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# DUAL AXIS SOLAR TRACKING SYSTEM

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**Abstract:** Energy crisis is one of the prime issues in the third world developing country like India. There is an enormous gap between generation and demand of electrical energy. Nearly 50% population of the country is extremely isolated from this blessing. Renewable energy is the only answer to solve this issue. Solar energy is one of the most effective resources of the renewable energy which could play a significant role to solve this crisis. This research presents a performance analysis of the dual axis solar tracking system using Arduino. The main objective of this research is whether a static solar panel is better than solar tracker or not. This work is divided into two parts hardware and software system. In hardware part, four light dependent resistors (LDR) are used to detect the utmost light source from the sun. Two servo motors conjointly used to move the solar panel to maximum light source location perceived by the LDRs. In software part, the code is written by using C programming language and has targeted to the Arduino UNO controller. The outcome of the solar tracker system has analyzed and compared with the fixed or static solar panel found better performance in terms of voltage, current and power. Therefore, the solar tracker is proved more practical for capturing the maximum sunlight supply for star harvesting applications. The result showed dual axis solar tracking system produced extra 10.53-watt power compared with fixed and single axis solar tracking system.

**Keywords:** solar tracking; single axis; dual axis; light depending resistor (LDR), servo motor, Arduino, altitude, azimuth, charge controller.

## INTRODUCTION

Now a day's our socio-pecuniary growth depends on a lot of electrical energy. However, in rising countries, this electrical energy is feebly managed. So we can solve this problem by using renewable energy. Solar, wind, gas, biomass, water etc. sources of renewable energy. Among this solar power is being rife attributable to its non-contaminated assets. This solar power is regenerated into electricity for supplementary use. This revolution is done by exploitation photo-voltaic switch. Solar panels are utilized in incarcerate the solar irradiance. However solar tracker is best than the panel because it senses the twist of the world rotates by its axes following the formatter will need to create these components, incorporating the applicable criteria that follow. Solar energy is the main furnish source of all energy produced by sunlight. The energy of the sun reaches on earth with entirely different rays. A huge amount of energy is transmitted from the sun every day; within the earth, we get a diminutive magnitude of it [20]. The larger part of the solar energy is lost within the world. It sparkling and absolve to the entire and that we can never face the insufficiency of solar energy like more than a few different energies. During this work dual axis, solar tracker is the main focus to talk about [20]. This paper also demonstrates the renewable energy state of dealings, entirely special light sensors, some expected value of solar tracker etc. We are going to end with the premeditated tricks which might be functional for upward the solar energy.

## SOLAR ENERGY

### A. Solar Energy Circumstances of India

Developing country like India, we don't have an adequate electric energy. Presently the quantity has augmented to 53% [2]. The government has located up the purpose of on condition that electricity to all by 2020 and to make sure consistent and eminence supply of electricity at a level-headed and inexpensive cost [2]. Extension of Renewable Energy is one of the vital strategies adopted as a piece of petroleum diversification agenda [2]. Renewable Energy policy 2009, the Government is policy to smooth the progress of both public and private sector investment in Renewable Energy projects to replacement indigenous non- renewable energy supplies and scale up contributions of existing Renewable Energy based electricity productions [2]. The Renewable Energy strategy envisions that 5% of total vigour fabrication will have to be achieved by 2015 and 10% by 2020 [2]. To achieve this intention, Government of India is looking for an assortment of options sooner Renewable Energy assets. The Government of India has already launched "500 MW Solar Power Mission" to promote the use of Renewable Energy to solve the scarcity of electricity [2].

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**B. Solar Energy Perception in India.**

India has a hopeful radical prospective in solar energy. To fulfil this demand India government has premeditated to increase countrywide power production competence up to 16000 MW of that 800 MW is expected to be generate from renewable sources [5]. The necessities of electricity are often met by using the solar tracker. Within the coastal region of India, the bright sunshine varies from 3 to 11 hours daily [20]. This information reveals that encompasses a sensible expectation in using solar panel and PV function [5]. Vacate all the tax on raw materials of the solar system by the government of India. So, it is often on the market to any citizen of India. Daily basis solar emission 4.65kWh=m2=day for Dhaka city just the once a year collected from NASA Surface meteorology and Solar Energy.

## SOLAR TRACKER

A solar tracker is a perfect tool for track the path of the sun from east and west during daytime [20]. Usually, solar tracker is classified into two group i.e. i) Single axis solar and ii) dual axis tracker. For a conscientious line of longitude, every day sun moves from east to west on a fixed solar path [20]. However, the sun moves through 460 degrees north and south throughout the seasonal revision. In our proposed model we have partiality to use micro controller based dual axis solar tracking system [16]. The angles of occurrence of sun beam are going to be 0°. We use light dependent resistors (LDR) for trace intensity of the light of the sun [20]. LDR incessantly monitor the solar emission and this data is transferred to the servo motor via micro-controller [20]. Where the intensity of sunshine is highest the servo motor moves the panel that direction [20]. Our proposed model is to calm the ability expenditure and make the highest use of solar power generation [20]. The main plus point of our proposed model is that we use two servo motor. In order to control two motor, system desires a lot of power. Within the projected model we tend to don't use two servo motor at the same time. At the preliminary stipulation two servo motor begins running [20]. Since the sun change its location device detects the position of the sun and it takes four minutes [16]. When the sun moves from east to west, second servo motor can stop working which situated in vertically in the solar tracker. The second servo motor will begin running if through the sun moves to the north or south position [16]. During summer the solar path relics close to same in India. The second servo motor won't run if there's no seasonal change. The movement of the solar panel towards in vertical and horizontal on azimuth and altitude angle is taken as a reference [5]. The solar elevation approach is distinct for the reason that the angle located stuck between the horizontal and as a result the line linking to he sun [16]. At nightfall or break of day distance from the ground approach is 0° and formerly the sun is at the pinnacle the height above sea level angle relics 90° [14]. *"Fig. 1,"* shows the position of the sun over the year.

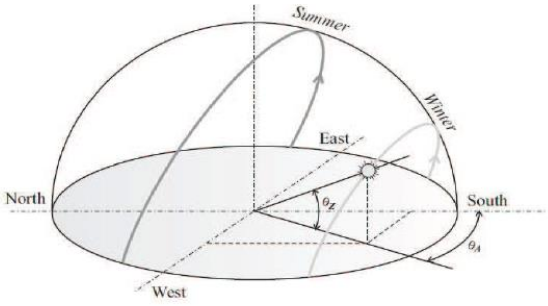


Fig. 1. The different position of the sun over the year

The proposed tracking system can track a lot of daylight in actual fact by PV panel rotation in different axis [15]. In dual axis system we can track the sun in four directions as a result we can achieve more energy from the solar panel [15]. During this emerge, we are able to incarcerate additional sun rays. Movement in two axes is explained with the assist of "Fig. 2," that's explaining basic plan in the rear dual axis tracking [15].

The dual-axis in service is as good as to single axis however it captures the solar energy more productively by rotating within the horizontal as well because the vertical axis the likely anticipated for dual axis tracker. 4 LDR sensors, 2 servo motor and Arduino microcontroller consists our proposed system. One rest of sensors and one motor is used to incline the tracker in sun's east – west route and the other rest of sensors and also the other motor that is mounted at the base of the tracker is used to tilt the tracker within the sun's north-south route [12].

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Fig. 2. Dual axis tracker

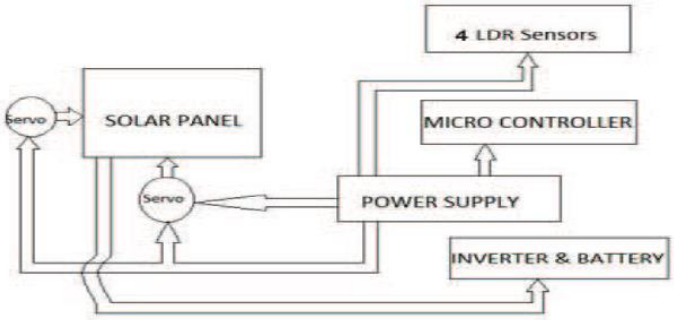


Fig. 4. Block diagram of overall system

The block diagram is showing that LDR sensors once sensing the sunshine forward the signal to Microcontroller [15]. The microcontroller is a logical device that's enchanting dealings on the root of sensor put in and starting the motor driver's track consequently [15]. Assume if the sun changes its individual locality and go from east to west, it'll cause light absorption to vary on one sensor as related to different one [15]. On the base of light intensity feature on sensors, the controller starts driver circuits and moves servo motor to new positions wherever light falling on sensor pairs is same [15]. The same method can maintain it up with a change in sun's locality surrounded by the sky [15]. As a result, this proposed model is able to capture supplementary sun rays and system's solar energy conversion capability is greatly superior [15]. How control algorithm is performing gesture assessment and is that the key deciding constituent which shows it in "Fig. 5," [15]. When it collects data from LDR sensors then main algorithm is starts. Sensor's productivity is analogue that's stimulated to digital signals.

This serviceable task is performed using analogue to digital converter (ADC) [15]. Digitized signals are forwarded to Arduino microcontroller [15]. After collecting digital signals, it decides relating to the movement direction and steep angle of servo motors [15]. Control algorithm is viewing that Arduino microcontroller drives servo motors as long as sensor light sensing is not equal to one another and if sensor signals are equal. It goes to start of the algorithm. This methodology is incessant till light falling on detector pairs is equal and PV panel is adjusted in a position for optimum power [15]. The voltage generated by the solar panel is assorted and desires to be synchronized [15]. A regulator is often used when the solar panel which may regulate the voltage coming back from solar panel [15]. For this principle, supply is provided by generated solar energy [15]. There is not any would like to give exterior power supply that makes our system economical and cost effective too [15]. The purposed model can also use as an impartial system by introducing battery storage and proper supervision of storage system [15]. Battery storage is controlled by the thought of generated voltage [15]. Charging and discharging events for storage are electing the idea of generated voltage [15].

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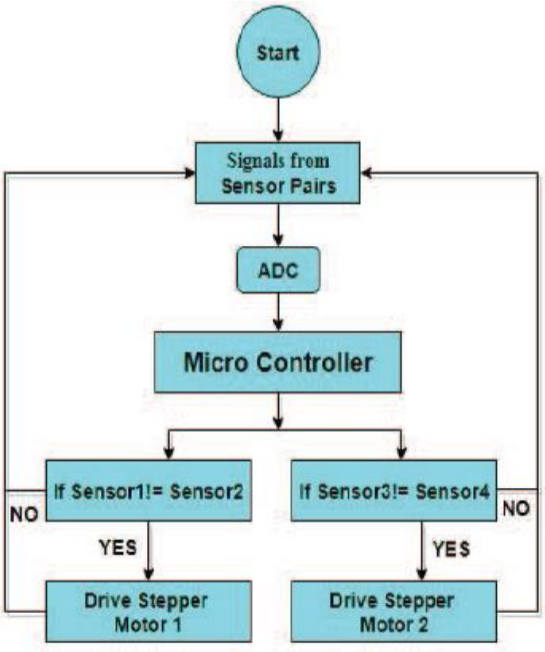


Fig. 5. Control algorithm

## HARDWARE IMPLEMENTATION

In all earlier section details of control formula and block diagram of proposed dual axis were represented [15]. Currently, we tend to return to the hardware implementation of the planned model [15]. We have implemented the planned system a lot of and final hardware model is shown in *"Fig. 6,"* For sustaining of the hardware we tend to devise a support model that is shown in *"Fig 6"* [15]. This support model is of 2 feet height. For higher control of tracker altitude of the panel is increased and it should be placed in open air atmosphere [15].

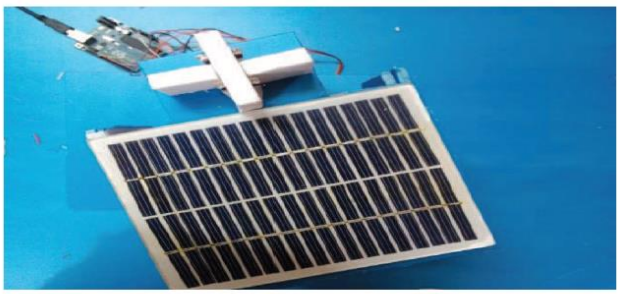

Fig. 6. Setup the main frame and hardware system

PV panel used for hardware accomplishment is 36-watts and it's of mono crystalline type [15]. Two servo motors of static magnet types are used. Servo motor moves in steps and is best suited for correct position control [15]. PIC microcontroller is used for controlling purpose that is less complicated to use as compared to microcontroller ATMEL family [15]. Details of PV Panel ratings, LDR sensors and servo motor ratings for our hardware design are enlisted in Table I [15].

TABLE I. COMPONENT RATINGS

| Component Name | Component Ratings |
|---|---|
| PV Panel Dimension | 16×16 inches square |
| PV Panel Rating | 35 Watts |
| PV Panel Material | Mono crystalline |
| Servo Motor | 5v, 0.6 A, 9gr Servo HXT900 |
| Controller | Arduino Uno |
| LDR | GM 9516 |

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## CHARGE CONTROLLER

A charge controller [8], or charge regulator is fundamentally a voltage and current regulator to stay batteries from overcharging. It regulates the voltage and current from the solar panels reaching to the battery. It prevents overcharging and will shield against overvoltage, which might scale back battery performance or period of time, and will create a safety risk. It is going to additionally prevent fully draining ("deep discharging") a battery [9], or perform controlled discharges, counting on the battery technology, to guard battery life. The charge controller is located in between the output of the solar battery and therefore the input of the battery holder. Once the intensity of daylight is high then solar battery produces more electricity, and once daylight is a smaller amount then produces less electricity. The charge controller is used to calming the variation in electrical input to the battery [10]. It furthermore prevents over charging of the battery thereby increasing its life. A superfluous function of the charge controller is to stop reverse current flow, predominantly during night times.

## EXPERIMENTAL RESULT

Experimentations outcomes were performed by placing the proposed system in the rooftop. These annotations were performed. The output power data is collected during 8:00 A.M. to 6:00 P.M.

TABLE II. FIXED SOLAR PANEL MODULE

| Time | Voltage(v) | Current(A) | Power(watt) |
|---|---|---|---|
| 8:00 | 7.51 | .02 | 0.15 |
| 9:00 | 8.70 | 0.10 | 0.87 |
| 10:00 | 15.08 | 1.12 | 16.89 |
| 11:00 | 17.10 | 1.18 | 20.18 |
| 12:00 | 17.18 | 1.12 | 19.24 |
| 13:00 | 17.76 | 1.14 | 20.25 |
| 14:00 | 17.72 | 0.83 | 14.71 |
| 15:00 | 17.79 | 0.92 | 16.36 |
| 16:00 | 15.08 | 0.56 | 8.44 |
| 17:00 | 6.45 | 0.17 | 1.09 |
| 18:00 | 6.44 | 0.11 | 0.70 |

Table II shows the output power for fixed module.

TABLE III. SINGLE AXIS TRACKER MODULE

| Time | Voltage(v) | Current(A) | Power(watt) |
|---|---|---|---|
| 8:00 | 4.57 | .001 | .0045 |
| 9:00 | 8.97 | 0.73 | 0.5481 |
| 10:00 | 15.1 | 1.34 | 20.24 |
| 11:00 | 16.48 | 1.35 | 22.25 |
| 12:00 | 14.31 | 1.37 | 19.61 |
| 13:00 | 16.53 | 1.62 | 26.77 |
| 14:00 | 15.18 | 1.17 | 17.76 |
| 15:00 | 15.87 | 1.15 | 18.25 |
| 16:00 | 15.88 | 1.19 | 18.89 |
| 17:00 | 13.49 | 0.65 | 8.76 |
| 18:00 | 5.7 | 0.18 | 1.026 |

Table III shows the output power for single axis solar tracking system.

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TABLE IV. DUAL AXIS TRACKER

| Time | Voltage(v) | Current(A) | Power(watt) |
|---|---|---|---|
| 8:00 | 9.18 | 0.1 | 0.92 |
| 9:00 | 16.55 | 1.16 | 19.19 |
| 10:00 | 21.16 | 1.46 | 30.89 |
| 11:00 | 21.82 | 1.49 | 32.51 |
| 12:00 | 22.07 | 1.53 | 33.76 |
| 13:00 | 22.12 | 1.67 | 36.94 |
| 14:00 | 21.44 | 1.38 | 29.58 |
| 15:00 | 20.58 | 1.34 | 27.57 |
| 16:00 | 20.47 | 1.29 | 26.40 |
| 17:00 | 19.58 | 1.26 | 24.67 |
| 18:00 | 11.49 | 0.65 | 7.46 |

Table IV shows the output power for dual axis solar tracking system. As we know that single axis solar tracker system is not capable to cover all intensity of the sun light. As a result, single axis solar tracker system is better than a fixed module. In single axis solar tracker unable to collect the expected solar energy from sun light as we expected. Because single axis solar tracker system only tracks the single axis of the path of sun not the dual axis. That's why we proposed to set up dual axis solar tracking system in the rooftop of every building.

TABLE V. GENERATED POWER FOR THREE CASES

| Time | Fixed Array (watt) | Single Axis (watt) | Dual Axis (watt) |
|---|---|---|---|
| 8:00 | 0.15 | .0045 | 0.92 |
| 9:00 | 0.87 | 0.5481 | 19.19 |
| 10:00 | 16.89 | 20.24 | 30.89 |
| 11:00 | 20.18 | 22.25 | 32.51 |
| 12:00 | 19.24 | 19.61 | 33.76 |
| 13:00 | 20.25 | 26.77 | 36.94 |
| 14:00 | 14.71 | 17.76 | 29.58 |
| 15:00 | 16.36 | 18.25 | 27.57 |
| 16:00 | 8.44 | 18.89 | 26.40 |
| 17:00 | 1.09 | 8.76 | 24.67 |
| 18:00 | 0.70 | 1.026 | 7.46 |

In Table V shows the assessment of output power is shown in tabular form for three cases. We are liable to performed graphical comparison for three cases by plotting three power curves for three cases with the help of information provided in Table 5. In *"Fig. 7,"* shows the graphical evaluation of output power for three cases and those data was represented experimental data. Graphical evaluation is undoubtedly showing the improved solar energy conversion for dual axis tracking case [15]. Though single axis solar energy conversion curve is higher on top of the fixed PV array system, however, dual axis is showing higher influence as compared to the single axis. Dual axis system high power capturing property is obvious from the graphical comparison [10].

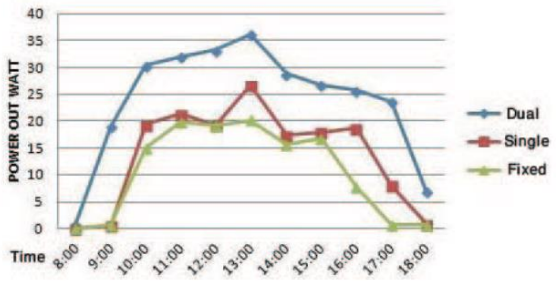


Fig. 7. Graphical comparison of experimental data

Except for dual axis solar tracking system there is some other available technique for solar power tracking system such as power towers, parabolic trough concentrator, central receiver concentrator, parabolic dish concentrator etc. All of this system is very efficient and produce more electricity. But all of are very expensive to setup. If our proposed system compared to all of this available solar tracking system, the dual axis solar tracking system is more efficient, easy to setup and cost effective.

## CONCLUSIONS

Dual axis tracker utterly aligns with the sun route and tracks the sun movement in a very a lot of cost-effective looms and includes a marvellous performance upgrading. The investigational outcomes clearly show that dual axis tracking is good enough than single and fixed solar systems. The proposed system is value effective conjointly as a stroke adjustment in single axis tracker provided notable power increase within the system. Through our experiments, we've got found that dual axis tracking will increase energy by about 40% of the fixed arrays. With a lot of works and higher systems, we tend to believe that this figure can raise more.

## FUTURE WORK

Commercially, dual axis solar tracking is still rare even in countries wherever a major part of electricity is being produced by solar energy as they claim that single axis tracking is doing the work. However dual axis tracking will noticeably increase the potency. For our research work we've implemented this procedure on a sporadic power PV panel. Cost effectiveness and proposed system potency may be discovered on a business level.

This research used mono crystalline PV panel. But a polycrystalline material-based PV panel also can be used for this proposed model. We used LDR for this proposed model but LDR is not a good choice as a sensor as it affected by dust. So, in future, we can also use the more efficient sensor. A reliable structure is very expensive compared to solar panel cost; therefore, adding an additional panel to the system ins teed of spending on tracking structure is much more cost effective.

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