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Automatic Dual Axis Solar Tracking System using Arduino Uno

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Abstract:

Energy crisis is the most important issue in today's world. Conventional energy resources are not only limited but also the prime culprit for environmental pollution. Renewable energy resources are getting priorities in the whole world to lessen the dependency on conventional resources. Of all the renewable energies, solar energy is the only energy gained its popularity and importance quickly. In year 1985, Silicon Solar cells were introduced for the first time, and its efficiency was about 20%. Though various attempts were made to increase the efficiency of solar cells, but still perfection was a far-fetched goal for it. Consequently, peoples were forced to purchase a number of panels in order to meet their energy demands or purchase single systems with large outputs. Availability of the solar cells types with higher efficiencies is provided, but they are too costly to purchase. So, to make effective use of solar energy, its efficiency must be maximized. There are numerous ways to increase the solar panel efficiencies. Still one of the ways have to be selected for accomplishing the said purpose while reducing costs. Thus, for the extraction of maximum energy from the sun, simple tracking solar system using servo motors and light dependent sensors has been developed. Tracking helps in the wider projection of the panel to the Sun with increased power output. It could be dual or single axis tracker.

Keywords **—Dual axis solar tracker, Solar tracking system, Renewable energy, Arduino, LDR sensors.**

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I. INTRODUCTION

Increased energy demand, continued drawbacks of existing fossil fuel sources, and growing concerns about pollution, pushed researchers to look at new technologies for producing electricity from clean, renewable sources such as solar and wind. Solar energy is the world's oldest primary energy source. It is a clean, renewable energy source that may be found in abundance all around the globe. It is possible to transform solar energy into mechanical energy or electricity with sufficient efficiency using solar energy.For the development of a solar energy system, information about the quality and amount of solar energy available at a certain area is important. However, the amount of electricity generated is proportional to the amount of solar Radiation that strikes the photovoltaic panel.

A lot of scientists and engineers have investigated the efficiency of photovoltaic systems in order to obtain a larger amount of solar energy. In general, there are three strategies to improve photovoltaic system efficiency. The first technique is to improve the efficiency of solar cells' power output, the second is to improve the efficiency of energy conversion control algorithms, and the third is to use a tracking system to maximize solar energy. When a panel is fixed, they are tilted in ground or on a roof at an angle appropriate for sun's radiation. In solar trackers the panel is made to rotate in the directions with respect to sun. This paper presents a design and implementation of solar trackers to improve the overall efficiency of solar energy power plants.

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II. LITERATURE REVIEW

In "Bhagwan Deen Verma, Anurag Gour, Dr Mukesh Pandey, 2020, IJERT, A Review Paper on Solar Tracking System for Photovoltaic Power Plant" says that solar energy is a renewable energy using everywhere. In this paper explanation of solar tracker and fixed PV solar system and a comparison of efficiency of single axis solar tracker, dual axis solar tracker and fixed solar PV panel solar tracker produces the electricity in large amount because of their tracking technology, solar panel always track the sun as compared to fixed mounted PV system. Solar system produces more energy when sun is perpendicular to PV panel. At a perfect angle solar system consume large amount of solar rays and produce electrical energy. Solar tracker can adjust their angle towards the sun automatically, therefore they produce more energy. Fixed mounted PV panels are constructed at a fixed angle so they cannot consume sun rays all over day. [1]

According to "A.R. Amelia, 2020, IOP Conference Series: Materials Science and Engineering, Technologies of solar tracking systems" Green renewable energy systems have tremendous potential. The solar PV system has the potential to phase out fossil fuel-based power generation methodologies and deal effectively with GHG emissions and climatic concerns associated with it. However, the PV system's potential is limited to many factors involving technological, environmental, and orientational, i.e., its proper adjustment with respect to the Sun's movement, etc. However, PV system adjustment, i.e., tracking schemes, can improve its solar radiation intercept, energy production, and GHG mitigation potential even in the presence of technological and environmental limitations. For better understanding, a 1 MW dual-axis tracking scheme- based PV system located at Townsville has the equivalent potential to avoid 1852.7 tons CO_2 per annum, which takes 421.1 acres of forest or 170.4 hectares of forest to absorb. It is equivalent to recycling 638.9 tons of waste. Tracking schemes of a PV system have the potential to mitigate GHG emissions with a direct impact on energy production. Future work involves practical justification of the PV system's tracking impacts on energy and GHG mitigation potential and life cycle analysis of the PV system for complete direct and indirect GHG emission in all phases, i.e., materials extraction to disposal. [2]

"Deekshith K, Dhruva Aravind, Nagaraju H, Bhaskar Reddy, 2015, International Journal of Scientific & Engineering Research, Solar tracking system" gives a brief overview of solar tracking system based on microcontroller and also describes about the simple and attractive features of tracking system. This solar tracker operation costs and maintenance cost are comparatively low. Here the use of stepper motors in solar trackers enables accurate tracking of the sun and light dependent resistor are used to determine the solar light intensity. The paper concludes that solar tracking system provides more effective method to track the solar insolation and provide economic consistency for generation of electric power. Solar power technology is constantly advancing and improvements will intensify in future. [3]

"Emmanuel Karabo Mpodi, Zeundjua Tjiparuro, Oduetse Matsebe, 2019, 2nd International Conference on Sustainable Materials Processing and Manufacturing,Review of dual-axis solar tracking and development of its functional model" presents a solar-tracking method design and implementation for experimental sun follower platforms. The presented control algorithm commands the movement of a photovoltaic module in order to follow the sun's radiation and to maximize the obtained solar energy. The programming environment (LabVIEW) in which the presented algorithm is developed allows designers faster and easier development of block diagrams for any type of data acquisition, analysis, and control application. This implementation technique reduces the costs of tracking method and makes it a cost-effective technology. Regarding future work, this will follow two main directions. First, extensive experimental evaluation has to be carried out in order to validate our approach. Second, a comparison between different control strategies in similar operating scenarios will lead to choosing the best solution depending on the situation. [4]

III. PROBLEM FORMULATION

All In earlier stages, the solar energy power plants were based on fixed mount solar PV panels. A fixed array of panels is the easiest type of solar system to build. First, we fix a support structure to the ground or a building. Then we attach solar panels on top of the structure. These systems are simple to build with very little material, and in any shape or size. Since they have no moving parts, fixed systems are resilient and need little maintenance. But this system has a downside. As we know that solar panel produce maximum energy when the solar radiation falls perpendicularly on a PV cell. But the sun moves continuously in the sky and throughout the season, and the angle between the solar light and the fixed panel continuously changes. Hence, the PV are not aligned to sunlight and it produce low energy. That means we cannot make optimum use of solar panel by using fixed mount solar panels.

So, to make the best use of solar energy, solar tracking systems are used. In this method, the array solar panels are attached to a motor along with some sensors to make an automatic solar tracking system. These arrays follow the sun, increasing their energy production. Solar trackers are either single axis (they move in one direction, following the sun throughout the day), or dual axis (they follow the sun throughout the day, and adjust for the time of year). The amount of output mainly depends on the cosine angle of incidence which is known as the angle between the sunray and horizontal surface. As compared the efficiencies of static panels and tracking systems of single axis and dual axis fixed mount. The readings are taken from morning 8 AM to evening 7 PM for a fixed panel, single-axis tracker and dual-axis tracker for every one hour. The results say the efficiency of the single-axis tracking system over that of the static panel is calculated to be 32.17%.[6]

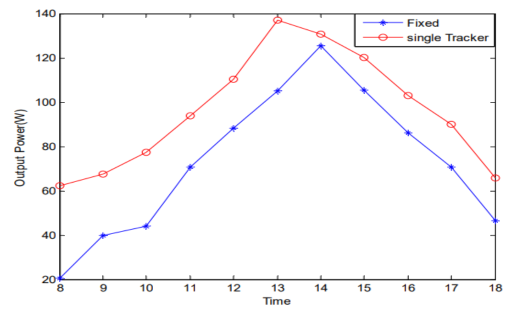

Fig 1 Power Output comparison between fixed system and single-axis tracker system

HOUR	POWER FOR FIXED MOUNT(mW)	POWER FOR SINGLE-AXIS(mW)
0800	20.664	62.403
0900	39.780	67.473
1000	44.176	77.212
1100	70.616	93.772
1200	88.110	110.430
1300	104.960	137.160
1400	125.334	130.754
1500	105.342	120.335
1600	86.172	103.096
1700	70.620	89.910
1800	46.494	65.625

Table 1 *Power Output comparison between fixed system and single-axis tracker system*

IV. METHODOLOGY

AllThe main intention of this project is to design a high-quality solar tracker. The project is divided into two parts: hardware and software.

A. Hardware

The main components of hardware in this project are solar panel, Light Dependent Resistor (LDR), Servo Motor and Arduino-Based Controller. A brief description of all the components is given below.

1) ***Light Dependent Resistor (LDR):***Photo resistor or light dependent resistor (LDR) showing in Fig 2 is a resistor in which the resistance decreases with increasing incident light intensity or exhibit photoconductivity. LDR output voltages for light intensity are shown in Table 2. The resistance of an LDR is extremely high, sometimes as high as 1 Mohms. The light resistances will drop dramatically when illuminated.

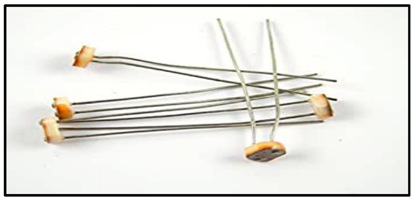

Fig.2 Light Dependent Resistor (LDR)

SR. NO.	LIGHTINTENSITY	LDR OUTPUT(V)
1.)	Dark	0.4
2.)	Average	4.0
3.)	Bright	4.6

Table 2 Light intensity measurement

2) ***Solar Panel:***Solar panels are devices that convert light into electricity. They are called "solar" panels because the most powerful source of light available is the sun. Fig 3 is a solar panel packaged, connected assembly of photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications.

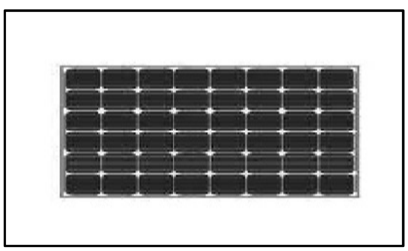

Fig. 3 Solar Panel

3) ***DC Geared Motor:***A servo motor is an electrical device which can push or rotate an object with great precision. It rotates an object at some specific angles or distance. A servo motor showing in Fig 4 is just made up of simple motor which run through servo mechanism. It can reach a very high torque in a small and light weight package. Due to these features, they are being used in many applications like Robotics, machines, cars etc. A servo motor can usually only turn 900 in either direction in for a total of 1800 movement. Servo motors are rated in Kg/cm (kilogram per centimetre). This Kg/cm tells how much weight the servo motor can lift at a particular distance. The position of a servo motor is decided by electrical pulse and its circuitry is placed beside the motor.

Fig. 4 DC Geared Motor

4) ***Arduino:***Photo resistor or light dependent resistor (LDR) showing in Fig 5 is a resistor in which the resistance decreases with increasing incident light intensity or exhibit photoconductivity. 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.

Fig. 5 Arduino Board

B. Software

The software part consists of a programming language that is constructed using C programming. The codes are targeted to Arduino UNO to be compiled and uploaded. The flow of the software procedure is shown in Fig 6.

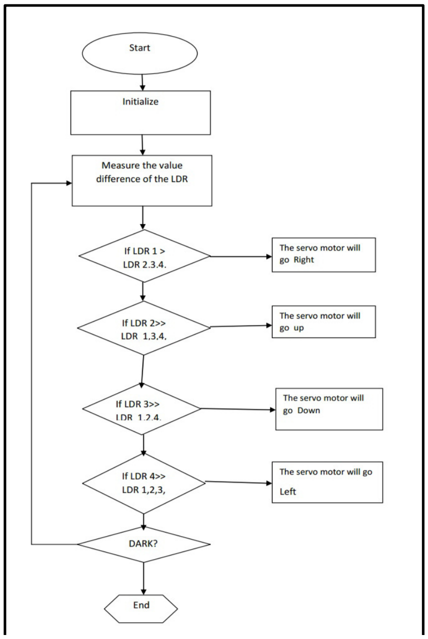

Fig. 6 Flowchart for the overall process

C. Circuit Diagram

The circuit design of solar tracker is simple but setting up the system must be done carefully. Four LDRs and four 100KΩ resistors are connected in a voltage divider fashion and the output is giving to 4 Analogue input pins of Arduino. The PWM inputs of the two servo motors are given from digital pins 9 and 10 of the Arduino. The circuit diagram of this project is shown in Fig.7.

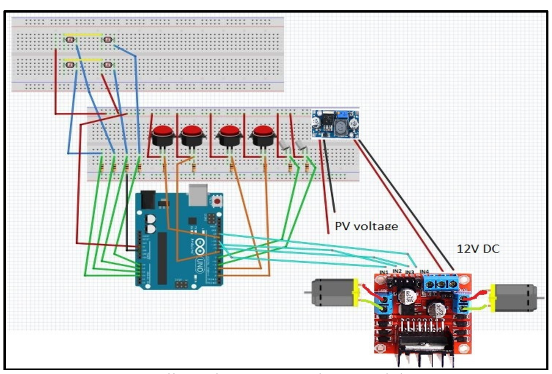

Fig.7 Breadboard connection layout of the project

Fig.8 Pictorial view of complete project

V. COMPARISON OF DUAL AXIS WITH FIXED SOLAR TRACKING SYSTEM

There is alloy of performance analysis is done by many researchers for Dual axis solar tracker with fixed solar PV system. Here are few points as given below: -

1 Dual axis solar tracker designed by using Arduino. Arduino control the movement of solar panel surface. The result is compared with fixed solar panel which is tilted 32 degrees towards south. And it is measured that dual axis solar tracker produce daily 40% more energy than fixed solar system.

2. The design of two axis solar tracker system is proposed with open loop control system of electric drive which gives good results in terms of tracking the motion of the sun. With the proper selection of elements of electric circuit and photo sensors is being used for the system control the tracking of the sun is very accurate. The result was evaluated that two-axis solar tracker is produced more amount of electrical energy about 27% than fixed solar PV system.

3. A continuous dual axis solar tracker was designed with some electronics elements such as Arduino, LM298n motor driver, an h-bride dc-dc buck converter, 4 photo resistors or LDR, resistors, and last but not the least a 60 watt PV panel. Programming of Arduino is based on C/C++

programming language which is required to make our model Automatic in tracking the sun.

4. Dual axis solar tracker [9] is designed that implement sun trajectory path algorithm to show the solar tracker position. This system uses GPS sensor to identify the solar panel position that is referring to longitude and latitude lines. The azimuth and altitude angle are employed to feed directly the positioning controller which command the motor to move either clockwise or anti clockwise. The result show that in clear weather and cloudy weather, the output energy is increased by 26.9% and 12.8 % for dual axis solar tracker when compared to fixed solar PV system.

VI. Result and Discussion

The table below shows the voltage drawn by the solar panel with and without tracking. The maximum generation on power is between 12 to 2pm.

Time	Voltagewithout tracking	Voltage with Tracking
11:10 AM	13.97	18.96
12:10 PM	9.63	19.82
1:10 PM	10.62	18.79
2:10 PM	11.60 V	20.01 V
3:10 PM	8.29 V	19.54 V
4:10 PM	7.23 V	18.63

Table 3 Voltage comparison with and without tracking

VII. CONCLUSIONS

In this project, the sun tracking system is developed based on microcontroller. The Arduino Uno is used in this system with a minimum number of components and the use of DC servo motors enables accurate tracking of the sun. It has been observed that the sun tracking systems can collect maximum energy than a fixed panel system and high efficiency is achieved through this tracker, it can be said that the proposed sun tracking system is a feasible method of maximizing the light energy received from sun. This is an efficient tracking system for solar energy collection. The method implemented in this project is simple, easy to maintain and requires no technical attention for its operation. The software developed for this work is easy to manipulate. The solar module with tracking system can collect maximum energy over a static module. Hence implementation of this technique in building solar systems will greatly improve utility satisfaction.

VIII. FUTURE SCOPE

The Solar Tracking system is an open book meaning that it has a great scope for research purposes. The primary reason for the development of tracking system is lower efficiency and low production of electrical power, of previous model of solar energy system. However, the energy production from solar tracking system has been increased to a great extent, but it has a potential to increase the power production even more.

The efficiency of the dual-axis tracking system can be increased even more by placing a mirror or concave lens on top of the panel. The use of lens or mirror increases the tracker's efficiency since large amount of sunlight is concentrated on the panel and large power is generated. It can also reduce the size of the solar cell required to generate large power. It also has high optical efficiency.

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