iJRASET
International Journal For Research in Applied Science and Engineering Technology



# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 12 **Issue:** V **Month of publication:** May 2024

**DOI:** https://doi.org/10.22214/ijraset.2024.60624

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 12 Issue V May 2024- Available at www.ijraset.com*

# Solar Tracking and Monitoring System

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***Abstract:*** ***We will eventually have to deal with the depletion of fossil fuels and other non-renewable energy sources as they are running out rapidly. Having a large number of renewable alternative energy sources is crucial. The sun's radiation properties meet both requirements. As a result, new technologies focused on solar energy harvesting are starting to appear. Concentrated or photovoltaic panels may yield the highest efficiency. Due to the planet's rotation, which causes humans to view the sun at different times of the day the efficiency may reduce. Devices that direct a solar panel or concentrating panel during the day are incorporated in the design, along with light-trackers to boost the system's effectiveness.***
***A solar tracker can monitor the sun's radiation in single direction. The device monitors daily tilt of the sun for optimal performance. The work focuses on the fundamentals of solar panel parameters and their application, as well as the design and construction of an automatic solar tracker prototype utilizing Arduino code based on microcontroller. By simulating the sun's 12-month tracking in a matter of minutes, the device incorporates automation mechanisms into the tracking system.***
***Keywords: Arduino, Automation, Monitoring, Photovoltaic, Solar tracker.***

## I. INTRODUCTION

Energy is a crucial factor in the development of any nation, as it powers various aspects of society. The extraction, distribution, conversion, and consumption of energy on a global scale is immense and steadily increasing due to the growing world population. Currently, oil and coal serve as the primary sources of energy, but it is important to note that these fossil fuels are limited and contribute significantly to pollution. The rising cost of petroleum and the environmental impacts of utilizing these resources, such as increased emissions of carbon monoxide, hydrogen chloride, nitrogen oxides, and sulphur oxides, are concerning factors. These emissions are directly linked to global warming and the greenhouse effect, leading to detrimental effects on the environment.

In an effort to address the mentioned issues, researchers and engineers have been conducting research since the late 19th century. One major breakthrough in this area has been the development of renewable energy sources as an alternative to fossil fuels. These sources are derived from natural processes that are constantly replenished, making them inexhaustible and environmentally friendly.

The table below shows the world`s primary energy producers as of 2021 using different resources, given in million tonnes of oil equivalent (Mtoe) per year.[1]

| Country | Total (Mtoe) | Coal | Oil-Gas | Renewable | Nuclear |
|---|---|---|---|---|---|
| China | 2950 | 71% | 13% | 10% | 6% |
| USA | 2210 | 13% | 69% | 8% | 10% |
| Russia | 1515 | 16% | 78% | 2% | 4% |
| India | 615 | 50% | 11% | 33% | 6% |
| Saudi Arabia | 610 | 0 | 100% | 0 | 0 |
| Canada | 536 | 5% | 81% | 10% | 4% |
| Indonesia | 451 | 69% | 17% | 14% | 0 |
| Australia | 423 | 64% | 33% | 3% | 0 |
| Iran | 354 | 0 | 99% | 0 | 1% |
| Brazil | 325 | 1% | 55% | 42% | 2% |
| Nigeria | 249 | 0 | 47% | 53% | 0 |
| UAE | 218 | 0 | 99% | 0 | 1% |
| Norway | 214 | 0 | 93% | 7% | 0 |
| South Africa | 151 | 91% | 1% | 8% | 0 |

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| | | | | | |
|---|---|---|---|---|---|
| Algeria | 150 | 0 | 100% | 0 | 0 |
| France | 128 | 0 | 1% | 34% | 65% |
| Germany | 102 | 27% | 3% | 47% | 23% |
| World | 14800 | 27% | 53% | 13% | 7% |

TABLE I: World`s Primary Energy Producers as of 2021

As per the report the percentage of renewable energy used for producing energy is too low only about 13%. It is necessary to increase the percentage of the energy produced by renewable resources.

Renewable energies, such as solar energy, tidal energy, are harnessed from natural resources like the sun, wind, tides, waves, and geothermal heat. Solar energy, in particular, is the direct energy produced by the sun and has been utilized throughout human history. It involves capturing radiant light and heat from the sun using technologies like photovoltaic and concentrators. Over the past two centuries, there has been a growing trend towards using the sun's energy directly to generate electricity.

A solar cell (also called a photovoltaic cell) is an electrical device that converts the energy of light (solar rays) directly into electricity by the photovoltaic effect. A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. [2]

On April 25, 1954, Bell Labs announced the invention of the first practical silicon solar cell. Shortly afterwards, they are shown at the National Academy of Sciences Meeting. These cells have about 6% efficiency. *The New York Times* forecasts that solar cells will eventually lead to a source of "limitless energy of the sun". Bell Laboratories (now AT&T labs) scientists Gerald Pearson, Daryl Chapin and Calvin Fuller developed the first silicon solar cell capable of generating a measurable electric current.[3]

Research on solar trackers has been widely developed, including the use of Bluetooth modules as a communication medium between Arduino and Android applications to improve the performance of solar trackers that can be monitored via smartphones.[4]

After years of experiments to improve the efficiency and commercialization of solar power, the solar energy gained support when the government used it to power space exploration equipment in 1958. In 1994, the National Renewable Energy Laboratory developed a new solar cell from gallium indium phosphide and gallium arsenide that exceeded 30% conversion efficiency. By the end of the century, the laboratory created thin-film solar cells that converted 32% of the sunlight it collected into usable energy. Due to dedicated research worldwide, the efficiency of photovoltaics has continued to increase while production costs have also dropped substantially over the years.

## II. LITERATURE REVIEW

Cemil Sungur had given the electromechanical control system of a photovoltaic (PV) panel tracking the sun on the axis it moved along according to its azimuth angle in 2017. Rong-Jong Wai et al. had given grid connected photovoltaic (PV) generation system with an adaptive step-perturbation (ASP) method and an active sun tracking scheme in 2006.[5] S. Shanmugam et al, had given the tracking of the sun for solar paraboloid dish concentrators in 2005.[6] The elevation angle of the sun be in the same place almost invariant in a month and varies little (latitude 10°) in a year. Therefore, single axis position control scheme may be enough for the collection of solar energy in some applications (Yeong-Chau, et al., 2001. Wilamowski and Xiangli, 2002). The change in sun's position is monitored, and the system always keeps that the plane of the panel is normal to the direction of the sun. A few design methodologies of solar tracking system have been proposed in recent days.

## III. SOLAR TRACKER

Solar tracker is a device which uses different parameters to detect the sun position overall the day. There are few different methods to track the sun which are as follows:

### *A. Based on control system*

1) Closed Loop Tracking: The controller uses the output signals of the motor position or electro-optic sensors to reorient the solar module.
2) Open Loop Tracking: The controller gives driving signal to the system on the basis of predefined algorithms and latest data, to change the position of the solar module.

*B. Based on the Degree of Freedom*

*1)* Single Axis Tracker: In this type of tracker system the solar module is tilted on horizontal or vertical axis by means of actuators (electric motor).

*2)* Double Axis Tracker: As the name suggests, this type of tracker system used for tilting the solar module in two axis at a time i.e., vertical and horizontal axis.

*C. Based on the Driver*

*1)* Active Tracker: This system uses electronic components like microcontroller and electro-optic sensors to detect the accurate position of the sun, with respect to the position of sun the solar modules are moved in the maximum light incident area to increase efficiency of the solar module.

*2)* Passive Tracker: The passive tracker uses boiling point of a compressed fluid which moves from one side to the other by solar heat which creates a gas pressure which results in tracker movement.

*D. Based on Tracking Strategy*

*1)* Date and Time: This type of tracking system uses geographical data and controlling algorithms to move the tracker system. Algorithms are based on mathematical calculation s about sun's trajectory.

*2)* Sensors Date and Time: It is very similar to the date and time tracking system in addition, monitoring sensors are used to check the correctness of the operation.[7]

## IV. METHODOLOGY

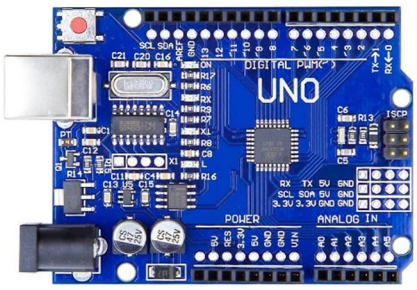
We are using closed loop single axis tracking system to track the solar energy. The main components of the project are LDR (Light Dependant Resistor) sensors, Arduino UNO, Servo Motor, Solar module, and some electronic components like resistors. The monitoring of the solar tracking system can be done by using any computer, laptop or any monitoring or display unit. Monitoring includes intermediate or continuous monitoring of voltage and current produced by the system. The main working of project depends on the code fed into the arduino.

*1) Components-*

LDR sensors are used to detect the solar rays (radiant light). LDR is a type of resistor which varies the resistance to the current with respect to the light intensity on the LDR. As light intensity decreases the resistance of the LDR decreases and vice-a-versa.



Arduino is a type of microcontroller. Microcontrollers are used to control different functions of any embedded system in machines. Microcontroller comprises components like memory, peripherals and most importantly micro-processor.



Servo motor acts as an actuator to move or orient the position of the system. Motors use commands from microcontroller to operate such that the required orientation or position is achieved.
Solar module will work as an output device, which will show readings of voltage and current throughout the process.




*2) Working-*



The project works on combination of electronic components and mechanical linkages. The main sensing element is LDR, which senses the intensity of light rays coming from sun. According to light received by LDR the resistance of the system varies. LDR generates analogue signal which is received by the arduino, arduino reads the data from LDR and with the help of code, it builds the logic to run servo motor. Arduino gives command to the servo motor to rotate in either in clockwise or in anti-clockwise direction according to light intensity. When the luminosity of the multiple LDR's (two in this case) is same, system comes in equilibrium and motor stops. The power required by Arduino can be supplied by using battery or we can directly use power output of solar module to power the Arduino. We can directly get output
The block diagram, flow diagram and circuit diagram are shown below:

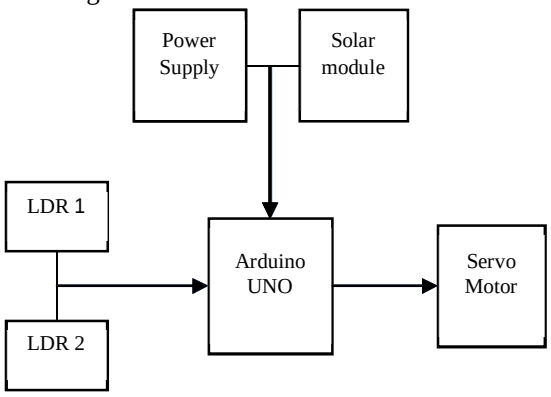



FIGURE I: Block Diagram

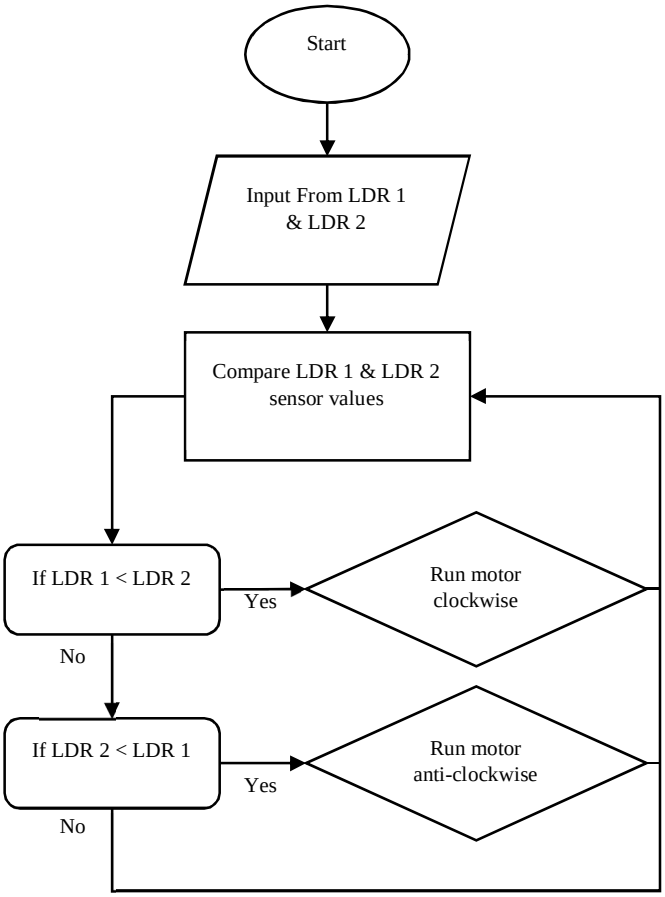



FIGURE II: Flow Diagram

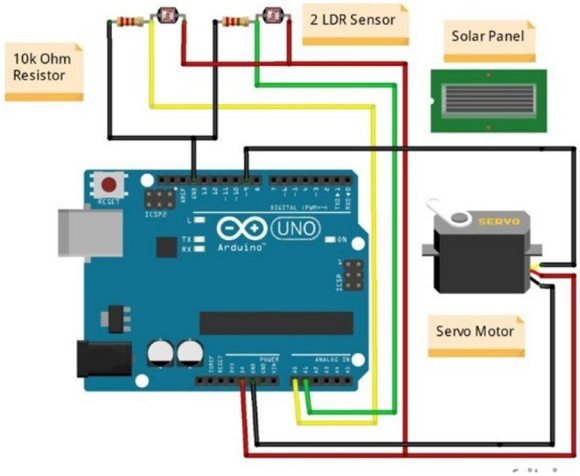



FIGURE III: Circuit diagram

## V. RESULTS AND DISCUSSION

The paper has presented a means of tracking the sun's position with the help of microcontroller and LDR sensors. Specially, it demonstrates a working software solution for maximizing solar cell output by positioning a solar panel at the point of maximum light intensity / perpendicular to sun light. Moreover, the tracker can initialize the starting position itself which reduce the need of any more photo resistors. The attractive feature of the designed solar tracker is simple mechanism to control the system.

As solar power production is used in large scale worldwide so, even an increment in efficiency by 1% than stationery plane will increases the net power production by large amount. Hence, no matter by how much tracker increases an efficiency it is always welcomed. In addition, with monitoring facility there will be no need of preventive maintenance, as we can easily determine the condition of the system by comparing current output and previous outputs.

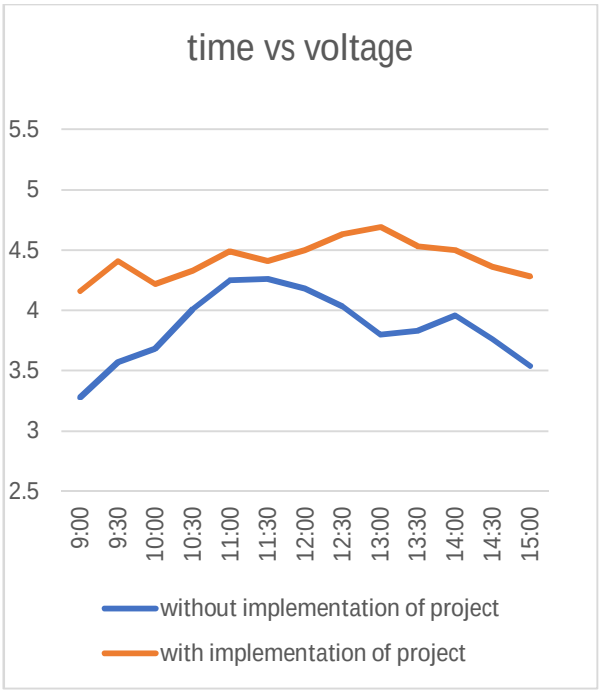


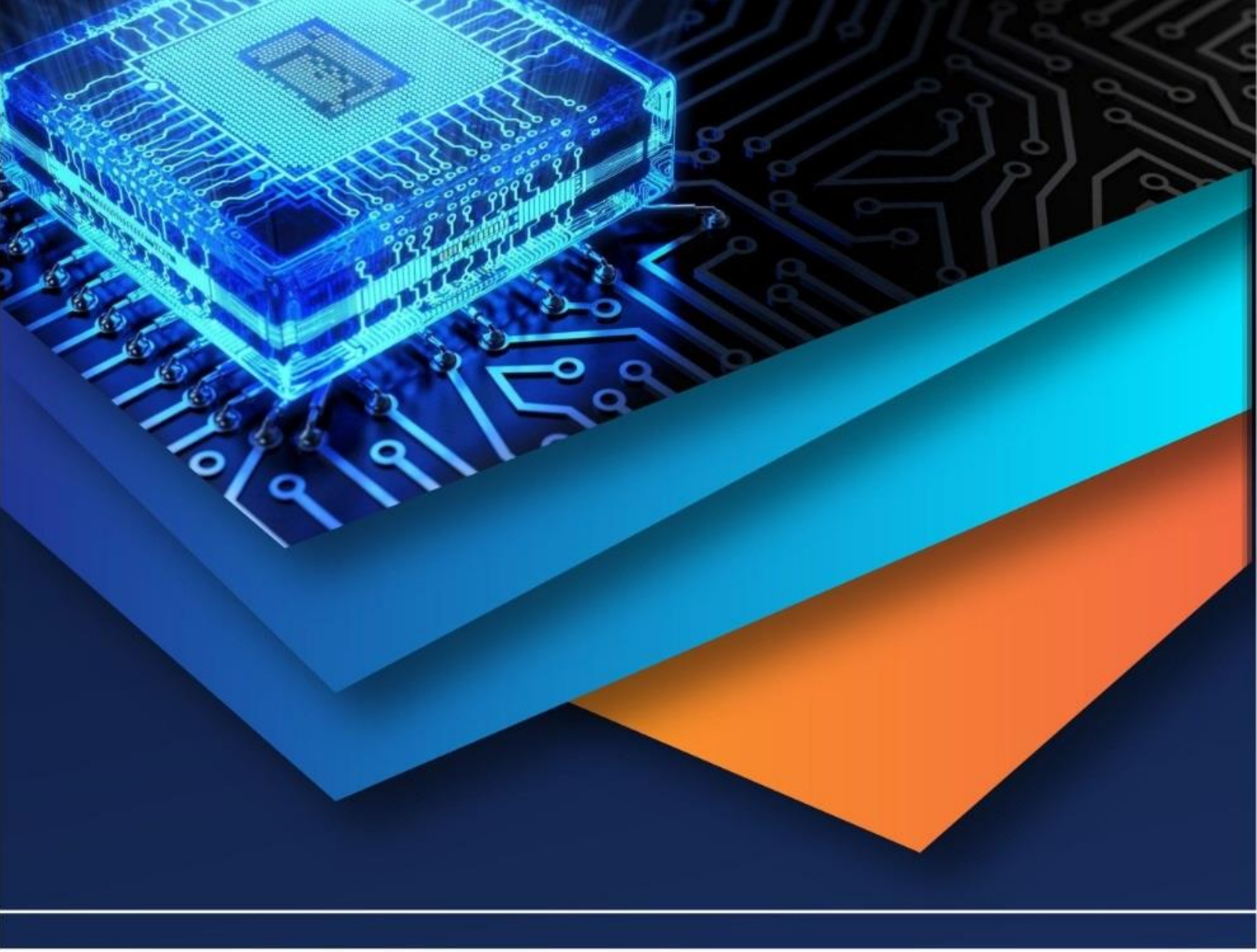

FIGURE IV: Time vs Voltage Graph for Without Implementation of Project and With Implementation of Project.

As per the data generated by team, it is very clear that with implementation of project the output of the solar module is increased to 14.67 %. By using large solar modules ad precise motor positioning the output can be increased upto 20 to 25%.

In a conclusion, this mechanism could be manifested in wide range of applications that require solar tracking such as parabolic trough collector, solar dish, lens and other PV systems to collect maximum radiation from sun.

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