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Design Fabrication and Performance Evaluation of Single Axis Solar Tracking Mechanism in Different Weather Condition

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ABSTRACT

Solar tracking systems are designed to enhance the efficiency and output of solar photovoltaic (PV) panels by maximizing their exposure to sunlight throughout the day. This explores the concept of solar tracking, its benefits, and various types of solar tracking systems. The primary goal of solar tracking is to ensure that solar panels are always perpendicular to the sun's rays, thereby optimizing their energy generation potential. Solar tracking offers several advantages over fixed solar panel installations. By constantly adjusting the panel's position to align with the sun, solar trackers can increase energy production by up to 25-35% compared to fixed systems. This increased energy output leads to a higher return on investment and shorter payback periods for solar installations. Additionally, solar tracking allows for a more consistent power output throughout the day, reSSducing the reliance on energy storage solutions and grid integration challenges.

INTRODUCTION

India has a rich history and legacy as an agrarian nation, deeply rooted in its ancient traditions and diverse agricultural practices. Throughout its long history, agriculture has been the backbone of the Indian economy, shaping its culture, society, and way of life. The country's agricultural sector has played a crucial role in sustaining the livelihoods of millions of people and providing essential food resources for the ever-growing population. References to India's agricultural prowess can be traced back to ancient times, with texts like the Rigveda, dating as far back as 1500 BCE, containing hymns that praise the importance of agriculture in Indian society. Over the centuries, various civilizations and empires that thrived on the Indian subcontinent, such as the Indus Valley Civilization and the Mauryan Empire, relied heavily on agriculture for their sustenance and prosperity. Even in the present day, India continues to be a significant farming nation, with a large percentage of its population engaged in agricultural activities. The diverse geographical features of the country, from fertile plains to lush mountainous regions, have allowed for a wide variety of crops to be cultivated, ranging from grains like rice and wheat to cash crops like cotton and spices (K. Dharma, 1892).

Fig. 1.1 India as Farming land

Farming Power

Farm power is a fundamental aspect of agricultural production, serving as the driving force behind various farming operations and mechanization processes. It encompasses the utilization of different sources of energy to perform tasks that would otherwise be arduous or impossible to accomplish manually. The application of farm power has significantly transformed traditional farming practices, enhancing productivity, efficiency, and overall agricultural output (Brady, N.C et al., 2002).

Sources of Farm Power

There are different sources of Farm power, They are:

1. Human power
2. Animal power
3. Electrical power
4. Mechanical power
5. Renewable energy

Justification

Solar energy is the primary source of energy and has been utilized in the agricultural sector for many years. India is a farming nation, hence farm power needs to be improved. An important factor in the modernization of agricultural electricity is renewable energy. Although solar energy has traditionally been used to power a variety of farm machinery and tools, its efficiency is still being investigated. This project work makes it possible to use suitable methods to not only capture solar radiation but also to track it and maximize energy output, which will improve the efficiency of various farming techniques.

REVIEW OF LITERATURE

Guo et al., (2013) described the design and simulation of a sun tracking solar power system. The simulation was realized on MATLAB/Simulink platform. The simulation consisted of four modules: solar tracking cells, signal conditioning circuit, controller, and motor.

M.Kacira (2014) overlooked the cause of a dual axis solar tracking with development of power energy compared to a fixed PV panel in Sanliurfa, Turkey. They found that everyday power gain is 29.3% in solar radiation and 34.6% in power generation for a particular day in the month of July. In 2017

Chaitali Medhane, Tejas Gaidhani (2015) implemented a microcontroller based dual axis model working on a solar panel. Through this model, they observed that the solar panel extract maximum power if the solar panel is aligned with the intensity of light receiving from the sun. It improves the power output and also precaution necessary for the system from rain and wind. Midriem in achieving power energy. They also designed a compound algorithm method to merge approximation data of the sun acquired from astronomical based and visual based feedback. After simulation, it resulted that the azimuth and elevation sum squared errors from the proposed algorithm are 0.3688 and 0.3874 degree, and the astronomical algorithm are 1.0997 and 1.2877 degree.

S.B. Elagib N.H. Osman (2017) describes the development of solar tracking systembased on solar maps using microcontroller, which can forecast the real detectable position of the sun by latitude's location for maximizing the efficiency of energy level. Their main motive of this design was to work with minimal operator interaction in the isolated areas where there is lack network coverage.

Mohammed et al. (2021) designed an automatic two axes sun tracking system using solar cooker. This system removed standing in the sun for a period of time to get continual tracking and facing the intensive solar cooker. In the year 2008, they performed the test continuously for three days from 8:30 to 16:30 hours and the result obtained that for maximum, registered.

3. MATERIALS AND METHODS

This chapter deals with the details of constructional data and methods for performance related parameters are shown. The present study on PV power pack based single axis tracking system was carried out at the department of farm machinery and power engineering of VIAET, SHUATS, Prayagraj. The study area falls at 240 38 N – latitude, 730 42 E – longitude and at an altitude of 582.5 m above mean sea level. Pryagraj is situated in the north-eastern part of utter Pradesh and lies at 25.4137ON 81.8491OE longitude with and altitude above the men sea level. Prayagraj has a humid subtropical climate, temperatures remains moderate throughout the year it has an annual average rainfall of 1042-1200mm and the annual mean temperature is 18.0OC to 32.5 Of .this information is collected in collage weather reports. The following observation had been recorded on 25 June 2023 (clear sky, tracking), 26 July (clear sky non tracking) and 01 August 2023 (partial cloudy tracking), 02 August 2023 (non tracking condition).

3.1 Constructional details of develop solar tracking mechanicsm

The materials used in the project are shown in table 3.1

Table number 3.1: Materials used in the project

S. No.	Particular's Name
1.	Solar panel
2	Arduino uno
3	DC moter
4	LDR sensor
5	Resistance
6	Motor driver
7	Jumper wire
8	Battery
9	Digital multimeter
10	Tilt sensor

3.2 Designing of the structure in AutoCAD

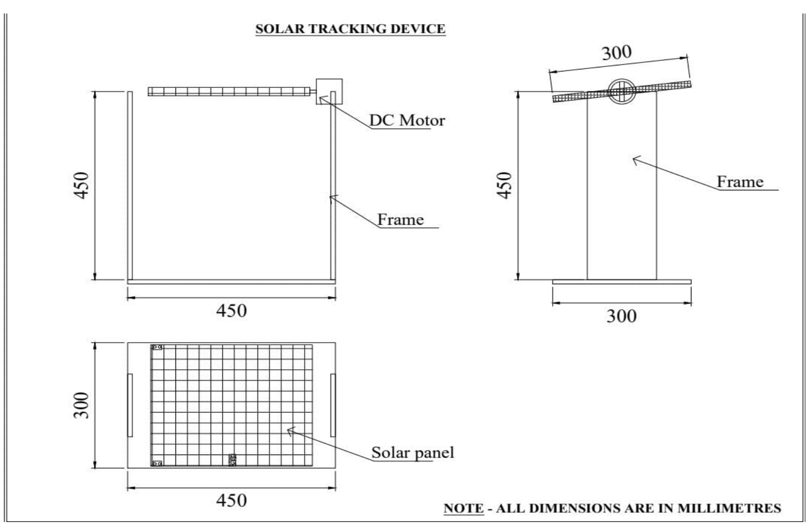


Fig.3.2 (a) structural design of single-axis tracking system

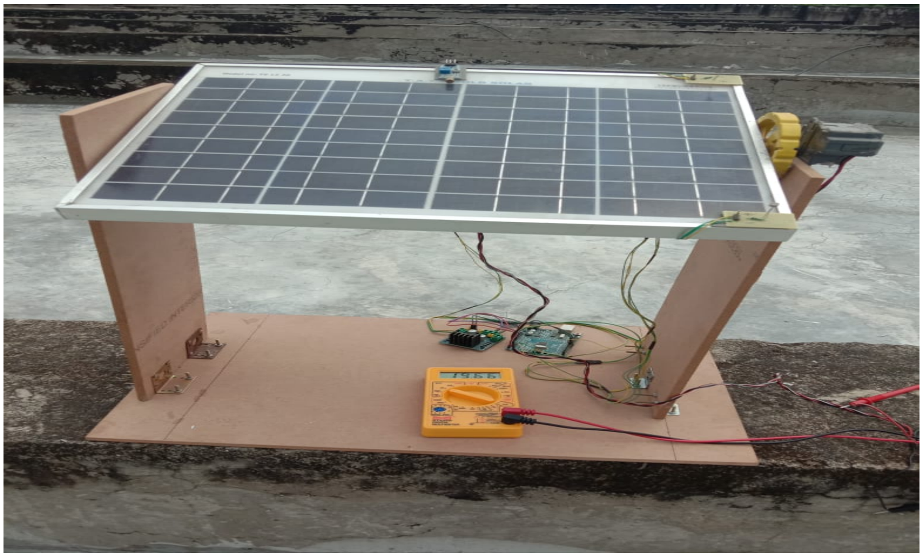
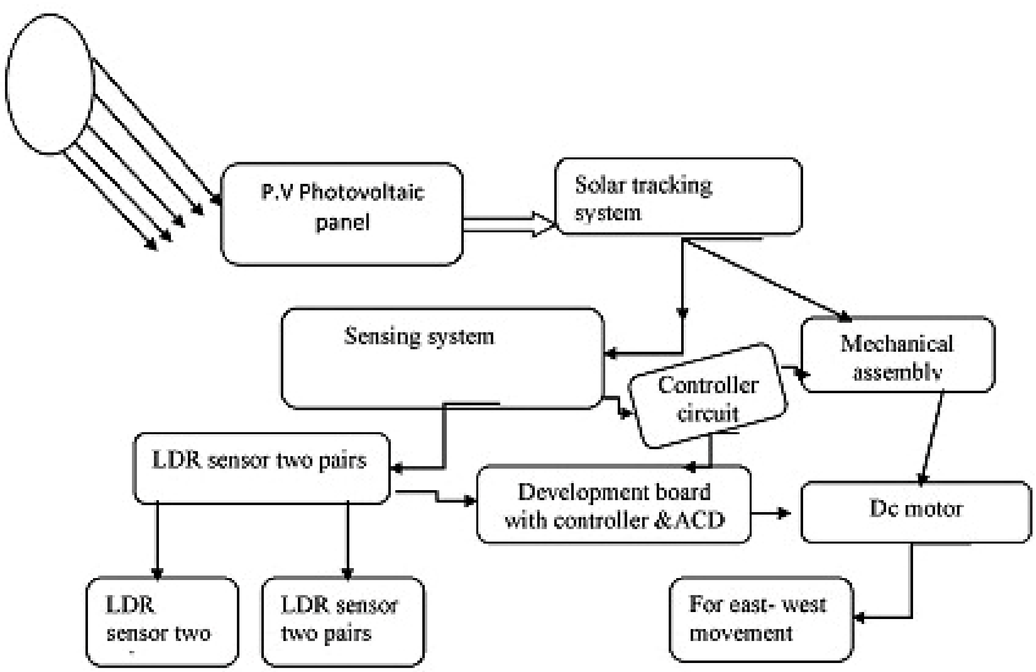


Fig3.2 (b) original figure of project

3.3 Block diagram of single axis solar tracking system



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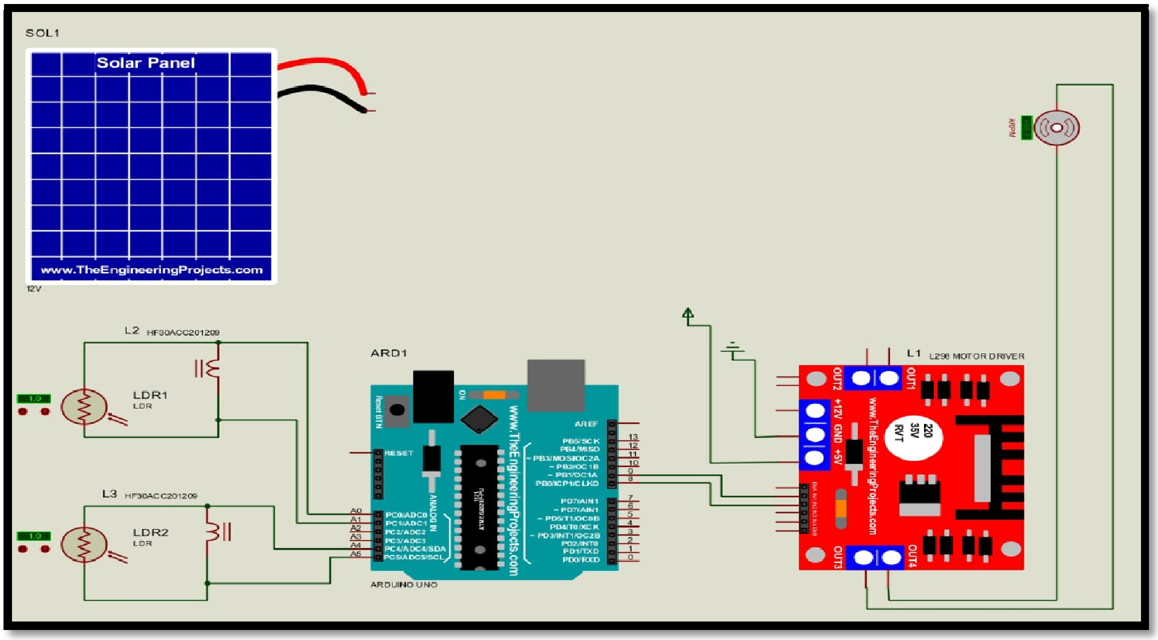

Fig.3.4 Circuit diagram of tracking system

4.RESULTS AND DISCUSSIONS

This chapter deals with the results obtained by designed single axis system and its comparison with the existing systems. The graphs to elicit the performance evaluation both in clear sky as well as in cloudy sky system Output power and efficiency of the system were calculated. Further the efficiency and power gain calculation was also done for complete performance analysis of the developed system. This chapter deals with results of design and performance analysis of PV power pack single axis solar tracking

4.1. Observations recorded in clear sky & partially cloudy sky weather condition by tracking and non-tracking mechanism

Short circuit current & open circuit voltage had been measures with help of multimeter in different weather condition in tracking and non-tracking mechanism. The measure value is being discussed in following tables :

Table no 4.1Measurement of the (Voc) and (Isc) of solar panel in partially cloudy weather (non-tracking)

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S. No.	Time	Voltage (Voc)	Current (Isc)
1	10:00AM	19.67V	0.28A
2	11:00AM	19.72V	0.62A
3	12:00PM	18.65V	0.26A
4	01:00PM	19.85V	0.63A
5	02:00PM	18,54V	0.11A
6	03:00PM	18.74V	0.13A
7	04:00PM	18.74V	0.16A
8	05:00PM	18.26V	0.08A

Table no 4.2 Measurement of the (Voc) and (Isc) of solar panel in partially cloudy weather (tracking)

S. No.	Time	Voltage (voc)	Current (Isc)
1	10:00AM	19.65V	0.16A
2	11:00AM	19.48V	0.20A
3	12:00PM	18.36V	0.22A
4	01:00PM	19.86V	0.35A
5	02:00PM	19,44V	0.31A
6	03:00PM	19.57V	0.41A
7	04:00PM	17.86V	0.07A
8	05:00PM	17.56V	0.09A

Table no 4.3 Measurements of the (Voc) and (Isc) of solar panel in partially clear sky (tracking)

S. No.	Time	Voltage (voc)	Current (Isc
1	10:00AM	19.24V	0.22A
2	11:00AM	19.79V	0.54A
3	12:00PM	19.44V	0.46A
4	01:00PM	19.79V	0.41A
5	02:00PM	19,40V	0.52A
6	03:00PM	19.05V	0.34A
7	04:00PM	19.62V	0.30A
8	05:00PM	19.17V	0.25A

4.2 calculation to find fill factor in different weather condition by tracking and non tracking mechanism
Fill factor is being calculated by equation(1)

S.No	Time	P_{idel} (Voc× Ios)	FF(%)
1	10:00AM	5.50	16%
2	11:00AM	12.22	7%
3	12:00PM	4.84	16%
4	01:00PM	12.50	10%
5	02:00PM	2.03	6%
6	03:00PM	2.43	8%
7	04:00PM	2.99	9%
8	05:00PM	1.46	5%

4.3 Comparison of fill factor in different weather condition by (Tracking and Non-tracking) mechanism.

S no	FF(%) non tracking	FF(%) tracking
1	6%	12%
2	12%	30%
3	26%	26%
4	20%	23%
5	18%	20%
6	14%	18%
7	11%	17%
8	9%	14%

5. SUMMARY AND CONCLUSIONS

SUMMARY

Solar photovoltaic system can convert the solar energy directly into electrical energy. The amount of energy produced depends on the solar radiation captured by the PV panel. A tracking system oriented panel tracks the sun throughout the day and thus it captures more amount of radiation for conversion. "A prototype PV power pack based single axis solar tracking system" was developed to increase the power production from PV panel. The complete system was designed and tested. The prototype was developed at Department of farm machinery & power Engineering

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CONCLUSION

On the basis of observation tables and graphical representation, this can be concluded that fill factor of clear sky weather is more in tracking condition in compare to non-tracking condition. This simply means that energy conversation in tracking mode is higher than non-tracking mode. In case of partially cloudy sky, the fill factor has some randomness, that can be seen in table no. 4.10. This is because there is variation in the amount of clouds and density of the clouds too.

Future Scope

- **I.** The mentioned project can be work on dual axis tracking mechanism.
- **II.** Instant efficiency can be calculated if solar radiation measuring devices is facilitated on this project.

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