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DUAL AXIS SUNLIGHT TRACKING SYSTEM WITH INVERTER AND PWM CHARGER

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ABSTRACT

The main goal of this research project was to improve the efficiency and convenience of solar energy generating. Energy outages have become a significant issue in our nation due to a massive energy shortage of between 3000-7000MW, which causes load shedding for 6–13 hours every day. One of the finest options to address this problem is solar energy. As the position of the sun changes from east to west and north to south during the year, the angle of the incoming solar energy is squandered because the solar panel is only tilted in one direction. I therefore chose this topic appropriately so that the solar panel moves with the aid of LDR (Light Dependent Resistor) sensors to track the sun's energy and maximize its use. When the sunlight moves or there is any lack of light, the micro-controller sensor-based circuit signals the DC gear motors to move in either the east or west and north or south routes. Because it is susceptible to both over voltage and under-voltage, a circuit known as a charge controller was created to regulate the level of charging and discharging. In essence, it turned charging on when the battery wasn't fully charged and off when it was. The idea allows us to provide 40–60% more electrical energy than a stationary solar system. Lastly, a high frequency inverter using a push-pull architecture transforms DC power into AC power.

Keywords: Solar panel , PWM charger , Dual Axes Track , Load.

I. INTRODUCTION

The world has witnessed a surge in renewable energy systems in recent decades due to the depletion of fossil fuel resources. The globe is paying more focus on renewable energy systems as a result of the depletion of fossil resources. Over the next three decades, the world's energy need will nearly quadruple. Energy will only be available for the next two millennia due to the depletion of fossil resources [1]. One of the most potential sources of energy for the future is solar energy. Thankfully, Pakistan is located in an area of the world with abundant solar energy and year-round sunlight. Figure 1 displays the annual total of the world's irradiation. It is evident that the annual total of global irradiance in Pakistan is relatively high, at over 2000 kWh/m2. Approximately 2,200 to 2,500 hours of sunlight are received by the majority of Pakistani cities [2]. Developing effective solar systems that can capture the most power is necessary to meet the energy demands of a nation like Pakistan. Systems that rely on solar energy can increase their output power in two ways. Using various efficient materials to make photovoltaic (PV) cells or tracking the sun with a solar tracker are two examples. It is not a good idea to utilize an immovable PV array system because the sun's position and trajectory change during the day. An automatic solar panel that actually tracks the sun to maximize power is called a solar tracker [3].Currently, several sun tracking systems have recently developed. In [4], a single axis tracker with a low profile is introduced. The tracking system's drawback is that it only tracks one axis because the sun's location in the sky changes with the seasons (elevation) and the time of day.While single axis solar trackers are better than fixed PV arrays at converting solar energy, they are not able to precisely align the path of the sun. We employ a dual axis solar tracker to increase the sunlight conversion. In [5], a picture-processing-based computer tracking system is built. Picture processing tracking [6] is a less precise approach that requires intricate computations and has a low degree of accuracy. The advantages and disadvantages of several sun-tracking system types are examined in [7]. [8] Provides several both passive and active tracker topologies. A robust fuzzy-neural-network (FNN) control system is implemented to control a dual-axis inverted- pendulum mechanism that is driven by permanent magnet (PM) synchronous motors in [9]. However furzy logic based control has disadvantage as fuzzy logic rules are time consuming or yield unsatisfactory performance. Fuzzy logic and neural networks based controls use estimation approaches.

Dual axis research employing Arduino and DC geared motors is being conducted in [10]. For dual axis tracking, the suggested system in this study uses DC motors, which offer superior control. A microcontroller is utilized in [11] to operate the PV panel on a single axis. In [12], a single axis solar tracker's performance is analyzed, and a control structure for the tracker is shown. Dual axis solar PV arrays are preferable to single axis solar tracked and fixed arrays, as demonstrated by Chaowanan Jamroen [13].

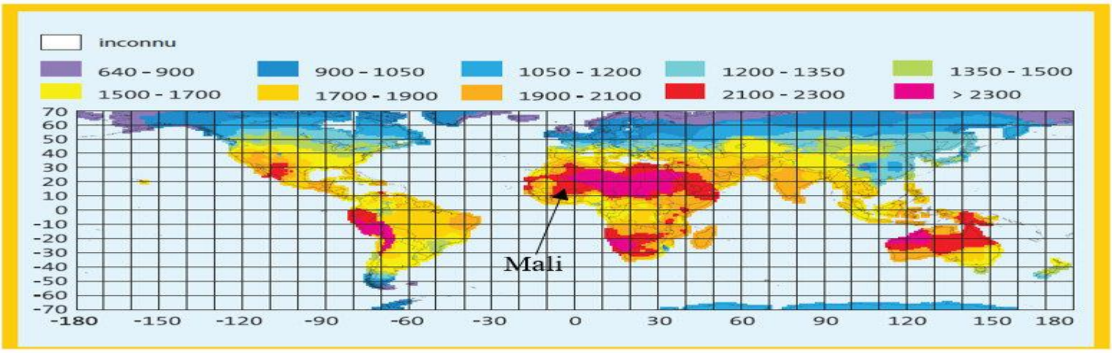

Figure 1

Designing a double axis solar tracking system with the goal of obtaining optimal power and evaluating the increase in solar conversion efficiency is the primary goal of this research model. This study also compares the suggested dual-axis solar tracker against fixed PV arrays and single-axis trackers.The section on experimental setup provides an explanation of the suggested system model. Dual axis tracking block diagram and control algorithm are developed with the aid of appropriate figures.We have carried out the intended system model on hardware, and the hardware implementation section explains the hardware design and equipment specs. The experimental results section describes the outcomes of the proposed system's hardware testing. The section on conclusions compares dual axis to other tracking systems and provides information on how efficiency might be increased. It also describes potential future research for dual axis solar tracking.

II. DEVELOPED CLOSED-LOOP TRACKING SYSTEM

Figure 2 shows the block diagram of the designed closed-loop solar tracking system, which explains the system's components and connections. How to make the photovoltaic system's location (output) as closely match the location of the sunlight (input) as possible is the solar tracking challenge for the closed-loop tracking strategy. The comparator, differential amplifier, and LDR sensor make up the sensor-based feedback controller. The LDR sensor uses the intensity of the sun as an input signal of reference during the tracking process. A feedback error voltage is produced by amplifying the voltage imbalance caused by the LDR sensor. The distinction between the location of the PV panel and the sunlight determines the error voltage. The comparator now compares the erroneous voltage to a predetermined threshold, or tolerance. In order to revolve the dual-axis (azimuth and elevation) tracking motor and turn the PV panel toward the sun, a relay and motor driver are triggered if the comparator output goes into high state. As a result, the feedback controller carries out the essential tasks: it continuously monitors the PV panel and sunlight and sends a differential control signal to operate the PV panel unless the error voltage falls below a certain threshold value.

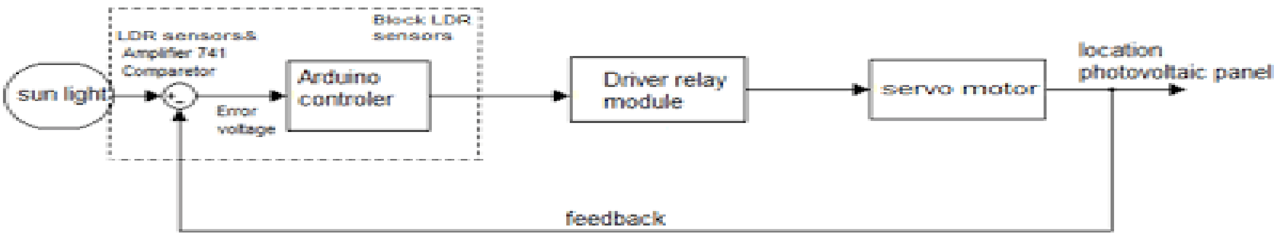

Figure 2

The system detects the Sun on its own in elevation and azimuth angles. The flowcharts in Figure 3 provide a summary of the entire working algorithms. The LDR-based sensor circuit measures the intensity of sunlight from four different directions. The sensing voltages generated by the east, west, south, and north LDRs are denoted by the voltages vE, vW, vS, and vN, respectively. Both the elevation and azimuth tracking processes can run concurrently until the PV panel is oriented perpendicularly to the sun in an effort to extract the most power possible from it. The installation of the tracker is not limited to a certain spot.

Project Design/Implementation

The entire process entails reading various sensor data and then digitally analyzing them to ascertain the sun's precise location in both east-west and north-south directions. Once more, the system receives a set of predetermined values based on the sun's location in relation to the north-south. All things considered, the system is capable of tracking the sun's movement both vertically and horizontally. The entire system is split into two sections to make the design and implementation process easier. They are as follows:

Mechanical system design

Constructing the mechanical system was the most complex component of this system because the purpose was to develop an energy efficient solar tracking system which necessitated sophisticated operations of the tracking motors. For daily tracking (east-west motion), one of these motors is often utilized, while the other is used for seasonal tracking (north-south motion). Accordingly, the yearly motion tracking motor only runs a few times a year, while the daily tracking motor runs constantly using light sensors. Therefore, the entire mechanical system is primarily separated into three sections for the design and implementation process:

1) DC Motors
2) Panel carrier
3) Panel carrier rotator

DC motors

As seen in the figure, this project typically uses two dc motors: one for daily tracking (east-west motion) and the other for creating yearly tracking (north-south motion).

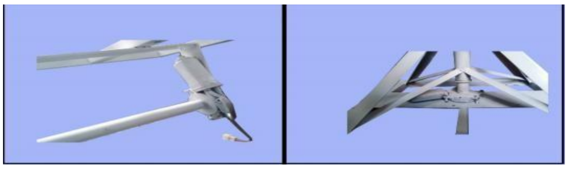

Figure 3

Chapter 1Panel Carrier

In essence, a panel carrier is an iron rectangular frame that uses a round rod to hold the solar panel in place. A single rod with a motor is attached to one end of the panel carrier's horizontal base, while the panel carrier rotator is linked to the other end. The panel carrier's design and implementation are depicted in Figure. On the iron frame's body is a DC motor with a gear. The panel actively tracks the daily motion of the sun to spin from east to west as the DC motor and its gears move.

All four light sensors are positioned at the solar panel's top midsection. Once more, the horizontal base of the rectangle iron frame features a rectangular mortise. The DC motor's single round rod hook passes through this mortise. In order to determine the tilt angle of the sun produced by seasonal or annual motion, it is helpful to raise the panel carrier in a circular motion. The panel rotates freely while the other DC motor does the same.

Chapter 2Panel Carrier Rotator

One end of the horizontal base of the solar panel carrier is secured in place by a panel carrier rotator. This rotator makes use of a single screw thread, gear, and position sensors to provide the panel carrier with a circular movement. A base made of iron supports its base. Figure 4 shows the design and implementation of the panel carrier rotator, and Figure 5 shows the experimental setup of the hybrid dual axis solar tracker.

Figures 4

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Experimental results of stationary module,Single axis and dual axis tracking

Experiments results were performed by placing the designed system in open air. Table 1, 2 & 3 show the output power for PV systems (stationary module, Single axis tracking and dual axis tracking). These observations were performed in April, 2023 for all three cases. The output power data is collected during 8:00 A.M. to 6:00 P.M. In Table 4 comparison of the output power is shown in tabular form for all three cases.

Table 1 Stationary Module

Time	Voltage(v)	Current(A)	Power(watt)
8:00	4.57	.001	.0045
9:00	8.97	0.73	0.5481
10:00	14.7	1.32	19.404
11:00	16.45	1.30	21.385
12:00	14.27	1.35	19.262
13:00	16.47	1.62	26.68
14:00	15.15	1.15	17.42
15:00	15.83	1.13	17.88
16:00	15.85	1.18	18.703
17:00	13.47	0.60	8.08
18:00	5.3	0.16	0.848

Table 2 Single Axis Tracker

Time	Voltage(v)	Current(A)	Power(watt)
8:00	7.49	.01	0.074
9:00	8.68	0.09	0.7812
10:00	15.04	1	15.04
11:00	17.04	1.16	19.766
12:00	17.14	1.12	19.196
13:00	17.70	1.14	20.178
14:00	17.68	0.89	15.735
15:00	17.77	0.94	16.7038
16:00	15.02	0.52	7.8104
17:00	6.31	0.12	0.757
18:00	6.3	0.1	0.63

Table 3 Dual axis module

Time	Voltage(v)	Current(A)	Power(watt)
8:00	9.16	0.1	0.92
9:00	16.52	1.15	18.99
10:00	21.12	1.44	30.41
11:00	21.78	1.47	32.01
12:00	22.00	1.51	33.22
13:00	22.05	1.64	34.16
14:00	21.39	1.35	28.87
15:00	20.56	1.30	26.72
16:00	20.45	1.26	25.76
17:00	19.52	1.21	23.61
18:00	11.45	0.61	6.98

Table 4 Comparison Table

Time	Fixed Array	Single Axis	Dual Axis
8:00	0.074	.0045	0.92
9:00	0.78	0.54	18.99
10:00	15.04	19.40	30.41
11:00	19.76	21.38	32.01
12:00	19.19	19.26	33.22
13:00	20.17	26.68	34.16
14:00	15.73	17.42	28.87
15:00	16.70	17.88	26.72
16:00	7.81	18.70	25.76
17:00	0.75	8.08	23.61
18:00	0.63	0.84	6.98

We performed graphical comparison for three cases by plotting three power curves for all three cases with the help of data provided in Table 4. Collected data was simulated in MATLAB and graphical curves are plotted withthe help of MATLAB. Graphical comparison of output power for all three cases is shown in Figure 5 below.

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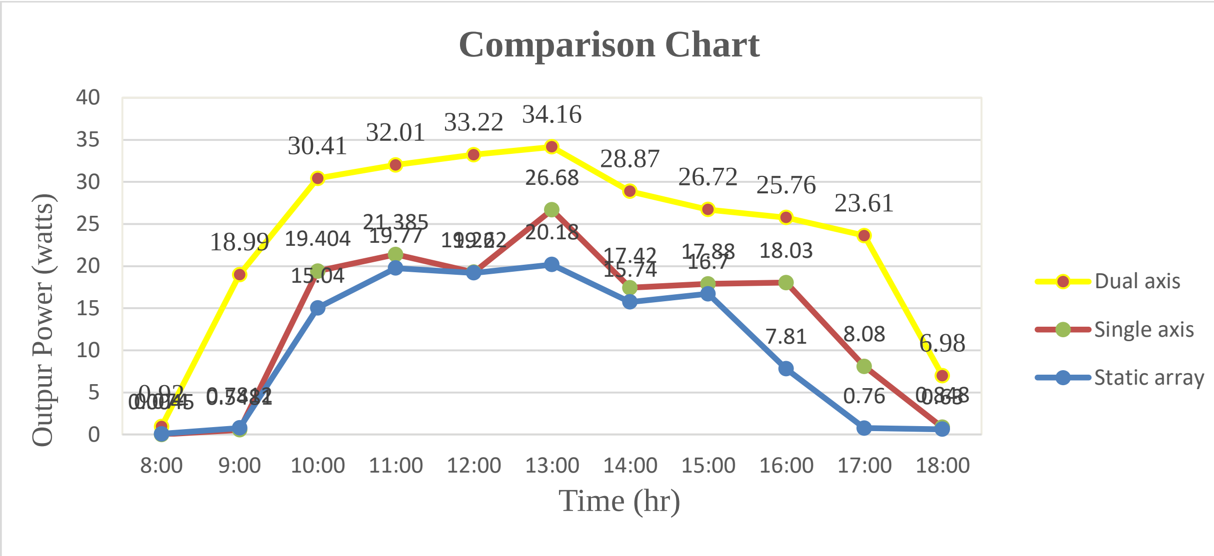
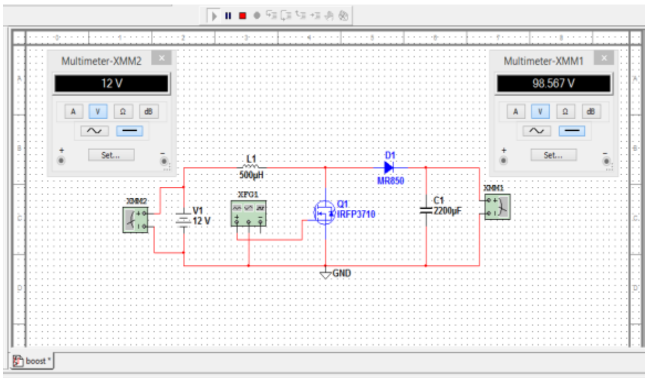
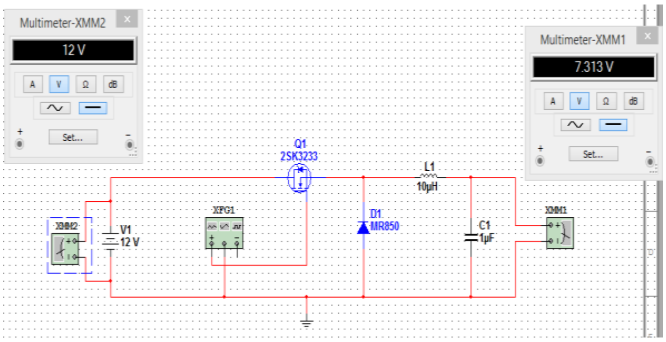


Figure 5

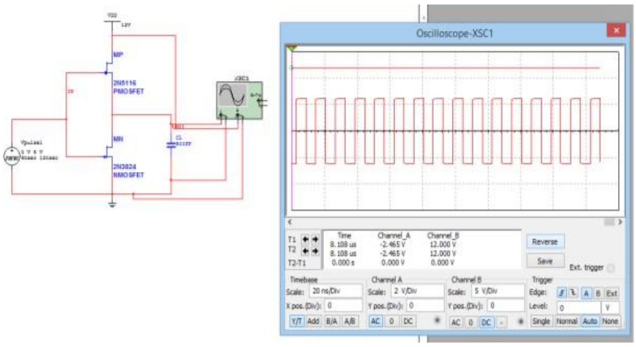
Simulations of Boost Converter



Simulations of Buck Converter



Simulation of Half Bridge inverter



III. CONCLUSION

Dual axis tracker perfectly aligns with the sun direction and tracks the sun movement in a more efficient way and has a tremendous performance improvement. The experimental results clearly show that dual axis tracking is superior to single axis tracking and fixed module systems. Power captured by dual axis solar tracker is high during the whole observation time period and it maximizes the conversion of solar irradiance into electrical energy output. The proposed system is cost effective also as a little modification in single axis tracker provided prominent power rise in the system. Through our experiments, we have found that dual axis tracking can increase energy by about 40% of the fixed arrays. With more works and better systems, I believe that the figure 5 can be improve more and can get maximum power.

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