# Optimizing Solar Power Generation by Microcontroller-based tracking System

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***Abstract***

*As per IEA ( International Energy Agency), global solar energy generation capacity is poised to grow at the rate of 70 GW every year and our government has fixed an ambitious annual target of generating 100 GW Solar Energy by 2022. Solar power generation is dependent on critical factors such as total irradiance, incidence angle of sun rays, efficiency of solar panels and its maintenance. Solar Tracking can enhance generation by 40 % and reduce the area requirement by 20%, but is still struggling to get a feasible techno-economical model. In this paper, an attempt has been made to use advanced Arduino microcontroller with LDR sensors and RTC linked to servo motors for effective tracking. This system allows use of the data analytics and artificial intelligence from the digital output with the help of a host of other sensors for optimizing performance efficiency and environmental factors. We also plan to integrate the microcontroller based automatic maintenance systems for optimizing generation and to control water wastage by using recycling systems. This will help us in developing an economically feasible futuristic advanced tracking and generation system.*

## 1. Introduction

Growing energy demand and concern regarding Environment Pollution and Global Warming has forced mankind to look for cost effective and environment friendly non-conventional renewable energy resources such as solar energy, wind energy, biomass energy, geothermal energy etc. Among the above alternatives, in India, Solar emerged as a technological winner where the tariff dropped exponentially from a level of Rs 19.12 per unit In 2010, when JNNSM( Jawaharlal Nehru National Solar Mission) was started to recently concluded tariff of Rs 2.45 per unit for Bhadla-III Solar Park in Rajasthan. This also led to upward revision of the target to produce total power of 100 GW against the original target of 20 GW by 2022.[2]

India has committed in summit of United Nations Framework Convention of Climate Change to reduce carbon emission by 33 to 35 % by 2030 from 2005 levels. Our country has also committed to achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel energy resources by 2030. [1]

India is playing a pivotal role in the Global arena for development of solar power. International Solar Alliance (ISA) was launched as a special platform for mutual cooperation among 121 solar resource rich countries at COP 21 in Paris In November 2015. 46 countries have already joined the alliance and signed the treaty. [2]

As per IEA, global solar energy generation capacity is poised to grow at the rate of 70 GW every year. As per MNRE , India has the potential to produce 750 GW of solar energy whereas the researchers estimate that by covering 0.16 % of the land on earth and with 10 % of efficiency, 20 TW of solar energy can be globally produced which is double the total global energy produced by fossil fuels today.[1]

A typical solar panel converts only 30 to 40 percent of the incident solar radiation into electrical energy. Considering the high cost of solar photovoltaic panels and its low efficiency, it is very important that the generating system should be as efficient as possible.

In this paper, we have attempted to create a solar tracker that rotates along with the movement of the sun to maximise the generation of electricity at all times, throughout the day. A dual axis tracker allows us to maximise the generation around the year. This system can be controlled via a microcontroller and various parameters may be monitored using a variety of sensors. This data can then be analysed for further optimisations.

## 2.Objective

Solar power generation efficiency is majorly dependent on the solar radiation and incidence angle of sun rays. The purpose of a solar tracker is to maximise the power generation efficiency of a solar panel by optimising the angle of incidence near zero with the help of Arduino based system. In fixed panels along the East West axis, the angle of incidence of the sun is at -90 degrees at sunrise, 0 degrees at noon, and +90 degrees at sunset. Therefore, the incident solar radiation during sunrise and sunset is 0%, and 100% at noon.

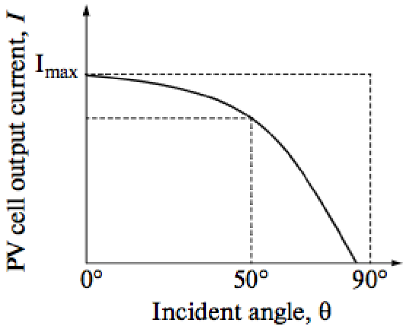


**Figure 1. Curve showing relationship of incident solar radiation with the angle of incidence**[4]

Similarly along the North South Direction the sun rays are incident at an angle depending on the geographical location of the site ( Azimuth). As we move from summer to winters this is required to be adjusted periodically.  This variation in incidence angle causes the fixed solar panel to lose almost 40% of total energy.

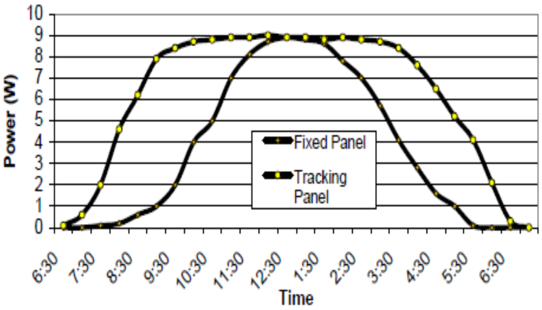


**Figure 2. Comparison of Total Energy Received From The Sun With and Without Tracker**[4]

To reduce this loss, a computerized solar tracker is used, to alter the incident angle, such that the panel is perpendicular to the Sun, so that maximum energy may be generated and the working efficiency of solar panel can be increased. Thus, this project makes this process of harnessing solar energy more efficient and hence smarter.

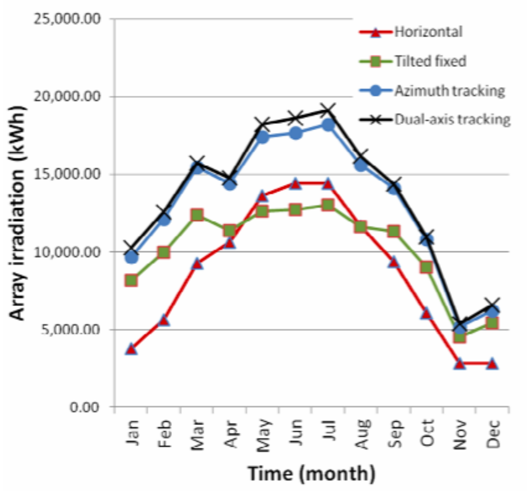


**Figure 3. Comparative Study of various types of Solar Panel Systems [5]**

## 3. Working

The block diagram describes the composition and interconnection of the system.

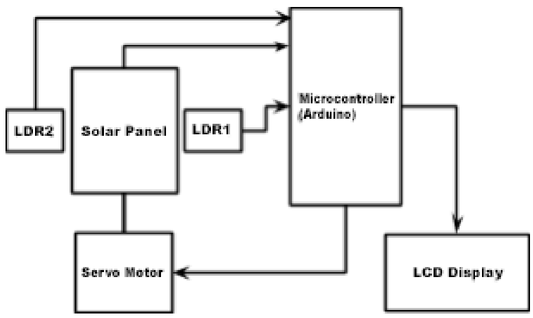


**Figure 4. Block Diagram of Solar Tracker**

In this work, a microcontroller based solar tracking system has been proposed. Solar tracker tracks the sun with the help of LDRs (Light detecting resistors mounted on the solar panel) which sense the intensity of the sunlight & pass signals to the Arduino UNO microcontroller. The controller sends signal to the DC servo motor which rotates the panel. Rest position of the panel is achieved when the comparator senses equal signals in both the LDRs. Instructions are sent to the motor to rotate the solar panel in clockwise or anticlockwise directions depending on the state of LDRs.

The system may also be programmed according to a RTC (Real Time Clock), such that it rotates in sync with the movement of the sun i.e. a rotation of 1 degree in 4 minutes, so that zero degree incidence angle is maintained at all times. The panel is initially set at a position of 30 degrees, and rotates through a span of 120 degrees. After the final position, it is reset to the initial position at the end of the day. The rotation is triggered each morning when a certain threshold light intensity is received by the two LDRs.

A dual axis tracker is similar to this, except it has two degrees of freedom, allowing for movement along both the x- and y-axes. However, it increases the cost, making the project less economic. When a single axis tracker is used, a slope accommodation of about 15 degrees will be required in the N-S direction, as we move from summer to winter.

## 4. Advantages and Limitations

The main advantages of a computerized solar tracker system over a fixed panel system are:

1. As compared to fixed panel system, the solar tracker system gives almost 40% increase in radiation reception from the Sun.
2. The system is an Arduino-programmed system which uses automated control and sensing options with LDR and RTC programming for orientation of solar panel along the E-W direction.
3. Solar panels produce electricity without giving greenhouse gases as a by-product. One PV Solar system can offset approximately six tons of CO2 emissions over a twenty year life span.
4. Solar energy is a renewable form of energy and provides a cheaper and clean alternative to using conventional fossil fuels for power. Solar energy can be utilised for both industrial and commercial purposes.

The limitations of the solar panel systems are listed below:
1. The efficiency of the solar panel is lowered due to any obstruction of incident radiation.
2. External power is required for rotation of the panels. However, if implemented on a larger scale, this can be overcome.
3. Solar panels have a high initial investment.

## 5. Enhancements and Future Scope

Implemented on a larger scale, the solar tracker system can be used to substantially increase energy generation, as compared to the fixed panel system. This can be monitored by integrating different sensors with the system, to read multiple generating parameters and then optimize the same for higher generating efficiency.

Arduino-based tracking options opens up avenues for multiple sensors, multi-axis control, and integration with cloud-based AI systems for monitoring and control of the generating system. The programming can further be enhanced to make use of the Real Time Clock(RTC), which can be used for improved monitoring of the system. It helps in better analysis and study of the generating parameters to optimise the generation efficiency.

Solar panels are required to be cleaned periodically as they are exposed to dust. Huge amount of water is required to clean to maintain the efficiency. Since the water available is generally hard we require a osmosis plant to get the treated water. We propose to utilise the same microcontroller to automatically clean the panels either by sensing the dust (reduction in generation of efficiency in similar conditions) or by RTC of the microcontroller. We can have a inlet tube with nozzles at the top end of the panel and a collecting trough at the bottom. The collected water can be recycled to the tank through a filter to remove the mud. This can enhance the generation efficiency and reduce the water requirement substantially.

## 6.Conclusion

Solar energy provides a feasible alternative to conventional resources, without generation of any waste or pollution. Implementation of a tracking system increases the efficiency of the solar panels, as compared to the fixed panel system. A dual axis tracker ensures that the sun rays are perpendicular to the panel at all times, throughout the year. This leads to maximum generation of energy from incident solar radiation..

Solar panels find applications in multiple fields, in various spheres. These can be used both in homes as well as in industries, to power the appliances or machinery. These panels can be used to power the traffic lights and streetlights.

Multiple sensors can be integrated with the tracking system to monitor the environmental conditions such as temperature and humidity.The data from these sensors can be analysed using artificial intelligence techniques to further optimise the generation of solar energy.

## References:

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