|| Volume 9 || Issue 4|| April 2025 || ISSN (Online) 2456-0774
INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH AND ENGINEERING TRENDS

DUAL AXIS SOLAR TRACKING SYSTEM

Vaishnavi Gujar[1], Rutuja Bhise[2],Bhumika Ghayal[3], Anuja Darokar[4], Tanvi Tayade[5], Vaishakhi Nalat[6], Prachi Londe[7], Samiksha Mhaisne[8], Bhumika Shende[9], Divya Ghodsal[10]

Department of Mechanical Engineering DRGITR, AMRAVATI MAHARASHTRA INDIA [1, 2,3,4,5,6,7,8,9,10]

---***---

Abstract: Dual-axis solar tracking systems represent a leap forward in solar energy optimization. Unlike single-axis systems, they pivot along both horizontal and vertical axes, ensuring precise alignment with the sun's position throughout the day and seasons. This dynamic adjustment maximizes energy capture, surpassing fixed installations in efficiency and output. Not only do these systems cater to diverse geographical conditions, but they also enhance reliability and longevity, promising a sustainable future for solar energy. The goal of this thesis was to develop a laboratory prototype of a solar tracking system, which is able to enhance the performance of the photovoltaic modules in a solar energy system. The operating principle of the device is to keep the photovoltaic modules constantly aligned with the sunbeams, which maximizes the exposure of solar panel to the Sun's radiation. As a result, more output power can be produced by the solar panel. The work of the project included hardware design and implementation, together with software programming for the microcontroller unit of the solar tracker. The system utilized an ATmega328P microcontroller to control motion of two servo motors, which rotate solar panel in two axes. The amount of rotation was determined by the microcontroller, based on inputs retrieved from four photo sensors located next to solar panel. At the end of the project, a functional solar tracking system was designed and implemented. It was able to keep the solar panel aligned with the sun, or any light source repetitively. Design of the solar tracker from this project is also a reference and a starting point for the development of more advanced systems in the future.

Keywords: *Dual Axis Solar Tracker.*

---***---

I.INTRODUCTION:

With the unavoidable shortage of fossil fuel sources in the future, renewable types of energy have become a topic of interest for researchers, technicians, investors and decision makers all around the world. New types of energy that are getting attention include hydroelectricity, bioenergy, solar, wind and geothermal energy, tidal power and wave power. Because of their renewability, they are considered as favorable replacements for fossil fuel sources. Among those types of energy, solar photovoltaic (PV) energy is one of the most available resources. This technology has been adopted more widely for residential use nowadays, thanks to research and development activities to improve solar cells' performance and lower the cost. According to International Energy Agency (IEA), worldwide PV capacity has grown at 49% per year on average since early 2000s. Solar PV energy is highly expected to become a major source of power in the future.

However, despite the advantages, solar PV energy is still far from replacing traditional sources on the market. It is still a challenge to maximise power output of PV systems in areas that don't receive a large amount of solar radiation. We still need more advanced technologies from manufacturers to improve the capability of PV materials, but improvement of system design and module construction is a feasible approach to make solar PV power more efficient, thus being a reliable choice for customers.

Dual-axis solar tracking systems represent a leap forward in solar energy optimization. Unlike single-axis systems, they pivot along both horizontal and vertical axes, ensuring precise alignment with the sun's position throughout the day and seasons. This dynamic adjustment maximizes energy capture, surpassing fixed installations in efficiency and output. Not only do these systems cater to diverse geographical conditions, but they also enhance reliability and longevity, promising a sustainable future for solar energy.

II.LITERATURE REVIEW

Hoffmann, R., et al. (1997) reported an efficiency improve of more than 30% on an open loop active tracker which was evaluated on PV concentrators (9). In 1998 an experimental review of closed loop active tracker, with solar cell used to sensor the position of the sun result in improvement of efficiency 30-50% **Yousef, H.** (1999) The tracking was tested in northern regions of Chile (10 (11) developed a tracker that deployed an artificial intelligence approach. A PC based fuzzy logic control, which acquired data through photo-diode to drive motors was engaged, the system increased conversion efficiency of PV system by 50%. A study on performance of different tracking configuration carried out in Germany outlined a 30% increase due to active tracker (12).

WORKING PRINCIPLE

The working principle of a dual-axis solar tracking system revolves around the dynamic adjustment of solar panels to accurately follow the sun's path across the sky. This intricate process begins with the collection of real-time solar data using sensors that measure parameters like solar altitude and azimuth angles. These measurements provide crucial information about the sun's position relative to the panels, allowing the system to calculate the optimal orientation for maximum energy capture.

Resistance of LDR depends on intensity of the light and it varies according to it. The higher is the intensity of light, lower will be the LDR resistance and due to this the output voltage lowers and when the light intensity is low, higher will be the LDR resistance and thus higher output voltage is obtained. A potential divider circuit is used to get the output voltage from the sensors (LDRs). The circuit is shown here. The LDR senses the analog input in voltages between 0 to 5 volts and provides a digital number at the output which generally ranges from 0 to 1023. Now this will give feedback to the microcontroller using the arduino software(IDE).

DESCRIPTION OF THE SOFTWARE PROGRAM STEPS:

1. First of all, both the servos are declared and object is created to control the servo motors.
2. The variables posx and posy are used to store the reference servo positions.
3. The ADC input pins for LDRs are selected for dual direction movement and one for reference.
4. A tolerance or a constant value is selected to establish the working of the motors
5. The servos are attached on digital pins to the servo object.
6. The required analog pins are selected as input using pinMode(pin , mode)
7. The servos are sets to mid-point or original position with a 1000ms or 1sec delay to catch up with the user.
8. Three variables are chosen to read the analog values and map it into integers value between 0 and 1023.
9. If the difference between the two variables is less than the tolerance value then it will stay to its or original location else it shows movement towards the direction of maximum intensity of light by incrementing or decrementing the values of posx and posy.
10. The position is then written to servo and the loop repeats till it encounters any changes in the values of input greater than the minimum tolerance.

CODE RELATING ANALOG TO DIGITAL CONVERSION:

- In the program below, the very first thing that you do will in the setup function is to begin serial communications, at 9600 bits of data per second, between your board and your computer with the line:
  Serial.begin(9600);
- Next, in the main loop of your code, you need to establish a variable to store the resistance value (which will be between 0 and 1023, perfect for an int datatype) coming in from your potentiometer:
- int sensorValue = analogRead(A0);
- To change the values from 0-1023 to a range that corresponds to the voltage the pin is reading, you'll need to create another variable, a float, and do a little math. To scale the numbers between 0.0 and 5.0, divide 5.0 by 1023.0 and multiply that by sensorValue :
- float voltage= sensorValue * (5.0 / 1023.0);
- Finally, you need to print this information to your serial window as. You can do this with the command Serial.println() in your last line of code:
- Serial.println(voltage)
- Now, when you open your Serial Monitor in the Arduino IDE (by clicking on the icon on the right side of the top green bar or pressing Ctrl+Shift+M), you should see a steady stream of numbers ranging from 0.0 - 5.0. As you turn the pot, the values will change, corresponding to the voltage coming into pin A0.

Advantages, Disadvantage and Application Advantages

- Higher degree of flexibility, allowing for a higher energy output on sunny days
- Higher degree of accuracy in directional pointing
- Solar energy is a clean and renewable energy source.
- Once a solar panel is installed, the energy is produced at reduced costs.
- Whereas the reserves of oil of the world are estimated to be depleted in future, solar Energy will last forever.
- It is pollution free.
- Solar cells are free of any noise. On the other hand, various machines used for
- Pumping oil or for power generation are noisy.
- Once solar cells have been installed and running, minimal maintenance is required.
- Some solar panels have no moving parts, making them to last even longer with no Maintenance.
- On average, it is possible to have a high return on investment because of the free Energy solar panels produce.
- Solar energy can be used in very remote areas where extension of the electricity Power grid is costly.
- With this dual axis solar tracking system it's possible to get maximum power output by tracking sunlight. Now a days dual axis solar tracking system is more efficient.

Disadvantages

- Higher mechanical complexity, making it more likely for something to go wrong.
- Lower lifespan and lower reliability
- Unreliable performance in cloudy or overcast weather
- Generation of electricity from solar is dependent on the country's exposure to Sunlight. That means some countries are slightly disadvantaged.
- Solar power stations do not match the power output of conventional power stations of Similar size. Furthermore, they may be expensive to build.

Applications

- Dual axis solar tracking system can be use for large and medium scale power generation.
- It can also be used for power generation at remote places.
- It may be use as domestic power back up system.
- It can be use in solar street lighting system.
- The large dual axis solar tracking system can be use in open places.

III.CONCLUSION

In conclusion, dual-axis solar tracking systems represent a cutting-edge solution for optimizing energy capture from sunlight. By dynamically adjusting the orientation of solar panels along both horizontal and vertical axes, these systems ensure maximum exposure to sunlight throughout the day and across seasons. This precision alignment significantly enhances energy yield compared to fixed installations or single-axis trackers, making dual-axis tracking systems a highly efficient and cost-effective option for solar power generation. Moreover, the adaptability of dual-axis tracking allows for customization to various geographical locations and terrains, accommodating differences in solar elevation and azimuth angles. This versatility makes them suitable for a wide range of applications, from residential rooftop installations to large-scale solar farms.

- Our panel senses the light in a sensing zone, beyond which it fails to respond.
- If multiple sources of light (i.e. diffused light source) appear on panel, it calculates the vector sum of light sources & moves the panel in that point.

This project was implemented with minimal resources.

The circuitry wa kept simple, understandable and user friendly

IV.REFERENCES

1. https://www.instructables.com/Simple-Dual-Axis-Solar-Tracker/.https://nevonprojects.com/dual-axis-solar-tracking-system-with-weather-sensor/https://www.sciencedirect.com/topics/engineering/dual-axis-tracking
2. Solar Tracking Hardware and Software by Gerro J Prinsloo
3. Design and Implementation of a Sun Tracker with a Dual-Axis Single Motor “Jing-Min Wang and Chia-Liang Lu’’.
4. Sensors-and-Transducers...SecondEdition...’’D.Patranabis”
5. Atmel ATmega48A/PA/88A/PA/168A/PA/328/P-datasheet
6. Utilisation of Electrical Power. Author, Er. R. K.Rajput. Arduino Programming Book. Author, Brian W. Evans
7. ATiny2313 Data Book. (2003, September). AVR Microcontroller. Retrieved April 12, 2011, from ATmel Corporation
8. Adedjouma A.S., Adjovi G., Agaï L. and Degbo B., 2006. A system of remote-control car lock with a GSM based geo-location by GPS and GSM. African Journal of Research in Computer Science and Applied Mathematics, Vol. 1.
9. Baille A., Kittas C. et Katsoulas N., 2001. Influence of whitening on greenhouse microclimate and crop energy partitioning. Journal of Agricultural and Forest Meteorology, Vol. 107
10. Bouchikhi B., El Harzli M., 2005. Design and realization of acquisition system and climatic parameters control under the greenhouse. Phys & Chem. News, Vol. 22
11. 12.El Harzli M., 2009. Study and realization of a multifunctional sensor, heat flux, temperature and humidity. Application to the greenhouse control. National PhD , Faculty of Sciences, Meknes, Moulay Ismail University, Morocco
12. 13.Bhagwan Deen Verma, Prof. (Dr.) Mukesh Pandey, Asst. Prof. Anurag Gour.
13. 14."A Review Paper on Solar Tracking System for Photovoltaic Power Plant”.
14. 15.International Journal of Engineering Research & Technology Vol. 9 Issue 02, February(2020): 2278-018