 88° to 92.6°.
4.00 PM		After a while, the solar panel then rotated from 92°6 to approximately 120° tracking the movement and the position of the sun.
6.00 PM		By 6.00 PM, the sun light source is already begun to deplete as the day shifts to night. However, the minimal light source can still be detected from the LDRs mounted on the

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		solar panel. The solar changed its position to 161°.
8.00 PM		The solar then resets and maintains its position at 180° since the last sun light recorded was at 6.45 PM and the sun light was insufficient to be traced. At 8.00 PM the light intensity began to deplete and the LDRs resistance dropped below 50 Ohm and the LEDs on the prototype lights up and the LCD prints NIGHT MODE.

Fig. 7 shows the graph of time versus the angle of solar panel for the solar powered boat system. The angle of the solar panel rotates from 0° to 180° respectively. The rotation of the solar panel aims to track the sun source to gain energy in the form of solar which is converted to electrical energy for the solar boat system. The angle of the solar panel varies from the sun position from time differences. The position of sun changes from the morning at 10 am until the evening at 6 pm. The angle rotates towards the sun light source with the aid of the sensors which are the LDRs that is equipped to the solar panel rotation system. The graph displays the movement of the solar panel which increases as the time passes. However, the angle does not have big differences because at 12 PM until 2 PM, the position of sunlight is almost the same.

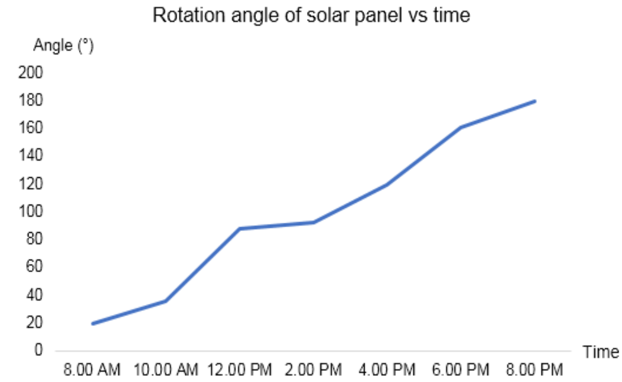

Figure 7: The graph of time against the angle of solar panel

4. Conclusion

As a conclusion, this solar powered boat has put advancement in the fishing industry and also helps to reduce the global warming effect after replacing traditional diesel engine with electric motors to power up the boat and other system. The ambient light intensity has able to be monitored and from the results, it shows that the solar power is most efficient in broad daylight and can generate full voltage depending on the capacity of solar panels used. The solar tracking system is equipped to maximize the light absorption which is used for powering up the system or storing energy for the system.

For further improvement, it can be upgraded by considering maneuver system which can control the movement and direction of the boat. Restructuring the prototype for better aerodynamics, tensile strength and weight distribution also increases the efficiency of the prototype. In order to increase the control and monitoring purpose for the solar powered boat prototype, it is also recommended for future researches to embed the system with Internet of Things (IoT) for better functionality and real time monitoring.

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