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DUAL AXIS SOLAR TRACKING SYSTEM USING AURDUINO

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Abstract: The dual-axis solar tracking system represents a significant advancement in solar technology, harnessing the power of Arduino microcontrollers for enhanced energy capture. Utilizing Light Dependent Resistors (LDRs) as photosensors, the system dynamically adjusts the orientation of solar panels in both horizontal and vertical axes, ensuring optimal alignment with the sun's trajectory. The Arduino Nano, programmed in C language, serves as the brain of the operation, commanding servomotors that reposition the panels in response to solar movement. This smart integration of simple electronics and sophisticated software culminates in a highly efficient solar energy solution, promising long-term environmental and economic benefits.

The system's design is focused on simplicity and cost-effectiveness, employing readily available components to create a scalable solution suitable for various applications. The dual-axis mechanism significantly outperforms static installations, capturing the full potential of solar energy from dawn till dusk.

Index Terms **– Arduino Nano, Dual-Axis Tracking, Solar Energy, Servomotors, Light Dependent Resistors (LDRs), Photovoltaic Efficiency, Sustainable Technology, Sun Tracking Algorithms, Energy Harvesting**

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 maximize 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. Aiming for that purpose, this project had been carried out to support the development of such promising technology.

One of the main methods of increasing efficiency is to maximize the duration of exposure to the Sun. Tracking systems help achieve this by keeping PV solar panels aligned at the appropriate angle with the sun rays at any time. The goal of this project is to build a prototype of light tracking system at smaller scale, but the design can be applied for any solar energy system in practice. It is also expected from this project a quantitative measurement of how well tracking system performs compared to system with fixed mounting method.

LITERATURE SURVEY:

Prof. (Dr.) Mukesh Pandey et al., (2020) described exploring the usage of solar trackers and their cost-effectiveness in a paper with the title "A Review Paper on Solar tracking System for Photovoltaic Power Plant". This paper talks about a Solar tracking system that is defined by its degrees of rotation. According to the degrees of rotation, tracking systems can be categorized namely Single Axis Solar Tracking and Dual Axis Solar Tracking. Single-axis solar tracking is able to track the sun either horizontally or vertically.

Dual-axis solar tracker could track the sun in both horizontal and vertical ways and guarantees maximum efficiency. There are several methods of solar tracking namely Active tracking, Passive tracking, and Chronological tracking.

G. Pavan Kalyan et al., (2019) discussed sun tracking system in "Sun tracking system using microcontroller". This paper explains the movement of the motor by an indication from a sensor circuit when the intensity of solar rays is heightened. This project discusses the construction of a prototype that features a single axis of freedom. The different ways of accelerating the efficiency of solar panels are discussed here. Very efficient trackers will show high efficiency because they're ready to track the sun with accuracy.

D. T. Cotfas et al., (2019) listed very important methods to enhance the efficiency and the lifetime of photovoltaic panels in a paper "Multi concept methods to enhance photovoltaic system efficiency". Several cooling methods and the maximum power point tracker methods are presented in this paper. The methods to increase the solar radiation which pounce on the PV panels are Sun tracking system, Reflective system, active reflectance, Passive reflectance, refractive system. The clear and detailed classification of various types of solar trackers is discussed in this paper. The Important cooling methods of the photovoltaic panels that are mentioned in this paper are Air cooling, Water cooling, Phase change material, and Thermoelectric. Karami et al. gave some criteria in choosing the best MPPT technique for various applications like Implementation, sensors, efficiency, and cost.

M. Prem Kumar et al., (2019) discussed various MPPT methods for the PV systems in their research paper "An effective maximum power point tracker for partially shaded solar photovoltaic systems". This paper talks about a maximum power point tracking technology to obtain the peak power from the PV array during partially shaded conditions. The results from the simulation show that the Whale Optimization technique presents high efficiency of tracking and less merging time with lesser power oscillations. The PV solar characteristics under different operating conditions with graphs are mentioned.

Shin'ya Obara et al., (2018) proposed the development of a solar tracking system of a nonelectric power source by using a metal hydride actuator. This study deals with the sun tracking system of a non-electric power source by employing a metal hydride actuator with a sun radiation drive. The proposed tracking system includes two MH reactors that are placed perpendicular to the photovoltaic cell array. This study showed the result of the proposed system after four months of testing. In order to attain highly reliable solar tracking with the proposed system, excessive cooling by wind should be prevented by installing a windshield. The Hydrogen element is discharged from MH by heating, and it is reserved by cooling. The pressure of the proposed reactor depends on its MH temperature. Therefore, it's possible to modify the actuator by creating a temperature difference between the MH reactors, which then creates a pressure difference.

Jose A. Carballo et al., (2018) introduced a new low-cost solar tracking system based on open-source hardware for educational purposes. In his paper, a small prototype based on low-cost open-source hardware is developed in Simulink. This prototype has been developed to be a powerful tool that can be used for a wide range of applications. The accuracy is conditioned by constant aberrations. In the literature, there are reviews about solar tracking systems one and two axes tracking systems with open-loop, closed-loop, control based on continuous movements, maximum beam, electro-optical sensors, solar equations, or a hybrid. In this work, a new solar tracker is proposed, with the main objective of developing a unique educational tool to understand solar tracking problems regardless of solar technology. The proposed system can detect the position of the Sun and the receiver; also, it is time and location independent.

Fabio Moacir Hoffmann et al., (2017) discussed monthly profile analysis based on a two-axis solar tracker proposal for photovoltaic panels. The objective of this study is to develop a dual-axis solar tracker and evaluate the performance of a solar panel, compared to a fixed system. Each system is composed of a mechanical structure, a solar panel, and a resistive load. This work talks about the development and performance of a dual-axis solar tracker and evaluates the movement cost of the PV system. To study the alternatives, this paper depicts the development of a dual- axis solar tracker.

Masoumeh Abdollah pour et al., (2018) proposed a dual-axial tracker that works based on processing images of a bar shadow through a research paper "Development of a machine vision dual-axis solar tracking system". The system is composed of a shadow casting particle, a webcam, few electronic circuits, and stepper motors. The study results presented that the tracking system followed the sun with an accuracy of about ±2° and generates an increased power output. Arul Kumar and Arjun, 2016 developed an automatic solar tracking system that was a single axis, five positions in the LDR sensor, and was designed for low power. Kadmiri et al. showed a novel solar tracker system based on Omni-directional vision technology. Performance of the morphological and regression analyses was compared in terms of root-mean-square error and mean absolute percentage error. In this study, a moderated dual-axis tracker independent of initial settings and local location based on image processing of a bar shadow was developed, which uses the shadow length to determine the zenith angle and height.

Boon-Han Lim et al., (2020) explained the design of a dual-axis sun tracker with a vertical axis and multiple row elevation. The algorithm of the software determines the number of counts is required to set the amount of pin-gear rotation to a specific amount. For every excitation of the motor initiated by a control signal, the number of rotations will be constant due to feedback control in the form of a counter; therefore, a good tracking precision is achieved. The range of motion and slew rate for various months is studied for both tracking axes.

L.M. Fernandez-Ahumada et al., (2019) proposed a unique backtracking approach for two-axis solar PV tracking plants. One of the foremost important aspects in tracking is shading between the modules and also appearance of hot spots within the modules. The tactic presented here is useful for the optimization of the planning of the latest photovoltaic two-axis tracker plants. Therefore, this

novel backtracking approach explains that the tracker must point towards the irradiance direction within the non-shaded region. Consequently, this novel method is expected on algorithms that are significantly simpler and faster. Thus, this method is simpler to be wont to simulate energy production with different radiative models.

Muhammad E. H. Chowdhary et al., (2019) proposed a new algorithm in a research paper "A Low-Cost Closed-Loop Solar Tracking System Based on the Sun Position Algorithm". The Astronomical Almanac's algorithm was executed for its reliability, simplicity, and fast computation capability of the solar position. Results revealed that incorporation of the sun position algorithm in a solar tracking system supports in performing the stable system and optical tracking system. AS a fact, there are few ways to increase the efficiency of PV systems like to increase the efficiency of power generation of the PV cells, the efficiency of the control algorithms for the energy translation, and to endorse a tracking system to achieve extreme solar energy. The core area of this paper is to accelerate efficiency by blending the second and third approaches. The angle between the direction of the sun and the zenith is called the zenith angle. A real-time solar position tracking system is successfully executed using the AA algorithm.

Rafid Khan et al., (2018) described Enhanced energy extraction in an open- loop single-axis solar tracking system with tracker rotation about a tilted axis. Fatha Badi came up with a dual-axis solar tracker with minimum tracking error. Based on the tracking algorithm, solar tracking systems can be broadly classified as open- loop and closed-loop systems. Al Naima and Yaghobian proposed the dual-axis solar tracking system based on astronomical coordinates of the sun and demonstrated that the system performed better than conventional sensor-controlled systems.

A.Z. Hafez et al., (2018) discussed technologies and tracker drive types in their paper "Solar tracking systems: Technologies and trackers drive types – A review". A single-axis sun tracking system helps to track the sun from one side to another using a single pivot point to rotate. This system has three types: horizontal, vertical, and tilted single-axis tracking system. Nomenclature, Greek symbols, and acronyms are listed in this paper. The historic overview of the solar tracking systems is described and new techniques of the solar tracking systems are discussed. The solar tracking system types are described, as well as introduced the solar trackers drive types.

Rakhi Sharma (2019) introduced urban flash flood observation, mapping, and prediction via a tailored device network system. Optimization of a PV system is completed by simulation software system tool PVsyst five.52. Choice of PV array, controller, pumping unit, water system network is needed to fulfill style needs. The theoretical study has supported the factors that are specialized in simulation software systems. The theoretical analysis of the solar PV water pumping system includes hydraulic power calculation, filler of electrical phenomenon array, motor filler, and efficiency calculation of the system. This study represents a simplified style optimization approach for a solar photovoltaic Water Pumping System with the help of theoretical computations and PVsyst simulation software system.

EXISTING SYSTEM:

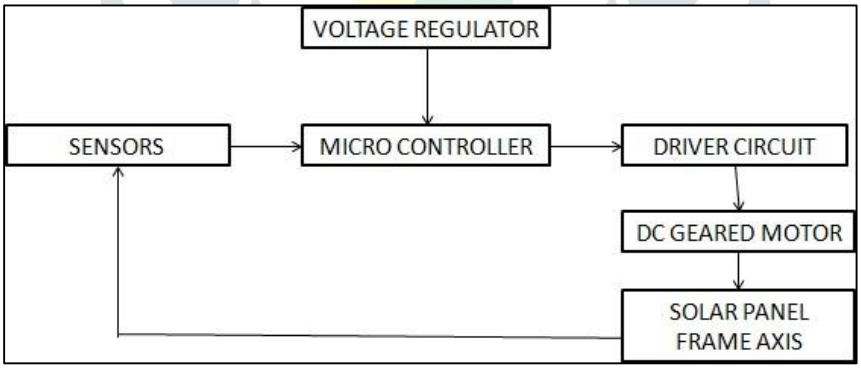


Fig: Block Diagram of Existing System

In the given block diagram of the single-axis solar tracking system which is considered an existing system. It consists of a microcontroller, sensors, voltage regulator, driver circuit, dc geared motor, and solar panel frame axis. Here the sensors are arranged in such a way that the solar panel rotates in only one degree of freedom. When the sun travels from east to west, the sun's highest position also changes. Hence this system is only helpful in tracking either of the axes. Due to this ideal energy is not provided to the solar panel. As a result, the output energy is also not ideal.

OBJECTIVE

The objectives of the proposed work are as follows

- To design a dual solar tracking system that can collect maximum amount of sunlight on the solar panel.
- To optimize and increase the efficiency of output than existing system.
- To analyze the performance of various solar tracking and find out the best efficient way to maximize the output.

PROPOSED SYSTEM:

The Dual-axis solar tracking system that tracks the maximum sun rays using LDR sensors. This system is designed according to track solar rays in both axes all day. The system includes a power supply, Arduino, two servo motors, four LDR sensors, battery, charge controller, and solar panel. This total system is designed in a form so that it tracks the sun efficiently and obtains maximum solar energy from the sun and increases the output efficiency and provides better performance even in cloudy conditions

Key Components:

- **Arduino Nano**: Acts as the central processing unit.
- **Servo Motors**: Facilitate the physical movement of the panels along two axes.
- **Light Dependent Resistors (LDRs)**: Serve as the primary sensors to detect sunlight intensity.
- **Solar Tracker Kit**: A pre-assembled kit containing all necessary parts for building the system.

Functionality:

- The system uses LDRs to determine the sun's position and sends this data to the Arduino.
- The Arduino processes the information and controls the servo motors.
- The servo motors adjust the panels' tilt and rotation to follow the sun's path.

REQUIREMENT:

7.1 HARDWARE REQUIREMENTS:

- **Arduino Nano**: The microcontroller that serves as the brain of the system.
- **Gear Motors**: Used to adjust the position of the solar panels along two axes.
- **Light Dependent Resistors (LDRs)**: Act as sensors to detect the intensity and position of sunlight.
- **Solar Tracker Kit**: May include structural components, wiring, and other necessary hardware for assembly.
- **Solar Panels**: The photovoltaic cells that convert sunlight into electrical energy.
- **Mounting Structure**: Supports the solar panels and houses the movement mechanism.

7.2 SOFTTWARE REQUIREMENTS:

- **Arduino IDE**: The development environment used to program the Arduino Nano.
- **Tracking Algorithm**: The code that processes the input from the LDRs and controls the servo motors accordingly.

I. ADVANTAGE & DISADVANTAGE:

8.2 ADVANTAGE

- **Increased Efficiency**: Dual-axis trackers can increase electricity production by **10 to 25%** depending on location, as they ensure direct exposure to solar rays throughout the day.
- **Optimal Land Usage**: They generate more electricity in roughly the same amount of space needed for fixed systems, making them ideal for optimizing land usage.
- **Advanced Technology**: The use of Arduino allows for sophisticated control with relatively simple and accessible technology.
- **Energy Production**: They can generate nearly **40% more power** than fixed panels due to their ability to follow the sun's path accurately.

8.2 DISADVANTAGE

- **Higher Cost**: The complex technology and moving parts necessary for operation make dual-axis trackers more expensive than fixed systems.
- **Maintenance**: They generally require more maintenance due to the mechanical complexity and moving parts involved.
- **Complexity**: The system is more complex, which could lead to a higher likelihood of operational issues

APPLICATION:

- Used for solar power towers.
- Used to improve solar pumping system.
- Used for street lightning system.
- Used to provide electricity in remote areas.

II. BLOCK DIAGRAM

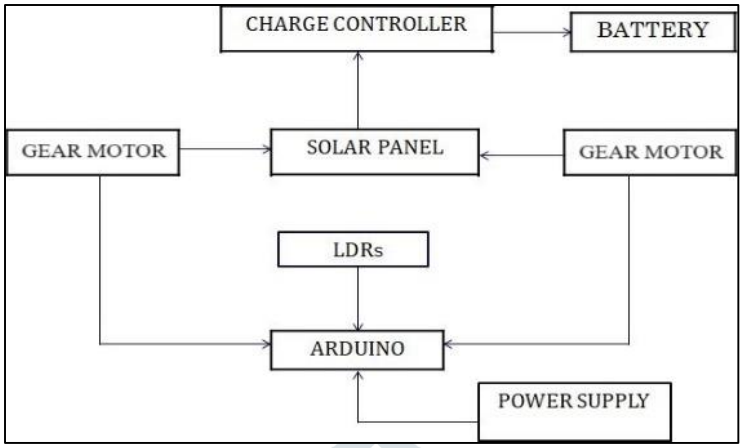


Fig. Block Diagram of Purposed System

Here's an explanation of each component and its role:

- **Solar Panel**: This is the primary component that converts sunlight into electrical energy. It's connected to both the charge controller and the servo motors.
- **Gear Motor's**: There are two servo motors connected to the solar panel, one for each axis. These motors adjust the panel's position to track the sun's movement across the sky.
- **LDRs (Light Dependent Resistors)**: Positioned to detect the intensity of sunlight, these sensors provide input to the Arduino about the sun's location.
- **Arduino**: The microcontroller processes the signals from the LDRs and controls the servo motors based on this information, adjusting the panel's position accordingly.
- **Charge Controller**: Connected to the solar panel, it manages the power transfer to the battery, ensuring the battery is charged efficiently and safely.
- **Battery**: Stores the electrical energy generated by the solar panel for later use.
- **Power Supply**: Provides power to the Arduino and potentially other components in the system.

OPERATION'S:

The flow of operation is as follows:

1. The LDRs detect the intensity and position of the sun.
2. The Arduino processes this data and sends commands to the servo motors.
3. The servo motors adjust the solar panel's position to ensure it is optimally aligned with the sun.
4. The solar panel converts the sunlight into electrical energy, which is then managed by the charge controller.
5. The charge controller regulates the charging of the battery, storing the energy produced.

RESULT:

Here are some key findings:

- **Performance Improvement:** A dual-axis solar tracker prototype demonstrated a 25% increase in harvested solar energy compared to a fixed solar panel under the same conditions.
- **Smart System:** A smart solar tracking system using Arduino (dual-axis) was developed, which is accessible and does not require advanced electrical knowledge for assembly.
- **Optimization:** The system is designed to benefit from sunlight with maximum efficiency throughout the day, adjusting the panel according to the sun's angles with the help of two servo motor.
- **Energy and Space Savings:** A maximum power point tracking algorithm was developed for a dual-axis servo motor feedback tracking system using an Arduino board, showing advantages in terms of energy and space savings.

CONCLUSION:

In this 21st century, as we build up our technology, population & growth, the energy consumption per capita increases exponentially, as well as our energy resources (e.g. fossils fuels) decrease rapidly. So, for sustainable development, we have to think alternative methods (utilization of renewable energy sources) in order to fulfil our energy demand.

In this project, Dual Axis Solar Tracker, we've developed a demo model of solar tracker to track the maximum intensity point of light source so that the voltage given at that point by the solar panel is maximum. After a lot of trial and errors we've successfully completed our project and we are proud to invest some effort for our society. Now, like every other experiment, this project has couple of imperfections.

(i) Our panel senses the light in a sensing zone, beyond which it fails to respond.

(ii) 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 was kept simple, understandable and user friendly.

SCOPE OF THE PROJECT:

In this report, an improved solar tracking system with a dual-axis tracking mechanism has been proposed. Due to the transition of the sun from east to west, the fixed solar panel may not be able to generate optimum energy. Single-axis solar tracking couldn't produce ideal energy. The proposed system solves this problem by an arrangement for the solar panel to obtain maximum sun rays throughout the day.

REFERENCE:

[1] Solar Tracking Hardware and Software by *Gerro J Prinsloo*

[2] Design and Implementation of a Sun Tracker with a Dual-Axis Single Motor "*Jing-Min Wang* and *Chia-Liang Lu*''

[3] Sensors and Transducers...Second Edition...''*D.Patranabis*"

[4] Atmel ATmega48A/PA/88A/PA/168A/PA/328/P-datasheet

[5] Utilisation of Electrical Power. Author, *Er. R. K.* Rajput.

[6] Arduino Programming Book. Author, *Brian W. Evans*

[7] Bhagwan Deen Verma, Prof. (Dr.) Mukesh Pandey, Asst. Prof. Anurag Gour. "A Review Paper on Solar Tracking System for Photovoltaic Power Plant". *International Journal of Engineering Research & Technology* Vol. 9 Issue 02, February(2020): 2278-0181

[8] Pavan kalyan .G, Dharma .B, Anil Kumar .B, Sagar Nayak. "Sun Tracking Solar System Using Microcontrollers. *"International Journal of Innovative Research In Technology* 147981: 2349-6002.

[9] Cotfas, D. T., and Cotfas P. A. "Mult concept methods to enhance photovoltaic system efficiency." *International Journal of Photoenergy* 2019 (2019).

[10] Premkumar, M., and R. Sowmya. "An effective maximum power point tracker for partially shaded solar photovoltaic systems." *Energy Reports* 5 (2019): 1445-1462.

[11] Obara, Shin'ya, Kazuhiro Matsumura, Shun Aizawa, Hiroyuki Kobayashi, Yasuhiro Hamada, and Takanori Suda. "Development of a solar tracking system of a nonelectric power source by using a metal hydride actuator." *Solar Energy* 158 (2017): 1016-1025.

[12] Carballo, Jose A., Javier Bonilla, Lidia Roca, and Manuel Berenguel. "New low-cost solar tracking system based on open-source hardware for educational purposes." *Solar Energy* 174 (2018): 826-836.

[13] Hoffmann, Fábio Moacir, Rolf Fredi Molz, João Victor Kothe, Elpidio Oscar Benitez Nara, and Leonel Pablo Carvalho Tedesco. "Monthly profile analysis based on a two-axis solar tracker proposal for photovoltaic panels." *Renewable energy* 115 (2018): 750-759.