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# Prototype System of Solar Tracking Design to Optimize the Energy Absorption Based on Arduino

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**Abstract.** This research optimizes the absorption of solar energy in solar panels by designing mechanical systems that can move solar panels in the direction of incoming sunlight. Light-sensitive sensors are used to track the sun. The solar tracking system is designed using two axes, namely rotation axis and the tilt axis. Both axes are driven by servo motors based on light-sensitive sensors. The system was developed using an ATmega328 microcontroller unit. The test results found that using solar tracking the amount of energy produced was greater than static solar panels. Radiation generated between solar tracking and static sun can increase by 55.2%.

**Keywords:** Atmega328, Light-sensitive sensors, Solar tracking, Servo Moto, Solar Energy

## INTRODUCTION

The development of increasingly advanced technology very quickly, especially the discoveries which simplify and lighten the work, at the present time live all completely, the technology has advanced variety of tools that can be created besides the more advanced era is also increasing energy demand, the continuous reduction of fossil fuel sources, with its era more advanced humans being begins to find to exploration the technologies for the production of electrical energy using sources of clean, renewable, such as solar power, wind energy etc.

Indonesia is a tropical country, which has a huge potential used as an alternative energy source is solar energy, Indonesia still has many islands and also there are many villages that are very minimal with the power source and therefore is necessary to be developed the energy sources that exists in nature is solar energy as solar power plants and also in solar energy has the potential, Given the solar energy potential is very large, many people have started to realize and utilize this solar energy in meeting their daily needs such as turn on the light, watching television and radio, cooking, Haryanti (2014). The government realizes that fossil fuels and natural resource will be less and also does not allow the purchase of fuel from abroad will take the large cost, the government realized to make renewable energy such as solar energy. The resulting solar radiation per day 4,8 kWh/m2/day,U.S Department (2010), by utilizing solar energy can fulfill daily need.

Solar energy is the energy form of light and heat from the sun. The sun is the energy that never runs out. Solar energy provides heat, light and energy for living things. It does not have a price and also produce air pollution, environmentally friendly. The development of solar tracking is applied for because the motion of the sun in farming is always changes, by utilizing solar tracking can increase the absorption of produced solar energy, Abdallah (2004), solar tracking has two kinds: one axis and two axis, on one axis solar panel can only follow the trajectory of the sun east to west, will get 20 percent efficiency and two axes solar panels can follow the movement of the sun from east to west as well as the orientation of the north to the south , will have an efficiency of 40 percent,Setyowati (2008). When solar radiation on solar panel with solar tracking will improve the efficiency more than the static solar panel, Akhiles (2010). It has been estimated that the yield from solar panels can be increased by 30 - 60 % by utilizing a tracking system instead of a stationary array Yazidi (2006). Up to 40% extra power can be produced per annum using a variable elevation solar tracker, Saxena (1990). From the above problems researchers have created a prototype solar power tracking system so that more optimal absorption of solar panels throughout the year and economical.

## MATERIALS AND METHODS

Solar tracking ini terdiri dari Light dependent Resistor (LDR), Arduino sebagai controller dan motor servo untuk menggerakkan solar panel untuk tetap mengarah ke arah sinar matahari. Gambar 1 menunjukkan keseluruhan sistem yang akan dikembangkan dalam penelitian ini.

The main intention of this project is to design a high quality solar tracker. The project is divided into two parts; hardware and software. it consists of three main constituents which are the inputs, main controller and the output as shown in Fig. 1. The inputs are from analog value of LDR, Arduino as the controller and the servo motor will be the output.

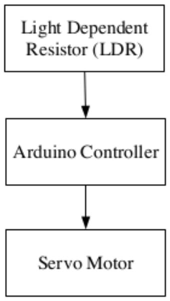


**Figure 1.** The Main Block diagram

Photoresistor or light dependent resistor is one type of resistor that functions convert light intensity into a resistance value. In this research is used as an input to be processed by the controller. LDR output voltages for light intensity are shown in Table 1. The resistance of an LDR is extremely high, sometimes as high as 1 Mohms. The light resistances will drop dramatically when illuminated

**Table 1.** Light Intensity Measurement.

| Light Intensity | LDR Ouput (V) |
|---|---|
| Dark | 0.6 |
| Bright | 4.6 |

Servo motor is a motor with a closed feedback system in which the position of the motor will be communicated back to the control circuit in the servo motors. This motor consists of a motor, the gear range, potentiometer and control circuit. There are two types of servo motor required, either 4.5 V or 6V supply to operate. Servo motor only rotates up to the maximum of 180 degrees. Pulse Width Modulation (PWM) is used to control the motor. PWM analog signal will go through an electronic circuit and convert the analog signal to a digital signal. The center position is usually attained with 1.5 ms wide pulses, while pulse width varying from 1 ms will command positions all the way to the right, and pulse widths of 2.0 ms all the way to the left. The servo motors PWM Timing Diagram (Voltage vs. Period) is shown in Fig. 2.

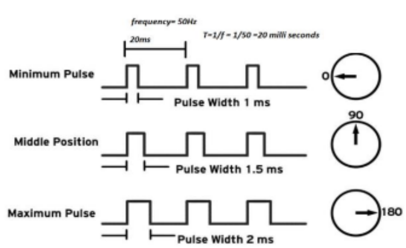


**Figure 2.** Servo motor PWM timing diagram, Zhaoyong (2004)

Arduino is an open-source electronics prototyping platform based on flexible, easy to use hardware and software. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings. Arduino projects can be stand-alone, or they can communicate with software running on a computer. In this development, Arduino UNO is used as the main controller; 14 digital input/output pins of which 6 can be used as PWM outputs, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button.

The software part consisted of a programming language that was constructed by using C programming. The codes were targeted to Arduino UNO board to be compiled and uploaded.The flow of the software procedure is shown in figure 3.

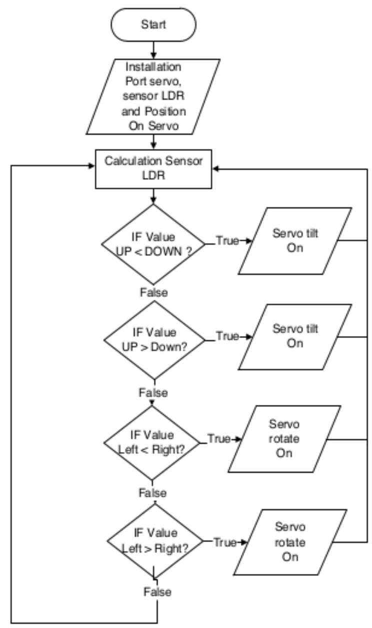


**Figure 3.** Flowchat for the overall prosess

## RESULTS AND DISCUSSION

In this study, the developed system is compared to a system without using dual axis tracking. Table 2 shows radiation data from solar panels using dual axis tracking and compared to solar panels that do not use solar tracking.

Figure 4 show the graph of output power comparing between the static panel and the tracker for 26 Juni 2016. For the solar tracker, the highest output radiation produced was 23,4 W/m$^2$ at 12.00p.m while the lowest output power was 10,8 W/m$^2$ at 07.00p.m. As for the static panel, the highest and the lowest output power produced were 23,2 W/m$^2$ and 5,1 W/m$^2$. the output power graph also shows that the output power produced by solar panel with tracking system is higher than the power of static solar panel at most of the times.

**Table 2.** Readings Radiation from Solar Tracking System.

| Date | Tracking systems | Fixed | Efficiency |
|---|---|---|---|
| 16/03/2016 | 199.2 W/m$^2$ | 128.1 W/m$^2$ | 55.4% |
| 23/06/2016 | 201.1 W/m$^2$ | 128.2 W/m$^2$ | 56,8% |
| 24/06/2016 | 180.5 W/m$^2$ | 115.6 W/m$^2$ | 56.1% |
| 25/06/2016 | 195.9 W/m$^2$ | 126.1 W/m$^2$ | 55.3% |
| 26/06/2016 | 203.8 W/m$^2$ | 133.5 W/m$^2$ | 52.5% |
| Average | 196.1 W/m$^2$ | 134.3 W/m$^2$ | 55.2 % |

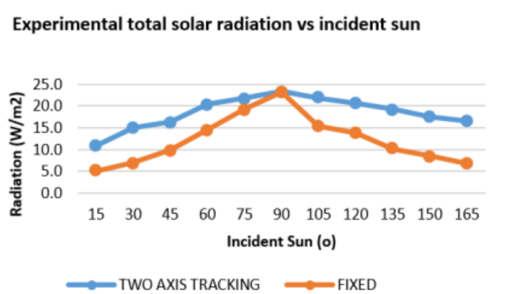


**Figure 4.** Output power comparison between static panel and two axis tracker

Figure 5 shows the overall prototype that has been developed. For the purposes of recording data and experiments, this prototype is connected to a computer, so that all data can be stored and analyzed for research purposes.

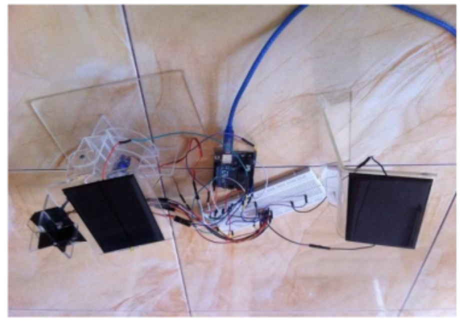

**Figure 5.** Complete hardware setup of static panel and tracker.

In this study the experimental incident angle of sunlight on the solar panels is shown in table 3.

**Table 3.** Readings Incident Angle of Sunlight from Solar Tracking System.

| Angle ($^0$) | $P_{Statis}$(Watt) | $P_{Tracking}$ (Watt) | $P_{Loses}$(Watt) | Solar Ratiation | θ on static | θ on tracking |
|---|---|---|---|---|---|---|
| 15$^0$ | 3.94x10$^{-4}$ | 8.3x10$^{-4}$ | 4.38x10$^{-4}$ | 10,8 W/m$^2$ | 61.7$^0$ | 0$^0$ |
| 30$^0$ | 5.32x10$^{-4}$ | 1.16 x 10$^{-3}$ | 6.23 x 10$^{-4}$ | 15.0 W/m$^2$ | 62.6$^0$ | 0$^0$ |
| 45$^0$ | 7.56x10$^{-4}$ | 1.26 x 10$^{-3}$ | 5.02 x 10$^{-4}$ | 16.3 W/m$^2$ | 53.0$^0$ | 0$^0$ |
| 60$^0$ | 1.12 x 10$^{-3}$ | 1.58 x 10$^{-3}$ | 4.55 x 10$^{-4}$ | 20.5 W/m$^2$ | 44.7$^0$ | 0$^0$ |
| 75$^0$ | 1.48 x 10$^{-3}$ | 1.68 x 10$^{-3}$ | 1.95 x 10$^{-4}$ | 21.8 W/m$^2$ | 27.9$^0$ | 0$^0$ |
| 90$^0$ | 1.79 x 10$^{-3}$ | 1.80 x 10$^{-3}$ | 1.1 x 10$^{-4}$ | 23.4 W/m$^2$ | 6.3$^0$ | 0$^0$ |
| 105$^0$ | 1.18 x 10$^{-3}$ | 1.69 x 10$^{-3}$ | 5.06 x 10$^{-4}$ | 21.9 W/m$^2$ | 45.6$^0$ | 0$^0$ |
| 120$^0$ | 1.06 x 10$^{-3}$ | 1.59 x 10$^{-3}$ | 5.23 x 10$^{-4}$ | 20.6 W/m$^2$ | 47.9$^0$ | 0$^0$ |
| 135$^0$ | 7.84 x 10$^{-4}$ | 1.49 x 10$^{-3}$ | 7.01 x 10$^{-4}$ | 19.3 W/m$^2$ | 58.1$^0$ | 0$^0$ |
| 150$^0$ | 6.50 x 10$^{-4}$ | 1.35 x 10$^{-3}$ | 7.03 x 10$^{-4}$ | 17.6 W/m$^2$ | 61.3$^0$ | 0$^0$ |
| 165$^0$ | 5.25 x 10$^{-4}$ | 1.28 x 10$^{-3}$ | 7.52 x 10$^{-4}$ | 16.6 W/m$^2$ | 65.7$^0$ | 0$^0$ |
| Average | 1.02 x 10$^{-2}$ | 1.56 x 10$^{-2}$ | 5.41 x 10$^{-4}$ | 203.8 W/m$^2$ | 48.6$^0$ | 0$^0$ |

Incident resulting used tracking system on the solar panels,with that can increase absorption energy on the solar panels used formula $\theta = \cos^{-1}\frac{P}{\eta I A}$ , with method can remove less on the solar panels because the radiation will fall on the solar panels so that incident angle of sunlight on the solar panels same θ = 0$^o$,radiation produced was 203,8 W/m$^2$ with theta same 0$^o$ . As for the static panel, the losses output power produced because of greater Incident angle of sunlight on the solar panels.

## CONCLUSION

Prototype system of solar tracking design to optimize the energy absorption based on arduino has been assembled. The experimental results show the dual axis tracking system better than the static solar panel. The dual axis tracking results in an increase in total incident sun of about 55,2% as compared with that of fixed as static panel.

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