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Dual Axis Solar Tracking System

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Abstract: *The dual-axis solar tracker project aims to optimize the efficiency of solar panels by ensuring they are always aligned with the sun. Originating from the necessity to enhance solar energy capture, this project builds on the work of previous researchers who developed various solar tracking mechanisms. Historically, solar trackers have been implemented using different methods such as single-axis tracking systems and manual adjustments, but these methods often fall short in maximizing solar exposure throughout the day. Previous works have successfully integrated basic solar tracking with microcontrollers and sensors; however, they frequently lack real-time adaptability and mobile charging capabilities.*

Our project addresses these gaps by incorporating a dual-axis tracking system driven by a microcontroller and Light Dependent Resistors for precise light tracking. The solar tracker employs a solar panel, capable of efficiently capturing solar energy. The energy captured is displayed on a display device, which provides real-time feedback on the system's performance. Additionally, the structure is supported by a pan-tilt mechanism that allows the solar panel to adjust its position along both horizontal and vertical axes, ensuring optimal alignment with the sun..

Keywords: *dual-axis solar tracker*

I. INTRODUCTION

In today's technological era, mobile devices have become an integral part of daily life, essential for communication, navigation, and accessing information. However, one of the most common and frustrating issues faced by users is the frequent depletion of mobile phone batteries. This problem is particularly pronounced in outdoor and off-grid environments where access to conventional power sources is limited or nonexistent. In such scenarios, the inability to recharge mobile devices can lead to significant inconveniences and even critical situations. Traditional charging methods for mobile devices typically depend on grid electricity. While this is usually sufficient in urban settings, it poses a significant challenge in remote or rural areas. The lack of infrastructure in these areas means that users often cannot rely on a stable and continuous power supply. Additionally, in emergency situations such as natural disasters, where power outages are common, the need for alternative charging solutions becomes even more critical.

Furthermore, the environmental impact of using non-renewable energy sources for electricity generation cannot be ignored. Fossil fuels, which are the primary source of grid electricity in many parts of the world, contribute to air pollution and greenhouse gas emissions. This not only exacerbates climate change but also leads to health problems among populations. In light of these issues, there is a growing need for innovative and eco-friendly power sources that canprovide reliable energy for charging mobile devices. Solar energy, being abundant and renewable, presents a viable solution. However, conventional solar panels with fixed orientations do not efficiently capture sunlight throughout the day, resulting in suboptimal energy generation. This inefficiency limits the practicality of solar power as a reliable charging solution. Our project aims to address these challenges by developing a dual axis solar tracker that maximizes solar energy capture. By dynamically adjusting the orientation of the solar panel to follow the sun's movement, our system ensures continuous and optimal exposure to sunlight.

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II. LITERATURE SURVEY

The available renewable energy resources are solar, Wind, Hydro, Fuel Cell (FC) etc. Among these, the solar energy is a pollution free, promising and reliable green source to meet the growing demand. The increasing demand for energy with the concern of depletion in conventional fuels, and protecting the environment from pollution have made the researchers to develop a new solution of utilizing the renewable energy. Considering all these factors. The PV system converts sunlight into electrical power using the principle of photovoltaic effect. Whenever light falls on PV cell, the energy from photon is transferred to the charge carriers. Then the charge carriers split into positively charged holes and negatively charged electrons due to the electric field across the junction. This results in the flow of current if a closed path is provided to the circuit by connecting a load. The basic operation of a PV cell is shown in Fig.1. The total amount of solar energy that consumed worldwide increased exponentially the total capacity, generated, and consumed energy has increased exponentially, and the total growth of solar energy capacity and usage is 29.6%

Objectives

➢ 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.

Block Diagram

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LDR Sensor :-

An LDR (Light-Dependent Resistor) sensor is a passive electronic component whose resistance decreases as the intensity of light falling on it increases. This property is based on photoconductivity, where light provides energy to electrons, allowing them to move more freely and conduct electricity. LDRs have a high resistance in darkness (several megaohms) and a very low resistance in bright light (a few hundred ohms), making them useful for applications like automatic streetlights, burglar alarms, and camera light meters**.**

Aurdino UNO :-

The Arduino Uno is a beginner-friendly, open-source microcontroller board featuring the ATmega328P processor. It includes 14 digital I/O pins (6 of which can be used for PWM), 6 analog input pins, a USB port for programming and power, and a reset button. It is powered by a 5V operating voltage, can be powered by a 7-12V external supply, and has 32KB of flash memory*Arduino Uno* : Arduino Uno is an open-source microcontroller board based on the processor ATmega328P. There are 14 digital I/O pins, 6 analog inputs, a USB connection, a power jack, an ICSP header, and a reset button. It contains all the necessary modules needed to support the microcontroller. Just plug it into a computer with a USB cable or power it with an adapter to get started. You can experiment with your Arduino without worrying too much about it. In the event of a worst-case scenario, you could buy a new one as the Uno is very economical compared to other boards like raspberry pi, STM, etc.

- The hardware structure of Arduino Uno

Microcontroller:
14 Digital Pin
6 Analog Pins
Power Supply
Power Jack
USB Port
Reset Button

DC Gear Motor :-

A DC gear motor is a DC motor with a gearbox that reduces speed and increases torque, making it suitable for applications needing high force at low speeds. The key parameters are speed (RPM), torque (load), and efficiency, which depend on the gear ratio and application requirements.

Solar Panel :-

Solar panels are devices that convert sunlight into electricity using photovoltaic (PV) cells, which are made from semiconductor materials like silicon. When photons from sunlight hit the cells, they dislodge electrons, creating a direct current (DC) electricity flow that can be used directly, stored in batteries, or converted to alternating current (AC) for use in homes and businesses. Key components of a solar energy system include the panels themselves, an inverter, and sometimes batteries for storage.

Types of Solar Panel :-

Monocrystalline: Made from a single silicon crystal, these panels are typically blackish, have a more uniform appearance, and are more efficient. They are a good choice if space is limited, but they tend to be more expensive.

Polycrystalline: Made from multiple silicon fragments melted together, these panels have a blue, mottled look and are less efficient than monocrystalline panels. They are a more budget-friendly option.

Thin-film: A cheaper and more flexible alternative, though they have a lower efficiency rate compared to crystalline silicon panels.

Data Logger :-

Data logger (also datalogger or data recorder) is an electronic device that records data over time or about location either with a built-in instrument or sensor or via external instruments and sensors. Increasingly, but not entirely, they are based on a digital processor (or computer), and called digital data loggers (DDL). They generally are small, battery-powered, portable, and equipped with a microprocessor, internal memory for data storage, and sensors. Some data loggers interface with a personal computer and use software to activate the data logger and view and analyze the collected data, while others have a local interface device (keypad, LCD) and can be used as a stand-alone device.

Data loggers vary from general-purpose devices for various measurement applications to very specific devices for measuring in one environment or application type only. While it is common for general-purpose types to be programmable, many remain static machines with only a limited number or no changeable parameters. Electronic data loggers have replaced chart recorders in many applications.

One primary benefit of using data loggers is their ability to automatically collect data on a 24-hour basis. Upon activation, data loggers are typically deployed and left unattended to measure and record information for the duration of the monitoring period. This allows for a comprehensive, accurate picture of the environmental conditions being monitored, such as air temperature and relative humidity.

Charge Controller :-

A charge controller, also called a solar charge regulator, manages the power flow between a power source like solar panels and a battery bank. Its primary functions are to protect the battery from overcharging and prevent it from discharging back through the panels at night. It also prevents deep discharge and ensures the battery charges and discharges at the correct voltage and current levels to extend its lifespan and maintain performance.

Battery :-

An electric battery is a source of electric power consisting of one or more electrochemical cells with external connections[1] for powering electrical devices. When a battery is supplying power, its positive terminal is the cathode and its negative terminal is the anode.[2] The terminal marked negative is the source of electrons. When a battery is connected to an external electric load, those negatively charged electrons flow through the circuit and reach the positive terminal, thus causing a redox reaction by attracting positively charged ions, or cations. Thus, higher energy reactants are converted to lower energy products, and the free-energy difference is delivered to the external circuit as electrical energy. Historically the term "battery" specifically referred to a device composed of multiple cells; however, the usage has evolved to include devices composed of a single cell.

Voltage Divider :-

A voltage divider is a simple circuit with two resistors in series that creates a lower output voltage that is a fraction of the input voltage. The output voltage is calculated using the formula $V_{out}=V_{in}\times \frac{R_{b}}{R_{a}+R_{b}}$, where R_{a} and R_{b} are the two resistors. These circuits are used to scale down voltages, create reference voltages, and in applications like sensors and microcontrollers.

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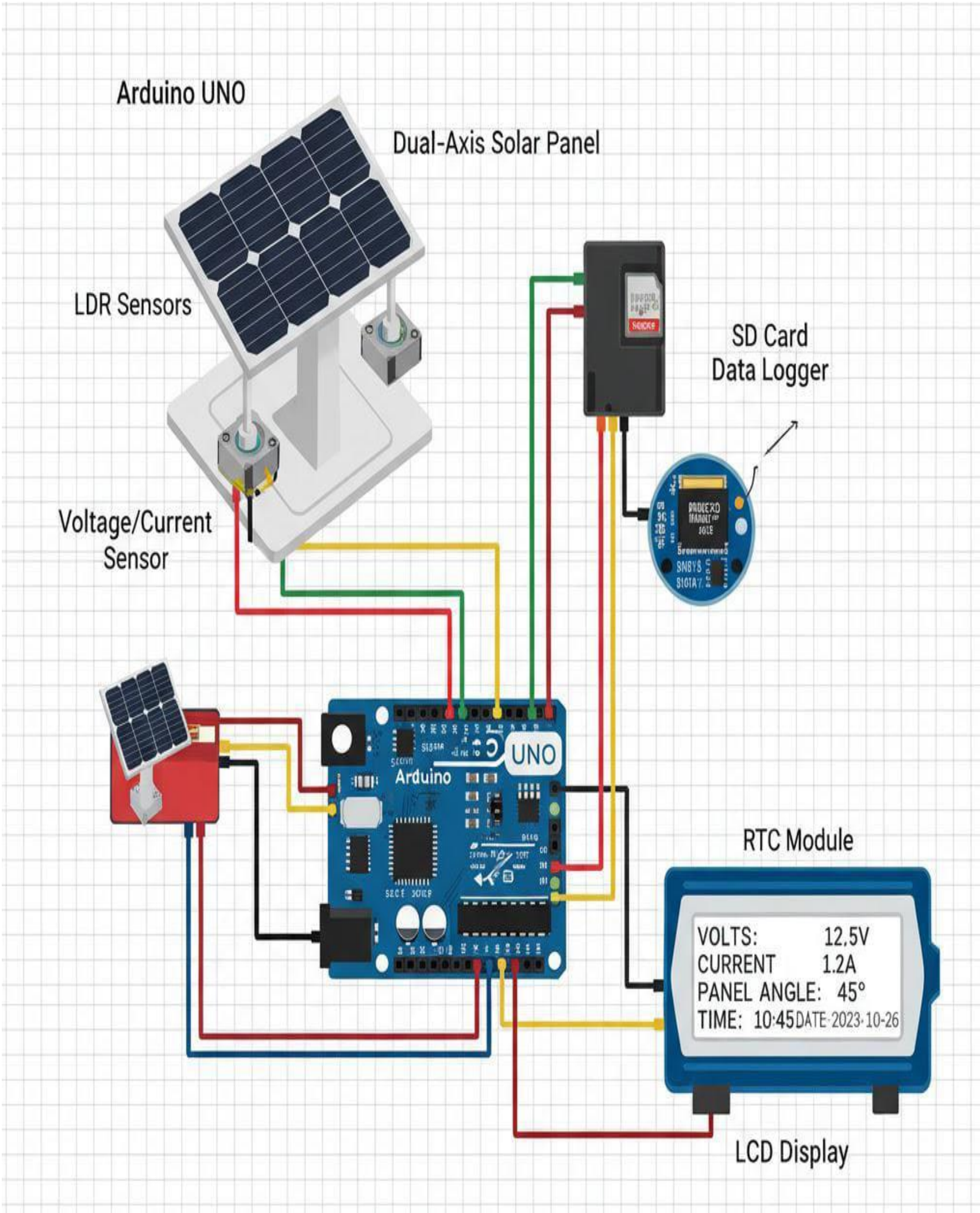
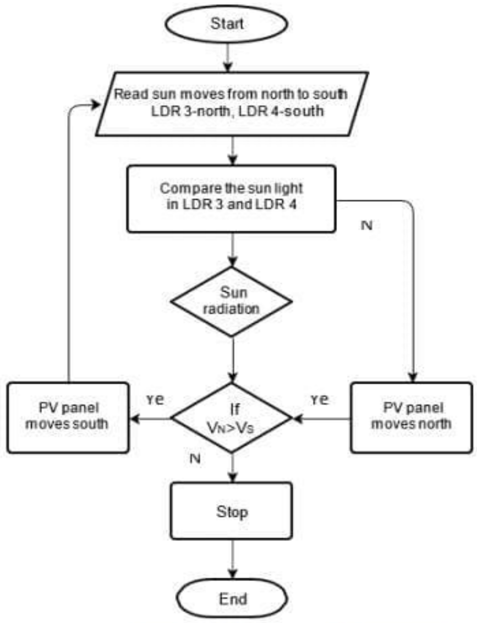
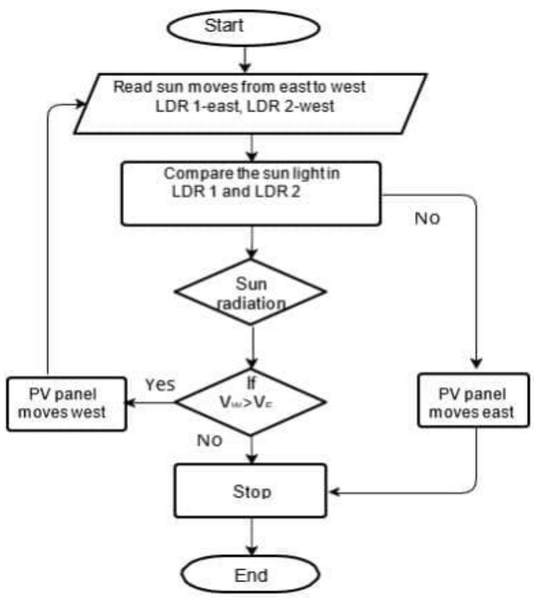
Circuit Diagram



Flow Chart



Flowchart of Vertical Movement.



Flowchart of Horizontal Movement.

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Components Required

Sr.No	Components	Qty
1.	LCD Display	1
2.	Aurdino UNO	1
3.	Solar Panel (5-10 w)	1
4.	LDR Sensor	4
5.	Breadboard	1
6.	Power supply/Adaptor	1
7.	Connecting wires & terminal box	1 set
8.	Miscellaneous(Tape, Screw, Nuts)	1

Advantages

➢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.

Disadvantages

➢Solar panels can be costly to install resulting in a time lag of many years for savings on energy bills to match initial investments.

➢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.

➢Solar power is used for charging large batteries so that solar powered devices can be used in the night.

➢ The batteries used can be large and heavy, taking up plenty of space

Future Scope

Future advancements can focus on improving the efficiency of solar tracking systems.This may involve incorporating advanced tracking algorithms, using more accurate Sensors and optimizing the control mechanism to maximize solar energy capture. Additionally, advancements in materials and manufacturing techniques can lead to the development of more efficient and lightweight tracking systems.

Integration with Renewable Energy Systems: Solar tracking systems can be integrated with other renewable energy systems to create hybrid setups. For example, combining solar tracking with wind turbines or incorporating energy storage technologies can enable the efficient utilization of multiple renewable energy sources, improving overall system performance and reliability.Future developments can focus on reducing the cost of solar tracking systems, making them more affordable and accessible. This can be achieved through advancements in manufacturing processes, component optimization, and the use of cost-effective materials. Additionally, economies of scale and increased market demand can contribute to cost reductions.

Future solar tracking systems can be designed to be adaptable and flexible, capable of tracking the sun's position in various weather conditions and environments. This can involve incorporating intelligent control systems that can adjust tracking parameters based on weather data, cloud cover, or shading, ensuring optimal energy capture under different circumstances. Future solar tracking systems can be designed with scalability in mind, allowing for easy expansion or

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integration with existing solar installations. Modular designs can enable the addition of tracking units to increase capacity as required, making it adaptable to various project sizes and installations.

The future scope of solar tracking systems is wide-ranging, with opportunities for improving efficiency, integrating with other renewable energy systems, leveraging IoT technologies, reducing costs, enhancing adaptability, and incorporating advanced sensors. These advancements can contribute to the widespread adoption of solar tracking systems and further the development of sustainable and efficient solar energy generation.

Application

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

III. RESULTS

From this tracker we can increase the solar panel efficiency of over the steady solar panel below are the observation taken from that we can identify easily. We know that the angle between the sun's rays and the solar panel is crucial for achieving maximum efficiency. We can conduct an observation by changing the angle of the solar panel at the same time with the same load to determine how the output changes in relation to the position of the solar panel.

Comparison of Power Output without tracking and with tracking.

Times	Without Tracking			With tracking		
(Hrs.)	Voltage (V)	Current (amp)	Power (W)	Voltage (V)	Current (amp)	Power (W)
09 a.m.	8	0.15	1.2	12	0.21	2.52
10 a.m.	9	0.18	1.71	13.5	0.26	3.51
11 a.m.	10.5	0.21	2.1	14	0.28	3.92
12 p.m.	12.5	0.28	3.5	14	0.33	4.62
1 p.m.	14	0.32	4.49	15	0.31	4.65
2 p.m.	13	0.3	3.9	14	0.3	4.2
3 p.m.	11	0.26	2.86	13	0.26	3.38
4 p.m.	8	0.17	1.28	10	0.25	2.5
5 p.m.	6	0.12	0.72	7	0.21	1.47

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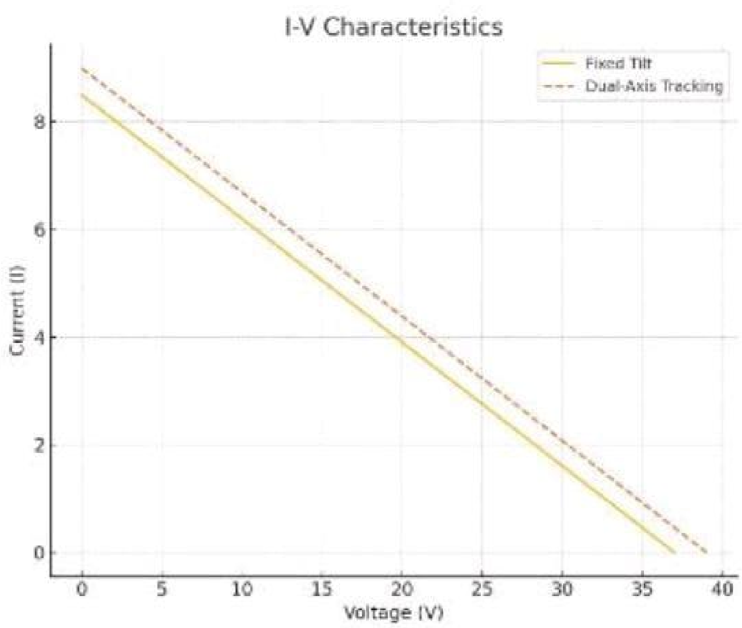
Comparison Chart.



I-V Characteristics for fixed tilt and dual axis tracking.

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