



## IOT Based Dual Axis Solar Tracker with Power Monitoring System

---

Amul Ghodasara, Manish Jangid, Hrishikesh Ghadhesaria,  
Harshil Dungrani, Brijesh Vala and Ravi Parikh

EasyChair preprints are intended for rapid dissemination of research results and are integrated with the rest of EasyChair.

February 27, 2021

# ***IOT Based Dual Axis Solar Tracker with Power Monitoring System***

***Amul Ghodasara<sup>1</sup>, Manish Jangid<sup>2</sup>, Hrishikesh Ghadhesaria<sup>3</sup>, Harshil Dungrani<sup>4</sup>***

***Prof. Brijesh Vala<sup>5</sup>, Prof. Ravi Parikh<sup>6</sup>***

Dept. of Computer Science And Engineering

Parul Institute of Engineering and Technology, Vadodara

**E-mail:** [amulghodasara456@gmail.com](mailto:amulghodasara456@gmail.com)<sup>1</sup>, [manishkumar76t@gmail.com](mailto:manishkumar76t@gmail.com)<sup>2</sup>, [hrishikeshpatel90@gmail.com](mailto:hrishikeshpatel90@gmail.com)<sup>3</sup>, [dungaraniharshil5@gmail.com](mailto:dungaraniharshil5@gmail.com)<sup>4</sup>, [Brijesh.vala@paruluniversity.ac.in](mailto:Brijesh.vala@paruluniversity.ac.in)<sup>5</sup>, [Ravi.parikh@paruluniversity.ac.in](mailto:Ravi.parikh@paruluniversity.ac.in)<sup>6</sup>.

## ***Abstract***

The main goal of this project is to design a very precise solar tracker and share the information through IoT. In this work sensing of the sun position carried out in two stages primary and secondary. Primary stage or indirect sensing performed via sun-earth relationship as a coarse adjustment and second stage or direct sensing performed via set of LDR sensors as output tuning to trims the azimuth and altitude angles. If the weather is cloudy or dusty, the tracking system uses primary stage or sun-earth geometrical relationships only to identify the location of the sun; so the system tracks the position of the sun regardless the weather condition. The energy extracted from photovoltaic (PV) or any solar collector depends on solar irradiance. For maximum extraction of energy from the sun, the solar collector panel should always be normal to the incident radiation Solar trackers moves the solar collector to follow the sun path and keeps the orientation of the solar collector at an optimal tilt angle. Solar tracking system improves substantially the energy efficiency of photovoltaic (PV) panel. The project is divided into two parts; hardware and software. Hardware part generally composed of solar panel, two-DC motors, LDR sensor module, temperature sensor, humidity sensor and electronic circuit. Software part represents the thinking behaviour of the system, that is how the system acting under several weather conditions. In this paper, an automatic solar tracking system is designed and developed using Light Dependent Resistor (LDR) and DC motors on a mechanical structure with gear arrangement. It is implemented through Arduino UNO controller based on Sun Earth Geometry. The results indicated that the automatic solar tracking system is more reliable and efficient than fixed one.

- ***Keywords:*** Arduino UNO; LDR; Photovoltaic (PV) panel; Solar Tracking System; Humidity Sensor; Temperature Sensor; Omni phobic material; IOT;

## INTRODUCTION

Nowadays, climate change on globe is at a critical level. Climate change can be divided into two categories, human and natural causes. Natural causes of climate changes are ocean current, solar variations, and earth orbital changes. The main parts of climate changes caused by human are man-made greenhouse gases. Global warming or climate changes can be seen through some of them natural phenomenon like the effect on crops and extreme weather conditions around the world.[20]

Renewable-energy is an energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). Renewable-energy is the best growing energy source on the globe. Renewable energy is a source of energy that doesn't consume the finite resources of the earth and can be easily and quickly replenished. Renewable-energy plays a key role in a country's energy needs; enabling businesses to gather energy cost investments and also revenue thus control the outcome of climate changes.[20]

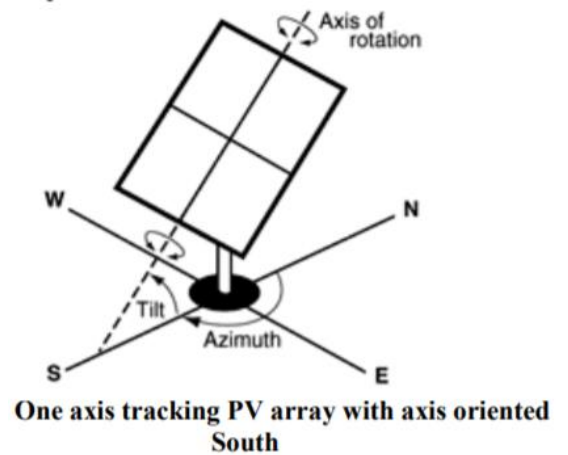
In Malaysia, oil and coal are the primary resources of electrical energy for relatively long periods of time. Knowing that oil and coal will be reduced, the government had

started to decrease the usage of oil and coal as the main energy resources of electrical energy and started an initiative of using another renewable-energy such as solar and hydro. In Malaysia, the residential energy use accounts for more than 14,365 GWh or 19% of total electricity consumed in Peninsular Malaysia in year 2006. Demand of electricity keeps increasing by years, solar energy is the alternative for those electricity problems. Solar energy is the energy derived from the sun through the form of solar radiation. The sun is the most inexhaustible, renewable source of energy known to man. Solar energy provides light, heat and energy to all living things. There is no price and also no air pollution created by solar energy, environmentally friendly and the solar energies are interminable supplies. The developments of the solar tracker are applied in this particular project because Malaysia's climate is categorized as equatorial, being hot and humid throughout the year. As for solar energy, it is pertinent that it has a lot of advantages and disadvantages when it comes to compare other energy sources. The fundamental issue of utilizing solar energy is not a matter of lack of other sources of energy but it is a matter of environmental concern as some conventional energy sources contribute high emissions to the environments.[11]

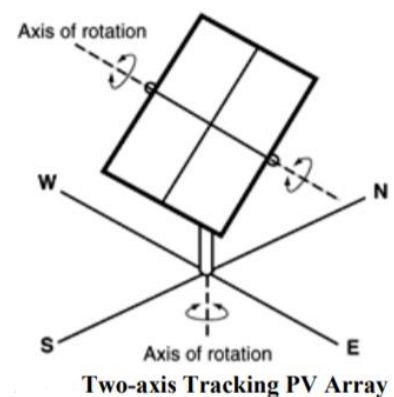
## SOLAR TRACKER

Sunlight has two components, the direct beam that carries about 90% of the solar energy, and the diffuse sunlight that carries the remainder. The diffuse portion is the blue sky on a clear day and increases proportionately on cloudy days. As the majority of the energy is in the direct beam, maximizing collection requires the sun to be visible to the panels as long as possible. A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. The two types of that are used maximum are:

A. Single axis solar tracker. Single axis solar tracker generally has only single degree of freedom and it can rotate from east to west. This tracker only considers daily movement of sun with respect to earth position. Single DC motor is used to achieve single degree of freedom. Despite of being cost effective and easy to build, single axis solar tracker is less efficient than other tracker.



B. Dual axis tracker Dual axis tracker has two degree of freedom and it considers daily movement of sun (from eastwest) as well as yearly movement of sun (NorthSouth). It generally consists of two DC motor to achieve two degree of freedom. This tracker is difficult to build, but higher efficiency overcomes difficulty in design.



## LITERATURE SURVEY

For working in different weather conditions use of different strategies by which the tracking error of the normal tracking strategy is 0.15, so it could provide high tracking accuracy for the solar systems.[1]

One of the advantages of a dual axis solar tracker how solar energy can be collected more effectively at unfavorable locations and weather conditions in comparison with single axis solar system.[2]

With an automated two axis solar tracker the average gain in the maximum power and efficiency obtained with two-axis PV tracking system is 5.0423 W per hour and 28.87 % respectively compared to the fixed PV system.[3]

A report provided the information on using data logging in an automated solar tracker for storing data as solar radiation, voltage, temperature on board, its design and implementation.[7]

For working under different conditions construction of a solar tracker following direct and indirect sensing system.

A study which shows implementation of a dual axis solar tracking system using a 555 timer to construct a simple solar tracker

with a rear sensor circuit incorporated to aid in the repositioning the solar panels for the next sunrise.[18]

Solar tracking system that consists of a combination of open loop tracking strategies based on solar movement models and closed loop strategies using a dynamic feedback controller was presented.[13]

Using a systemic approach to capacity development for solar PV, it also addresses other domains, such as economic development and gender equality, which can impact on capacity for solar PV lighting. By providing knowledge and educating and employing people in rural areas.[14]

## PROBLEM STATEMENT AND OBJECTIVE

Renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate. At the educational level, it is therefore critical for engineering and technology students to have an understanding and appreciation of the technologies associated with renewable energy. One of the most popular renewable energy sources is solar energy. Many researches were conducted to develop some methods to increase the efficiency of Photo Voltaic systems (solar panels). One

such method is to employ a solar panel tracking system.

This system deals with a RTC based solar panel tracking system. Solar tracking enables more energy to be generated because the solar panel is always able to maintain a perpendicular profile to the sun's rays. Development of solar panel tracking systems has been ongoing for several years now. As the sun moves across the sky during the day, it is advantageous to have the solar panels track the location of the sun, such that the panels are always perpendicular to the solar energy radiated by the sun. This will tend to maximize the amount of power absorbed by PV systems.

It has been estimated that the use of a tracking system, over a fixed system, can increase the power output by 30% -60%. The increase is significant enough to make tracking a viable proposition despite of the enhancement in system cost. It is possible to align the tracking heliostat normal to sun using electronic control by a micro controller.

- 1) During the time that the sun is up, the system must follow the sun's position in the sky.
- 2) This must be done with an active control timed movements are useful. It should be totally automatic and simple to operate. The operator interference should be

minimal and restricted to only when it is actually required. The major components of this system are as follows.

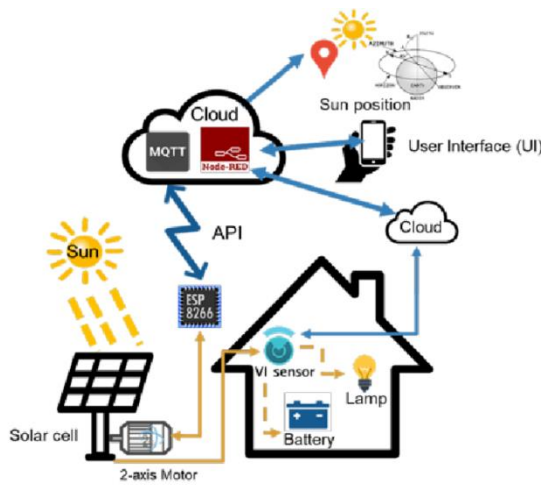
- 1) Solar Panel
- 2) LDR'S
- 3) Servo motors.
- 4) Temperature & Humidity sensor
- 5) Photovoltaic cells
- 7) Current sensor
- 8) Voltage Sensor
- 9) ESP8266 Wi-Fi Module
- 10) Omniphobic Material

Objective of the proposed system is to provide a dual axis solar tracking system capable of tracking sun in any weather condition more efficiently as compared to the traditional systems which are currently in use with less maintenance cost and more power generation capacity.

## **PROPOSED SYSTEMS**

Solar power plants need to be monitored for optimum power output. This helps retrieve efficient power output from power plants while monitoring for faulty solar panels, connections, dust accumulated on panels lowering output and other such issues affecting solar performance. So here we propose an automated IOT based solar power monitoring system that allows for automated solar power monitoring from anywhere over the internet. We use

Arduino based system to monitor a solar panel.

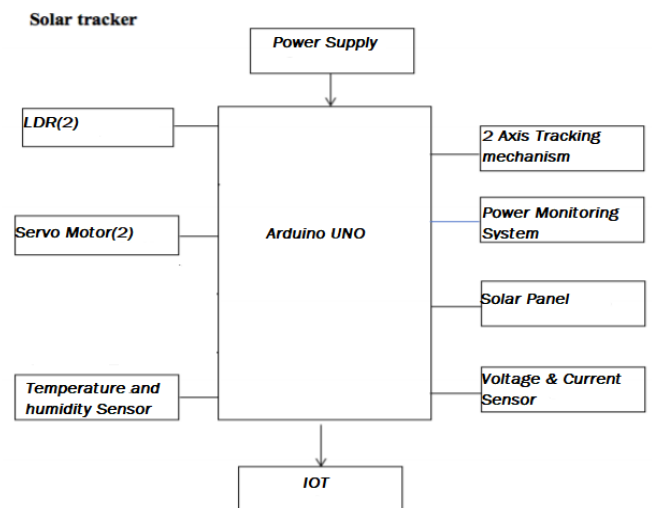


Our system constantly monitors the solar panel and transmits the power output to IOT system over the internet. Here we use IOT to transmit solar power parameters over the internet to IOT. It now displays these parameters to the user using an effective GUI and also alerts user when the output falls below specific limits. This makes remotely monitoring of solar plants very easy and ensure best power output.

In our model we added weather prediction, showing data online, temperature and humidity etc. Which are connected with Wi-Fi module and we can see all types of data on our mobile application. To protect the solar panels in dusty and windy conditions a layer of omniphobic material will be applied on it so it does not get

damaged and maintenance cost and time gets reduced.

Finally, the motivation of the research is to design and implement a hybrid dual-axis solar tracking system which reduces the motor power consumption while tracking accurately. The light intensity is compared by the microcontroller and it generates suitable control signals to move the motors in the proper direction.



## TRACKER COMPONENTS

### 1. Sun tracking algorithm:

This algorithm calculates the solar azimuth and zenith angles of the sun. These angles are then used to position the solar panel or reflector to point toward the sun. Some algorithms are purely mathematical based on astronomical references while others utilize realtime light-intensity readings.

## 2. Control unit:

The control unit executes the sun tracking algorithm and coordinates the movement of the positioning system.

## 3. Positioning system:

The positioning system moves the panel or reflector to face the sun at the optimum angles. Some positioning systems are electrical and some are hydraulic. Electrical systems utilize encoders and variable frequency drives or linear actuators to monitor the current position of the panel and move to desired positions.

## CONCLUSIONS

Solar tracking mechanisms improve the energy gain of solar power plants. Automatic solar tracking system is generally the one that reaches the highest energy gain in every region. It is therefore the most versatile system, since it can be installed anywhere, guaranteeing a high energy gain. Solar trackers are recommended everywhere from an energetic point of view, since they always increase the amount of collected energy. Two degrees of freedom orientation is feasible. Arduino Uno controller is used to control the position of DC motors which ensures point to point intermittent motion resulting from the DC geared motors. Standalone working and wireless

communication is achieved with computer or mobile which makes the system reliable and observable. The use of LDR sensors and high precision voltage and current sensor guarantees a more accurate and efficient tracking system. It now displays the sensors Parameters to the User over the internet Using effective application and also alerts user when sensors parameters above specific limits. This makes remotely monitoring of solar plants very easy and ensure best Power output.

## REFERENCES

1. Yingxue Yao, Yeguang Hu, Shengdong Gao, Gang Yang b, Jinguang Du. "A multipurpose dual-axis solar tracker with two tracking strategies". Elsevier.
2. Aditya Sawant, Deepak Bondre, Apurav Joshi, Prasad Tambavekar. "Design and Analysis of Automated Dual Axis Solar Tracker Based on Light Sensors". IEEE.
3. Prabodh Bajpai, Subhash Kumar. "Design, Development and Performance Test of an Automatic Two-Axis Solar Tracker System". IIT Kharagpur.



4. Tung-Sheng Zhan, Whei-Min Lin, Ming-Huang Tsai, Guo-Shiang Wang. "Design and Implementation of the Dual-axis Solar Tracking System." IEEE 37th Annual Computer Software and Applications Conference.
5. A. Yazidil, F. Betin, G. Notton, G.A. Capolinol. "Low cost two-axis solar tracker with high precision positioning." IEEE.
6. Hassan Fathabadi. "Novel high accurate sensorless dual-axis solar tracking system controlled by maximum power point tracking unit of photovoltaic systems." Elsevier.
7. Dr. M. Mani Roja, Sidharth Makhija, Aishwarya Khatwani, Mohd. Faisal Khan, Vrinda Goel. "Design & Implementation of an Automated Dual-Axis Solar Tracker with Data-Logging." International Conference on Inventive Systems and Control (ICISC-2017).
8. S.V. Mitrofanov, D.K. Baykasenov, A.U. Nemaltsev. "Development of Automated System for Remote Control and Diagnostics of Solar Power Plant Parameters with Dual-Axis Solar Tracker." 2019 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM)
9. Falah I. Mustafa, A. Salam Al-Ammri, Farouk F. Ahmad. "Direct and Indirect Sensing two-axis Solar Tracking System." The 8th International Renewable Energy Congress (IREC 2017)
10. Falah I. Mustafa, Sarmid Shakir, Faiz F. Mustafa, Athmar thamer naiyf. "Simple Design and Implementation of Solar tracking System Two Axis with Four Sensors for Baghdad city." The 9th International Renewable Energy Congress (IREC 2018)
11. Jhee Phong Lee, Nasrudin Abd. Rahim, Yusuf A. Al-Turki. "Performance of Dual-Axis Solar Tracker versus Static Solar System by Segmented Clearness Index in Malaysia." International Journal of Photoenergy.
12. S.B.Elalagib, N.H.Osman. "Design and Implementation of Dual Axis

- Solar Tracker based on Solar Maps.”  
ICCEEE
13. F.R. Rubio, M.G. Ortega, F. Gordillo, M. Lo´pez-Mart´inez. “Application of new control strategy for sun tracking.” Elsevier.
  14. Long Seng To, Alex Zahnd. “Enhancing Capacity For Solar Photovoltaics in Rural Nepal.” Murdoch University.
  15. Masoumeh Abdollahpoura, Mahmood Reza Golzariana, Abbas Rohania, Hossein Abootorabi Zarchib. “Development of a machine vision dual-axis solar tracking system.” Elsevier.
  16. J. Rizk, and Y. Chaiko. “Solar Tracking System: More Efficient Use of Solar Panels.” WORLD ACADEMY OF SCIENCE ENGINEERING AND TECH.
  17. Bouziane Khadidjaa, Korichi Drisa, Azoui Boubekerb , Settou Nouredinec. “Optimisation of a Solar Tracker System for Photovoltaic Power Plants in Saharian region, Example of Ouargla.” EUMISD
  18. Shrishti Rana. “A STUDY ON AUTOMATIC DUAL AXIS SOLAR TRACKER SYSTEM USING 555 TIMER.” IJTRA.
  19. Hossein Mousazadeh, Alireza Keyhani, Arzhang Javadi , Hossein Mobli, Karen Abrinia, Ahmad Sharifi. “A review of principle and sun-tracking methods for maximizing solar systems output.” Elsevier.
  20. Zolkapli, M. 1; AI-Junid S. A. M.; Othman Z.; Manut, A.; Mohd Zulkifli M. A. “High-Efficiency Dual-Axis Solar Tracking Developement using Arduino.” IEEE.