JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

AUTOMATIC DUAL AXIS SOLAR TRACKING SYSTEM

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Abstract: The energy potential of the sun is immense. Despite the unlimited resource, harvesting it presents a challenge because of the limited efficiency of the photovoltaic cells. The best efficiency of most commercially available photovoltaic cells ranges between 15 and 20 percent. This paper seeks to identify a way of improving solar panel system efficiency by implementing a solar tracking method. The tracking mechanism rotates the solar panel such that it is positioned for maximum power output. The three ways of increasing the efficiency of solar panels are through increasing cell efficiency, maximizing the power output, and the use of a tracking system. Maximum Power Point Tracking (MPPT) is the process of maximizing the power output from the solar panel by keeping its operation on the knee point of P-V characteristics. MPPT technology will only offer maximum power which can be received from stationary arrays of solar panels at any given time. The technology cannot however increase the generation of power when the sun is not aligned with the system. Solar tracking is a system that is mechanized to track the position of the sun to increase power output by between 15 to 20 percent compared to stationary systems. It is a more cost-effective solution than the purchase of additional solar panels.

***IndexTerms* – Solar Tracker, Motor, Buck Converter, Arduino, Light Dependent Resistor.**

I. INTRODUCTION

In this chapter, the fundamental understanding of solar energy, its necessity, the technology to harness this energy and also shortcomings of such technology are discussed. Here the rotation and revolution of Earth are highlighted so the supply of radiation as fuel is understandable through various angular parameters. Solar energy is energy radiated from the sun in the form of light and heat. The quantity of irradiation reaching the planet's surface is enough to fulfil the energy necessity of the earth. A fraction of this energy is converted to a usable form for industrial, commercial, and residential applications. To utilize solar energy a static, semiconductor device known as Solar panels is used which we convert the solar energy to electricity. Nowadays, because of the decreasing amount of renewable energy resources, the per watt cost of alternative energy produced by solar panels became crucial for it to be applied on an industrial scale. The solar panel is set to become mainstream in electricity generation if it overcomes its shortcomings, within the coming years as technological advancement improves both cost and efficiency the solar panel can become a major producer of electricity for the grid. The main good thing about solar power over other conventional power generators is that the daylight will be directly converted into solar power with the employment of the tiniest photovoltaic (PV) solar cells. The foremost advantages of solar power are that it's free, reachable to people and available in large quantities of supply compared to the worth of assorted fossil fuels and oils [1].

Solar radiation is received in three ways: direct, diffuse and reflected. Direct radiation is additionally brought up as beam radiation and is the radiation which travels on a line from the sun to the surface of the planet. Diffuse radiation is the description of the daylight which has been scattered by particles and molecules within the atmosphere but still manages to succeed on the surface. Diffuse/scattered radiation has no definitive direction, unlike direct radiation. Reflected radiation describes sunlight which has been reflected and removed from non-atmospheric surfaces just like the ground [2].

The objective of the research work discussed in this paper is to design and implement a dual axis tracker system which could increase the overall solar system efficiency for various solar panel configurations used both on a domestic and industrial scale, by just keeping the solar panels perpendicular to the solar radiation at any given time which would increase the net energy production of the system due to the maximum power operation of the panel even in non-peak hours of the day.

The remaining paper is organized as follows. Section II describes the working methodology, section III the hardware components. Section IV briefly describes the flowchart for the software program of the solar tracker. Section V outlines the frame design, Section VI results and Finally, Section VII concludes the paper.

II. WORKING METHODOLOGY

The building blocks of the proposed model are shown in below Fig.1. The major components are solar panel, MPPT, Arduino, and motor controller. The project is based on an ATMEGA328P controller. The system uses a solar panel and LDR sensor to sense the sun's position. Panel along with four LDRs is mounted on the panel. The complete panel is mounted on a DC motor-based TILT unit. The microcontroller senses the sun position using an LDR sensor, two sensors are used for sensing the X-axis position and the remaining two LDR sensors are used for sensing the Y-axis position. The data is processed in the microcontroller and the controller sends the position values to motors which move the panel in the sun direction. The motors are categorized as azimuth control motor and elevation control motor, both motors respond to the signal provided by LDR.

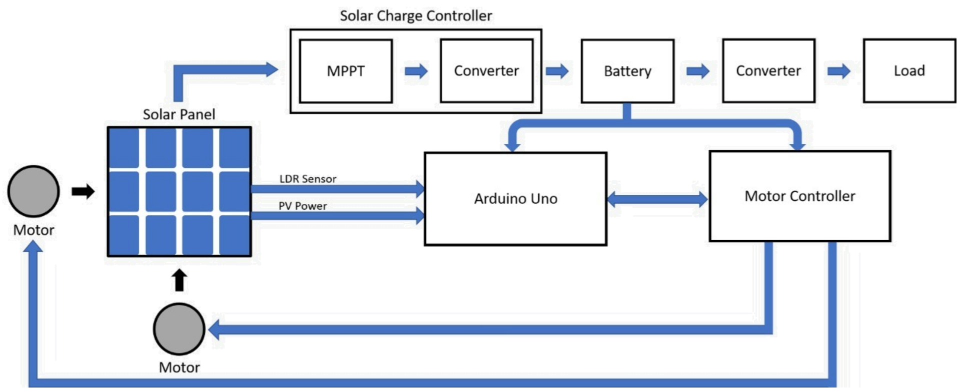


Fig.1 Block Diagram of Dual axis solar tracker

LDR sensor modules are mounted on the edge of the solar panel, in which the opposite mounted LDR modules controls one axis of rotation. When the light source falls on the top portion of the panel the LDR senses the input and gives a signal to the elevation motor to tilt the panel, similarly when the bottom LDR senses the input it gives the elevation motor to tilt in opposite direction. The remaining sensors also work similarly only instead of the elevation motor these sensors control the azimuth motor. Depending on the sensor input the azimuth motor tilts the panel in the desired position. The Circuit Diagram for panel rotation by DC motor is shown in Fig.2.

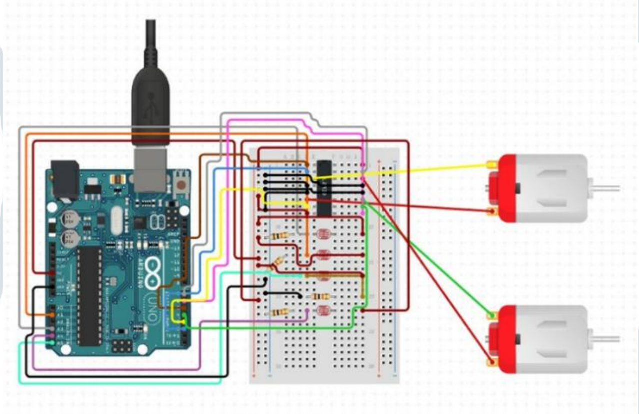


Fig.2 Circuit diagram for panel rotation

III. HARDWARE DESCRIPTION

This Section talks about the few important hardware used in the prototype and also speaks about the specifications of the technology used to achieve dual-axis solar tracking. The section also sheds light on the ICs and pieces of equipment used in developing the prototype and why they are chosen.

3.1 Solar panels

Solar Panels absorb the sunlight as a source of energy to generate electricity or heat. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications [3]. The specification of the solar panel used in the prototype is listed in Table 1.

Table 1. Specifications of Solar Panel

Maximum Power	10 W
Voltage at Maximum Power	17.71 V
Open Circuit Voltage (V_{OC})	21.60 V
Current at Maximum Power	0.57 A
Short Circuit Current (I_{SC})	0.6 A

3.2 Light Detecting Resistor (LDR)

LDR module are generally used to detect the ambient brightness and light intensity. Module light conditions or light intensity reach the set threshold, Digital Output port output high, when the external ambient light intensity exceeds a set threshold, the module Digital Output low: Digital output directly connected to the microcontroller (MCU), and detect high or low TTL, thereby detecting ambient light intensity changes; Digital output module can directly drive the relay module, which can be composed of a photoelectric switch; Analog output module can be connected through the Analog to Digital converter, you can get a more accurate light intensity value. The Fig.3 and 4 show the module and the circuit diagram of the LDR module respectively.

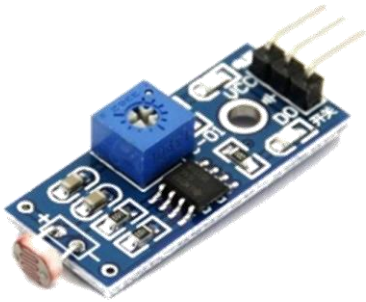


Fig.3. LDR module

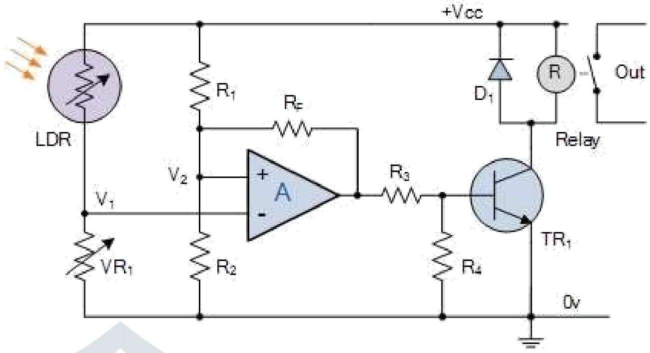


Fig.4. LDR module circuit diagram

3.3 Motor Driver IC

A motor driver IC is an integrated circuit chip which is usually used to control motors. Motor driver ICs act as an interface between microprocessors and the motors. Most commonly used motor driver ICs are from the L293x series such as L293D, and L293NE [4]. The L293D IC receives signals from the microprocessor and transmits the relative signal to the motors. It has two voltage pins, one of which is used to draw current for the working of the L293D and the other is used to apply voltage to the motors. The L293D switches its output signal according to the input received from the microprocessor. The L293D is a 16-pin IC, with eight pins, on each side, dedicated to controlling a motor.

3.4 MPPT Module

An MPPT, or maximum power point tracker is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels down to the lower voltage needed to charge batteries. The charge controller looks at the output of the panels and compares it to the battery voltage. It then figures out what is the best power that the panel can put out to charge the battery. It takes this and converts it to the best voltage to get the maximum current into the battery [5]. Fig 3.5 shows the MPPT module used in the prototype.

Fig.5 MPPT Module

IV. SOFTWARE DESCRIPTION

Fig.6 shows the flowchart that shows the flow of the program done in Arduino UNO for the working of the motor driver circuit with respect to the inputs taken from the LDR modules connected on the panel for solar tracking.

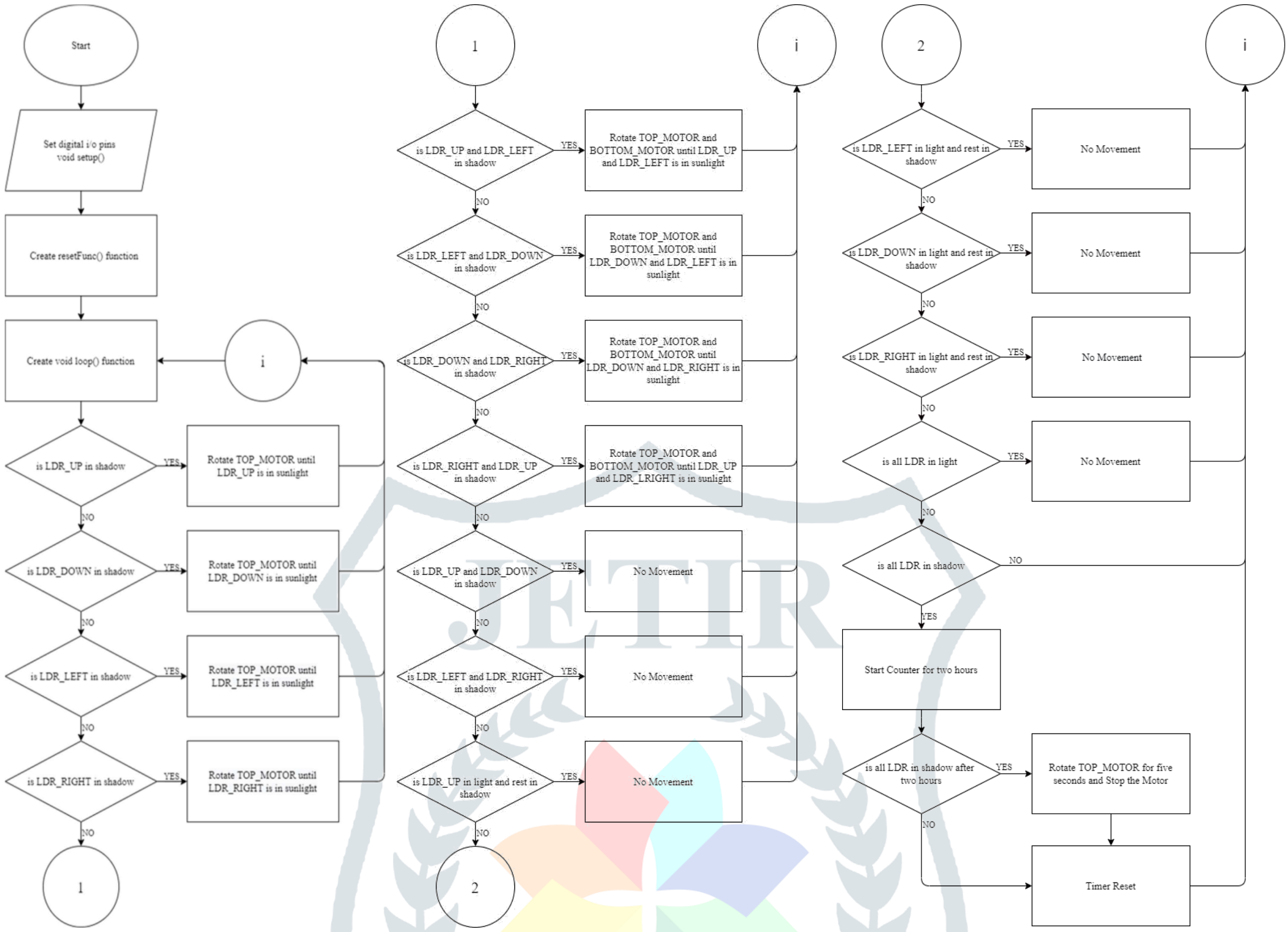


Fig.6 Flowchart for Dual-Axis Solar Tracker

V. FRAME DESIGN

The material chosen for the frame is Mild Steel. Mild Steel is easy to cut, drill and weld. Its malleability makes it easy to be shaped as needed. It has high tensile strength and high impact strength. It is most cost-effective and eco-friendly as it can be recycled indefinitely without losing its properties. The frame consists of three parts: the Solar Panel, the U-frame and the Central Stand. Fig.7 shows the structure of the frame made to hold the solar panels and the motors in place. The frame makes sure that the weight of the U-frame and the panel doesn't directly fall on the tonto shaft of the motor. A thrust bearing, shown in fig.8, is used for the distribution of weight and smooth rotation. The central stand hosts the bottom motor and U-frame holds two motors.

Fig.7 (a) Front view of the frame

Fig.7 (b) Side view of the frame

Fig.8 Thrust bearing

The motor in the stand has a vertical axis and rotates the U-frame left and right. The 2 motors on the U-frame have a horizontal axis and rotate the panel. By the means of the motors, Dual-Axis rotation of the Solar Panel is achieved. The CAD design of the frame is shown in Fig.9.

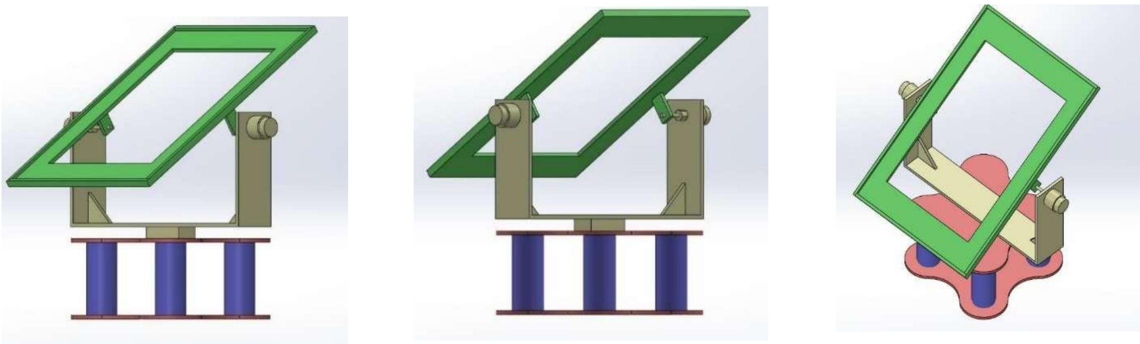


Fig.9 CAD Design of the Frame

VI. RESULTS

A prototype of the dual-axis solar tracker was implemented. The electrical output was analysed throughout the course of the project. Fig.10 shows the average power output for 1 day. The graph compares the average power output of the Stationary panel and the Dual axis solar tracker. The dual axis solar tracker gives an average power output of 4.375 W and the stationary panel gives an average output of 3.53 W in 1 day. The results show that there is an improvement in the power output due to the implementation of dual-axis trackers.

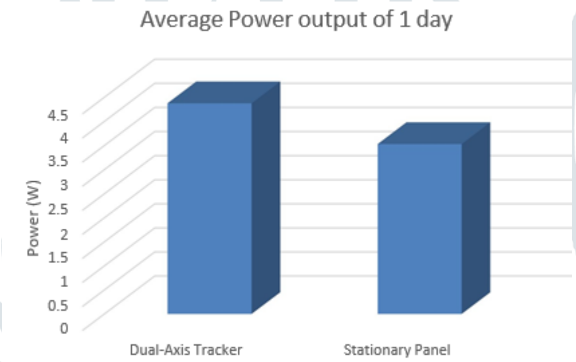
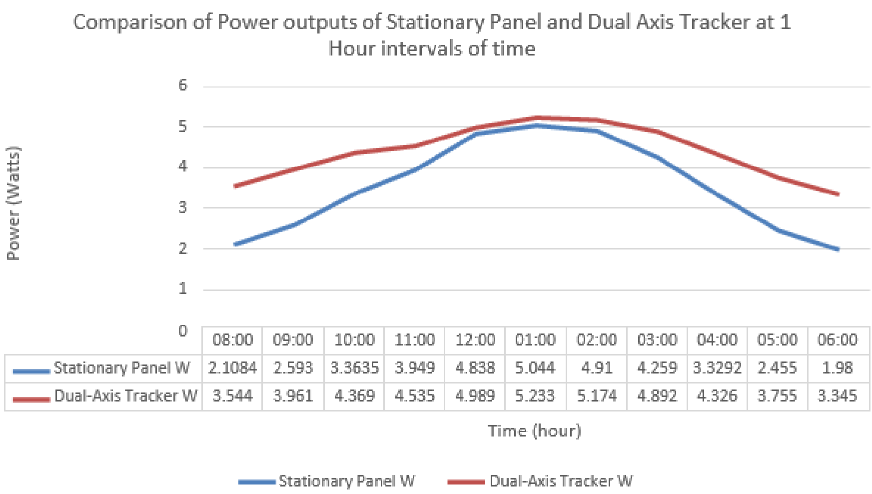


Fig.10. Average power output

The outputs were also analysed at 1-hour intervals throughout the day. The comparison of the hourly outputs is shown in fig.11. Due to the implementation of the dual-axis tracking system, it can be seen that there is an improvement in power during non-peak hours. The overall power of the dual-axis solar tracking system is 19.31% higher than that of the fixed panel. Hence replacing this system with a fixed solar panel will increase the annual power output, which will reduce the payback period of this system and also reduces the cost as more power can be drawn from lesser solar panels.



	08:00	09:00	10:00	11:00	12:00	01:00	02:00	03:00	04:00	05:00	06:00
Stationary Panel W	2.1084	2.593	3.3635	3.949	4.838	5.044	4.91	4.259	3.3292	2.455	1.98
Dual-Axis Tracker W	3.544	3.961	4.369	4.535	4.989	5.233	5.174	4.892	4.326	3.755	3.345

Fig.11 Comparison of Output Power

VII. CONCLUSION

A prototype of the automatic dual-axis solar tracking system with a uniquely designed sun-position tracker mechanism has been implemented in this Project. The proposed model of the dual-axis solar tracker tracks the sun throughout the year. The dual-axis tracker provides higher output power when compared to a fixed panel. According to the measured readings, the dual-axis tracker's power output is 19.31% higher than that of the fixed panel. The dual axis solar tracker has a 19.31% greater power output compared to fixed panel.

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