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Implementation Analysis Of Automatic Dual Axis Solar Tracking System Using Atmega328p

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Abstract: *This project involved both simulation design and mechatronics implementation of solar tracking system that ensures that solar panel is perpendicular to the sun to obtain maximum energy falling on it. The unique feature of this project is that it takes the sun as a guiding source by actively monitoring the sunlight and rotating the panel towards the direction where the intensity of sunlight is maximum. The light-dependent resistor's (LDRs) are the sensors that play the role of continuously monitoring the position of the sun which changes the position of the solar panel by switching on and off the servo motor. The Atmega328p logic circuit fetches the input from the LDR sensor and gives the command to the servo motor to rotate in order to position the solar panel to the direction of the sun. This has enabled this project to generate additional energy of around 15% to 25% with very low consumption by the system itself. The dual-axis sun tracker was designed and when tested for the power output of the solar panel, it was found that on the average the solar panel would achieve maximum power generated from the hour of 10:00 am to 4:00p.m, where 4.92W was stored at 10:00 am, 4.80W at 11:00 am, 4.92W at 12:00 pm, 4.68W at 1:00 pm, 4.88W at 2:00 pm, 4.87W at 3:00 pm and 4.93W at 4:00 pm which was a much greater output as compared to a fixed solar panel which achieved maximum power output between hours of 12:00 pm and 1:00 p.m. The dual-axis sun tracker would be recommended for use in solar power generation because it increases the efficiency of the solar power generated, and it's cost-effective.*

Keywords: Atmega328p, LDR, Servo motor, Solar Panel, Solar Tracker

INTRODUCTION

In recent years, the need for energy will increase many folds, while the reserves of conventional energy will get depleted at a rapid pace. To meet this growing demand for energy, the harnessing of non-conventional / renewable energy sources becomes a necessity. Solar energy is the most abundant and uniformly distributed from among all the available non-conventional sources. Renewable energy is rapidly gaining significant importance as an energy resource as fossil fuel prices fluctuate. At the educational level, it is, therefore, necessary for engineering and technology students to have an understanding and appreciation of the technologies associated with this renewable energy (Adabara, Hassan, & Ian, 2018). One of the most popular renewable energy sources is solar energy (Nitnaware & Mahawadiwar, 2017). A solar tracker is a device for orienting a solar photovoltaic panel during daylighting reflector or concentrating solar mirror or lens toward the sun. The solar energy is used to power few lighting systems (bulbs) and only basic appliances such as TV, Radio, Decoders, though other appliances are found not used at all (Kasali, Mustapha, & Adabara, 2019). Solar power generation works best when pointed directly at the sun, so a solar tracker can increase the effectiveness of such equipment over any fixed position. One of the most popular renewable energy sources is solar energy. Mechatronics is the synergistic integration of sensors, actuators, signal conditioning, power electronics, decision and control algorithms, and computer hardware and software to manage complexity, uncertainty, and communication in engineered systems (F. Harshama, M. Tomizuka, 1996).

To take full advantage of the Sun's energy, the solar system surface must be perpendicular to the Sun's rays. For this reason, a wide range of solar tracking systems have been proposed by several authors like Adabara et al., 2018 to increase the efficiency of Photo Voltaic systems (solar panels) without using light sensors. This was achieved through using an electrical characteristic of the panel which the open-circuit voltage that is able to detect the amount of sunlight that reaches the solar panel. Based on the experimental results, it was concluded that the automatic sun-tracking panel is not only capable of maintaining optimal tilt angle for the PV cells but also capable of giving actuator signals to prevent unnecessary moves and logging data with real-time performance monitoring. Toylan, 2017, used a fuzzy logic controller to control the speed of the motors. The results of the photovoltaic panel on the solar tracking system controlled by fuzzy logic are compared to those obtained by the photovoltaic panel system without solar tracking system according to instantaneous power performance throughout the day in Pinarhisar, Turkey. From the experimental, it was observed that the solar tracking system which uses fuzzy logic controller increases the efficiency of energy production from the photovoltaic system.

Kumar & Vijayan, 2016. Suggested the use of refrigerant tracking system as a medium to rotate the device with respect to the sun's rotation. Energy production of output power increases as a result of the continuous extraction and minimum utilization of light. While the conversion efficiency increases simultaneously. Use of double-axis solar tracking system in the place of a single system will increase the overall efficiency, and it was that the performance of solar energy conversion systems such as solar collector and solar PV system varies with respect to the direction of sunlight falling on its absorbing area. Without tracking the movements of the sun, the utilization and conversion efficiency of conversion devices are very minimum in a fixed position due to continuous movement. The need to track the sun's movement for extracting solar energy and maximize the utilization also increases the conversion efficiency of the devices. Also in 2016 Serraoui, Sellam, & Rebhi introduced the principle of the perturb and observe MPPT algorithm design, the system can detect the change in the sun position by sensing the change in panel power (without using light sensors), the objective of this tracker is not only track the sun position but the tracker is able to track the sun position and the maximum power point in the same time (mechanical tracking and electric tracking) without using light sensors. Simulation results showed the ability of the novel sun tracker

Closed-loop automatic dual-axis solar tracking has been attempted so as to track the motion of the sun for collecting maximum energy. The logic for Automatic Dual-axis solar tracking system is checked. Efficiency of power generating with the help of a Dual-axis solar tracking system is much more as compared to the single-axis solar tracking system (Patil, Khandekar, & Patil, 2016). An intelligent dual-axis sun-tracking solar system was proposed by Sharma & Sharma in 2016. The Sun tracking system with orientation and tiltation increases the power or efficiency of the solar panel up to 40 %. To obtain the maximum energy from the sun the panel has to move in the correct direction with the correct angle and make the panel perpendicular to the sun. The sun-tracking solar system was designed in that way that a minimum number of components can be used and they can be fit into the small package so that the cost of the system is less expensive. Solar power, unlike other energy sources, is now considered to be the best alternative due to its versatility in terms of renewability, cost-effectiveness, improved operating efficiency and its unlimited reserve, mainly being the Sun. Sun moves from east to west and tracking the sun during its movement helps us to achieve maximum utilization of solar energy. The solar panels, being the modern technology of alternative power source is the best possible way to absorb the maximum amount of sunlight and converting into usable electricity and thus achieving increasing popularity since the realization of fossil fuels shortcomings. The objective of the proposed work was to design a PLC based automated tracking of a solar panel for maximum throughput using photosensors (Sushma V.R, 2015). The solar panel will track Sun based on the output from the sensor successfully. The sensor output keeps varying based on the amount of sunlight falling on it. The output from the sensor is converted to digital (logic zero or one) and given to the PLC as input. The PLC output drives the motor to the position. The stepper motor is used for precise control of the solar panel here. The solar panel along with the sensor is interfaced and the tracking of the solar panel is efficient. PLC provides precise control signals to the motor which rotates to the particular position based on the sensor's output. Tracking of the solar panel is achieved with a precision of ten degree.

The empirical findings from Kumar in 2014 lead us to believe that the research work may provide some contributions to the development of solar energy applications. (1) a simple and cost-effective control implementation, (2) a stand-alone PV inverter to power the entire system, (3) ability to move the two axes simultaneously within their respective ranges, (4) ability to adjust the tracking accuracy, and (5) applicable to moving platforms with the Sun tracker. The novel and simple control implementation of a Sun tracker that employed a single dual-axis AC motor to follow the Sun and used a stand-alone PV inverter to power the entire system (Wang & Lu, 2013), The proposed one-motor design was simple and self-contained and did not require programming and a computer interface. The experiment results indicated that the developed system increased the energy gain up to 28.31% for a partly cloudy day. The design and implementation of the solar tracker with two axes that Use in a motor satellite dish to track the sun accurately and use the LDR sensor to determine the intensity of falling sunlight. (Sadyrbayev, Bekbayev, Orynbayev, & Kaliyev, 2013), this mechanism to improve the solar gain energy, also the costs of the solar tracker operation and cost maintenance is relatively low. The result found that the solar tracking system is more effective than the fixed solar panel. The energy gained from the solar panel with the dual tracker exceeds 35% of the energy gained from the fixed solar panel, In analyzing the data, the energy gained from the solar tracker is mostly in the morning and in the evening because at noon time there is little difference and this proves that the fixed solar panel is efficient during noon time only. The dual-axle solar tracking system is efficient as it can be placed anywhere and ensure a high energy gain.

Sadyrbayev et al in 2013 proposed a dual-axis sun tracking system based on LM324N microcontroller. The mechanical structure of the system is very simple and reliable, designed in such a way that the entire controller card should fit into the platform tracking system. The scheme of the designed with a minimal number of components to minimize cost and to simplify the assembly has been integrated onto a single board. The result shows the optimality of the dual-axis sun tracking system compared to a stationary photovoltaic cell, which produces 31.3 % more power than fixed photo module in the coordinates N 43°13 50 E 76°46 33.this projects proposes the use of Atmega328p with minimal component, minimal effort, increases efficiency of the solar power generated, and it's cost-effective.

SYSTEM DESCRIPTION

This project is a mechatronics system consisting of Solar panel, ATmega328p microcontroller, servo motors, chassis, power supply, LDR sensors etc. The position of the solar panel is based on the direction of the sun. The two-axis sun tracking system changes both the azimuth (horizontal) and the altitude (vertical) degrees of the solar tracker. Four LDRs are used for feedback from the servo motors. The LDRs (1, 2, 3, and 4) are to be taken as pairs of two. If one LDR in one pair gets more light intensity than the other, a difference will occur on node voltage sent to the respective ADC channels of the microcontroller. The microcontroller calculates these node voltage differences and compares them with the respective set values. After that, it will generate necessary logic signals to actuate the servo motor in such a direction that light intensities are equal. The voltage value coming through LDRs are compared with the predefined value to determine the position of the tracker. The LDR pairs are fixed to reciprocal positions on the border of the Solar panel. If LDR pairs are illuminated equally by the sun, the analogue signal received by the ADC channel of the microcontroller will have equal values and the microcontroller will not generate any logic signal to actuate the motors.

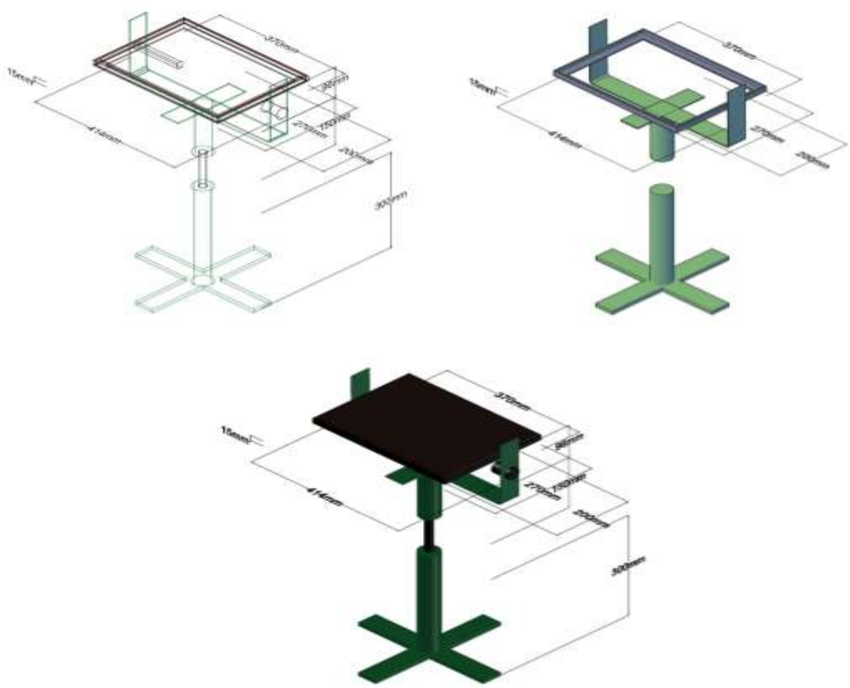

Figure 1: System Design of a dual-axis solar tracking system

A Basic Block Diagram of the Project is shown below

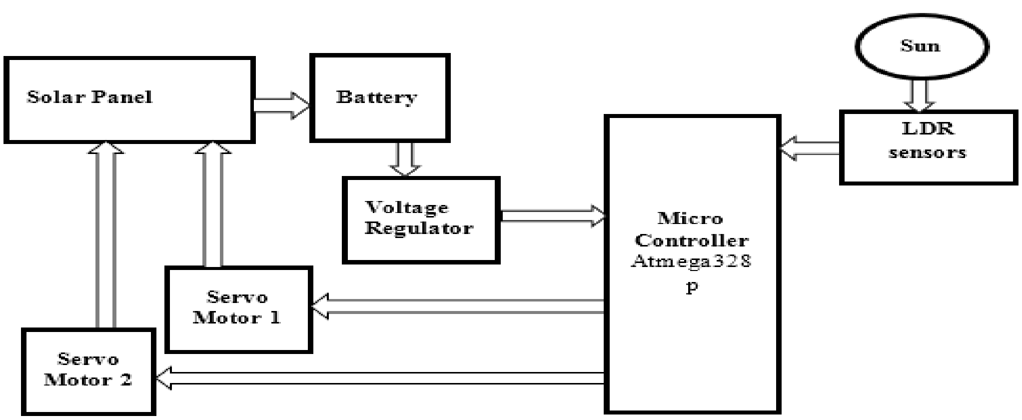

Figure 2: Block diagram of a dual-axis solar tracking system

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The block diagram consists of LDR sensors, Atmega328p microcontroller, a Solar panel, two servo motors, battery and a voltage regulator interconnected together. The LDR Sensors helps in locating the position of the sun and send the signal (information) to the Microcontroller regarding the Suns' position. The microcontroller calculates the voltage differences between this LDR sensors. It the generate necessary logic signals to actuate the servo motors in such a direction that light intensity is highest hence positioning the solar panel to the direction of the sun. The solar panel charges the battery whose voltage is intern regulated to power the entire system.

Electronic Control Circuit Diagram is shown below

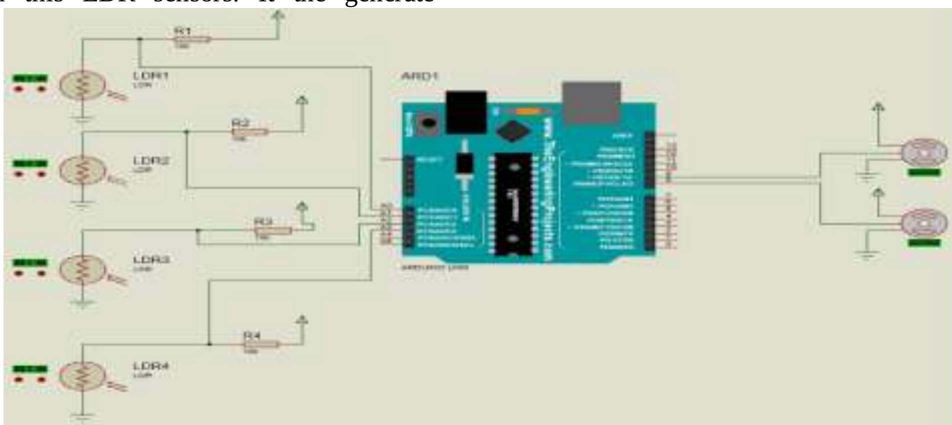

Figure 3: Electronic control circuit diagram of a dual-axis solar tracking system

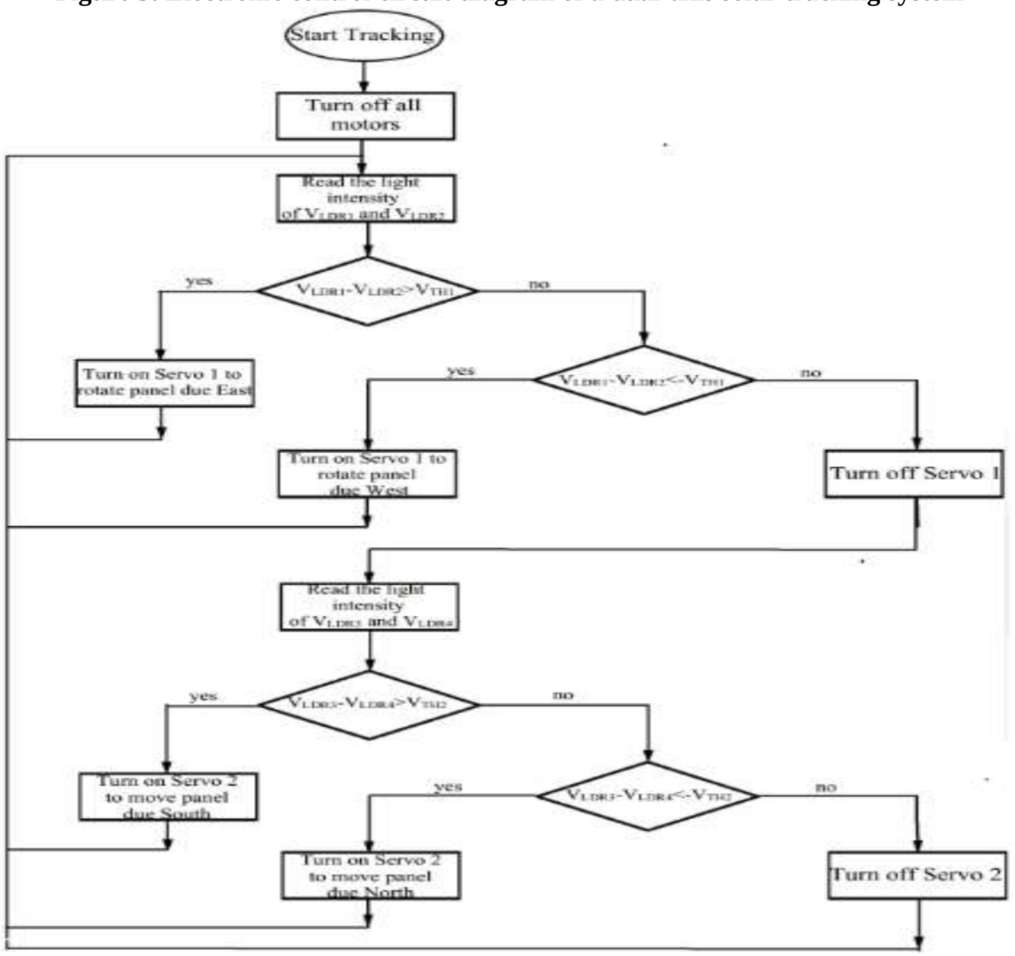

Figure 4: Flow chart of a dual-axis solar tracking system

APPLICATIONS

Their applications are categorized into three;

- Residential

- Agricultural
- Commercial

Residential

Its high quality, reliability and durability make it suitable for residential installations. However, the system can't be set up in the home's roof due to orientation and structural issues.

Agricultural

Due to its low maintenance cost, reliability and durability, solar trackers are used to improving on agriculture through irrigation, i.e. it helps to pump more water from a given source.

Commercial

They are used in power generation in solar farms. It's because they increase the amount of energy being generated.

Figure 5: Dual axis tracking system

TESTING AND RESULTS

The project was tested and all the developed circuits were found to be working perfectly. The testing was done in Kansanga, Kampala Uganda. For a period of five days measuring the output power of the dual-axis sun tracker and another additional five days measuring the power output of a fixed solar panel. The testing and taking of the results were done during the month of June 2019 (from 14th to 23rd).

The power output measurement was done by measuring the electric current output at intervals of one hour from 8:00 am to 6: 00 pm every day.

The current values measured were then multiplied by the rated voltage of the solar panel (12V) to get the power output of the solar panel at different instant of time. For example: -

At 8:00HRS

I=0.33A
Power output=I*V
Power output =0.33*12
Power output = 3.96 watt

For efficiency Area of the solar =Length*Width = (0.2* 0.15) = 0.03m^2

Efficiency = [Power / (A*i)] *100%
= [3.96/ (0.03*1256)] *100%
=10.5%

At 9:00HRS

I=0.41A
Power output= (0.34*12)
Power output= 4.08 watt

For efficiency Area of the solar =Length*Width = (0.2* 0.15) = 0.03m^2

Efficiency = [Power / (A*i)] *100%
= [4.08/ (0.03*1256)] *100%
=10.8%

Where: - V = Rated voltage of the solar panel
A = Area of the solar panel

I= Measured the instantaneous value of the current

The measurement results (power in Watts) of both dual-axis sun tracker and fixed solar panel were then recorded in tabular form as shown by the tables below.

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Table showing results of power output a solar panel with a dual-axis sun tracker

DAYS	TIME OF THE DAY										
	8:00HRS	9:00HRS	10:00HRS	11:00HRS	12:00HRS	13:00HRS	14:00HRS	15:00HRS	16:00HRS	17:00HRS	18:00HRS
DAY 1	3.96	4.08	4.92	4.80	4.92	4.68	4.88	4.87	4.93	4	3.98
DAY 2	4	4.5	4.85	4.94	4.87	4.88	4.91	4.96	4.77	4.56	3.56
DAY 3	3.97	4	4.79	4.9	4.91	4.93	4.94	4.87	4.86	4.78	3.9
DAY 4	3.98	4.21	4.94	4.91	4.91	4.92	4.94	4.95	4.94	4.47	3.8
DAY 5	3.87	4.12	4.88	4.89	4.89	4.95	4.95	4.94	4.94	4.84	3.49
AVERAGE POWER(W)	3.962	4.184	4.882	4.892	4.898	4.882	4.924	4.918	4.882	4.53	3.746

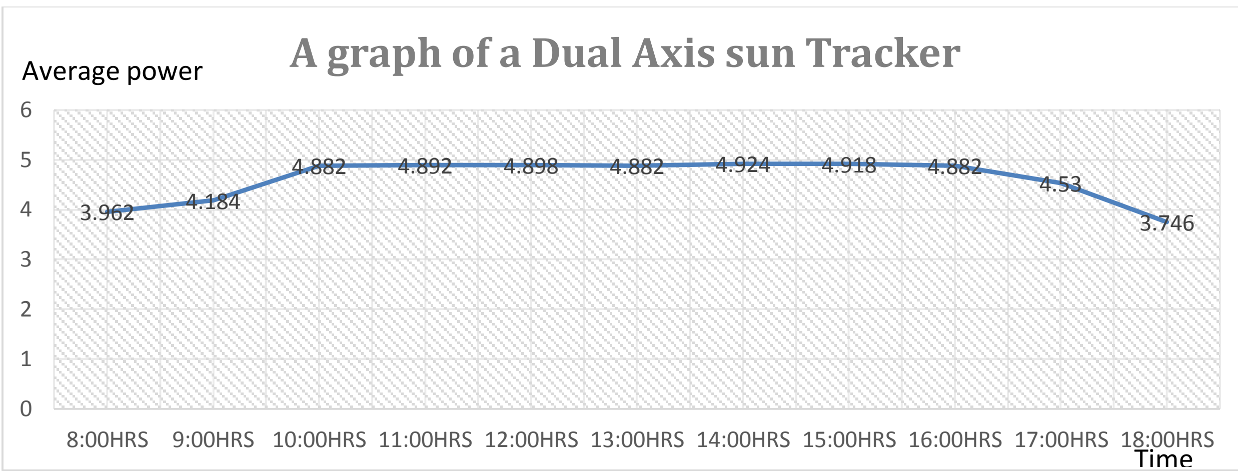

Figure 1: Dual axis sun tracker:

Table showing results for the power output of a fixed solar panel

DAYS	TIME OF THE DAY										
	8:00HRS	9:00HRS	10:00 HRS	11:00 HRS	12:00 HRS	13:00 HRS	14:00 HRS	15:00 HRS	16:00 HRS	17:00 HRS	18:00 HRS
DAY 1	2.4	2.55	3	4.55	4.95	4.9	4.5	4.44	3.55	2.4	2
DAY 2	2.5	2.93	3.51	4.35	4.4	4.5	4.33	4.29	3.75	3.42	3.03
DAY 3	2	3	3.9	4.3	4.4	4.6	4	3.72	3.33	3.2	2.65
DAY 4	2.55	2.75	3.32	4.44	4.5	4.5	4.23	4	3.7	2.8	2.67
DAY 5	2.45	2.91	3.5	4	4.35	4.3	4.1	3.7	3.22	2.99	2.51
AVERAGE POWER (W)	2.380	2.828	3.446	4.328	4.520	4.560	4.232	4.030	3.510	2.962	2.572

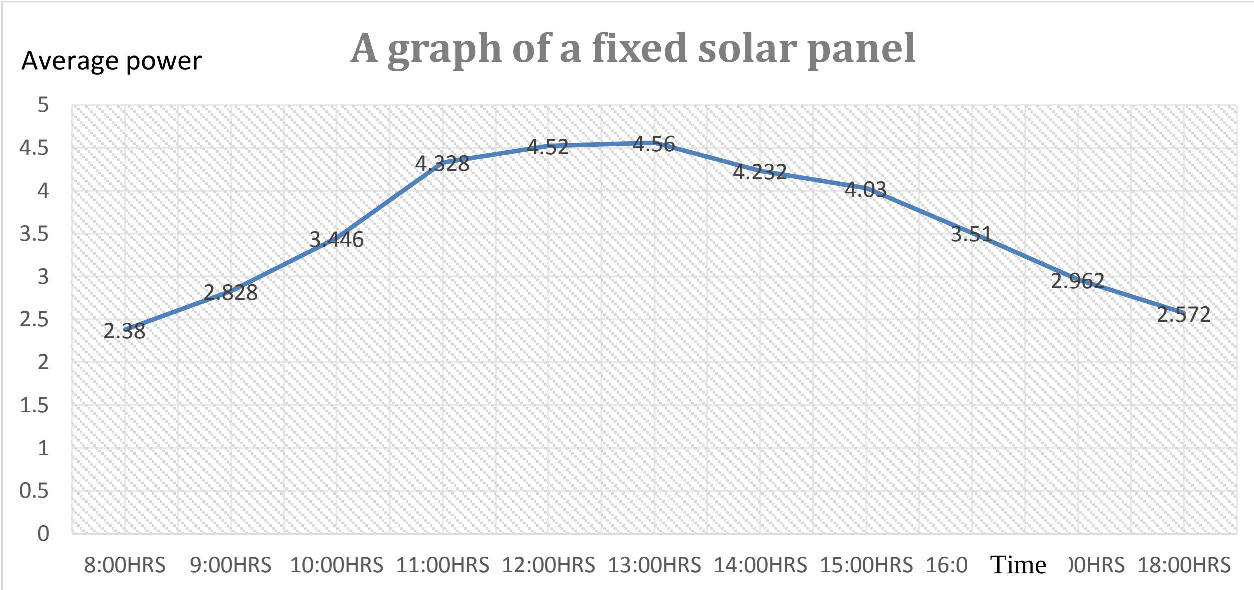

Figure 2: Fixed solar panel

CONCLUSION

The main objective of this study was to achieve maximum power generated by the solar panel by eliminating the light-gathering losses and with a peak laboratory efficiency of 32% and an average efficiency of 10-20% (Solar Tracker System 2007), it was necessary to recover as much power as possible from a solar system. This includes reducing inverter losses, storage losses and light gathering losses. Light gathering is dependent on the angle of incidence of the light source providing the power (i.e. the sun) to the solar cell's surface, and the closer to the perpendicular, the greater the power. This was achieved by designing circuits that detected the position of the sun along East/West and North/South axes using LDR sensors that measure the intensity of the sun. Two LDR sensors were used for East/West track, and were positioned on the PV panel frame on two opposite sides and likewise to the North/South axes.

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