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Solar Panel With Sun Position Tracking

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Abstract

Maximizing the efficiency of solar panels by ensuring they face the sun throughout the day is a significant challenge. This project proposes a Solar Panel with Sun Position Tracking system using Arduino, Two LDR sensors, battery, motor driver, DC motor, and solar panel.The system tracks the position of the sun using LDR sensors and adjusts the solar panel's angle to maximize sunlight capture. The Arduino processes sensor data to control the motor driver, which adjusts the panel's position. This innovative system enhances solar energy harvesting by ensuring optimal panel orientation. Solar energy is rapidly advancing as an important means of renewable energy resource. Solar tracking enables more solar energy to be generated because the solar panel is able to maintain a perpendicular profile to the sun's rays. Though initial cost of setting up a solar tracking system is high, this paper proposes a cheaper solution.

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I. Introduction

Sun is an abundant source of energy and this solar energy can be harnesses successfully using solar photovoltaic cells and photovoltaic effect to convert energy into electrical energy. But the conversion efficiency of a normal PV cell is low. One of the main reason for this is that the output of PV cell is dependent directly on the light intensity and with the position of sun in the sky changing continuously from time to time, the absorption efficiency of an immobile solar panel would be significantly less at certain time day and year, for the solar photovoltaic cells are maximum productive when they are perpendicular to the sun and less productive otherwise. So to maximize the energy generation and improve the efficiency solar trackers are required. The solar tracker also provided lucrative solution for third world countries to integrate it into their solar system with a comparatively low cost through software based solution. The study revealed that use of stepper motor enables accurate tracking of sun and LDR resistors used to determine the solar light intensity.

II. Literature Review:

The use of renewable energy resources is increasing for the purpose of producing electricity in modern world due to lack of non-renewable sources. As solar panels are becoming more popular day by day, it is a crying need to maximize the solar panel efficiency. The efficiency of solar panels can be increased to a great extent if the solar panels continuously rotate in the direction of sun. Microcontroller and an arrangement of LDR sensors can be used for the purpose of tracking the sun. But the system is less efficient because of the low sensitivity and disturbance of light dependent resistors. In this paper, a methodology of an automatic solar tracker is proposed by means of both sensors and image processing simultaneously. The mechanism of solar tracking was implemented by the use of an image processing software which combines the effect of sensors and processed image of sun and controls the solar panel accordingly. The methodology is a combination of hardware and software which can be used to control hundreds of solar panels in a solar power plant with more accuracy. It can be concluded that the proposed system is more accurate and efficient than the conventional solar tracking systems which can optimize the power requirement.

III. "Sun Tracking System with Microcontroller 8051":

The Sun tracking solar panel consists of two LDRs, a solar panel, and a servo motor and ATmega328 Microcontroller. Two light-dependent resistors are arranged on the edges of the solar panel. Light-dependent resistors produce low resistance when light falls on them. The servo motor connected to the panel rotates the panel in the direction of the Sun. The panel is arranged in such a way that light on two LDRs is compared and the panel is rotated towards LDR which have high intensity i.e. low resistance compared to others. The Servo motor rotates the panel at a certain angle. When the intensity of the light falling on the right LDR is more, the panel slowly moves towards the right and if the intensity on the left LDR is more, the panel slowly moves towards left. In the noon time, Sun is ahead and the light intensity on both the panels is same.

A smart solar tracker which consists of an automated tracking mechanism is reviewed in this literature. The studies over the components and types of solar tracking system are overviewed. The study reveals that the use of stepper motor enables accurate tracking of the sun. LDR resistors can be used to determine the solar light intensity. It is concluded that the above system can optimize the power requirement. In this paper a brief review is done over photovoltaic characteristics, design of tracking system and the software used for simulation model.

"Solar Tracking System Using Microcontroller"

The In this advancing era of technology we are more concerned about the advancements made in technology rather than thinking upon the alternative sources of energy. Energy costs and decreasing supplies of fossil fuels, emphasis on protecting the environment and creating sustainable forms of power have become vital, high priority projects for modern society. Since, as solar energy which is also considered a renewable form of energy can be used to offset some of the power coming from the main grid that is generated by let us say nonrenewable sources of energy. And creating these renewable sources in such a way that these provide us with the maximum efficiency is our main goal. This paper proposes a solar tracking system designed with microcontroller and ldr's that will actively track the sun and change its position accordingly to maximize the energy output. The ldr's incorporated on solar panel helps to detect sunlight which in turn moves the panel

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accordingly.

IV. Proposed System

The proposed Dual Axis Solar Tracking System with Weather Sensor addresses these limitations by automatically adjusting the position of the solar panel to track the sun's movement across the sky. The system uses two LDR sensors to continuously monitor the intensity and direction of sunlight, providing data to the Arduino Uno microcontroller. Based on this data, the Arduino controls the DC motors via a motor driver (L298N or equivalent) to adjust the solar panel's position along both horizontal and vertical axes. while a battery stores the harvested solar energy for later use. This automated and intelligent approach ensures maximum energy efficiency and optimal performance of the solar panels.

The control circuit for the solar tracker is based on an Node MCU micro-controller. This is programmed to detect the sunlight through the LDRs and then actuate the servo motor to position the solar panel where it can receive maximum sunlight. Compared with any other type of motor, the servo motor is more controllable, more energy efficient, more steady and has high tracking accuracy and suffers little environmental effect.

V. Block Diagram

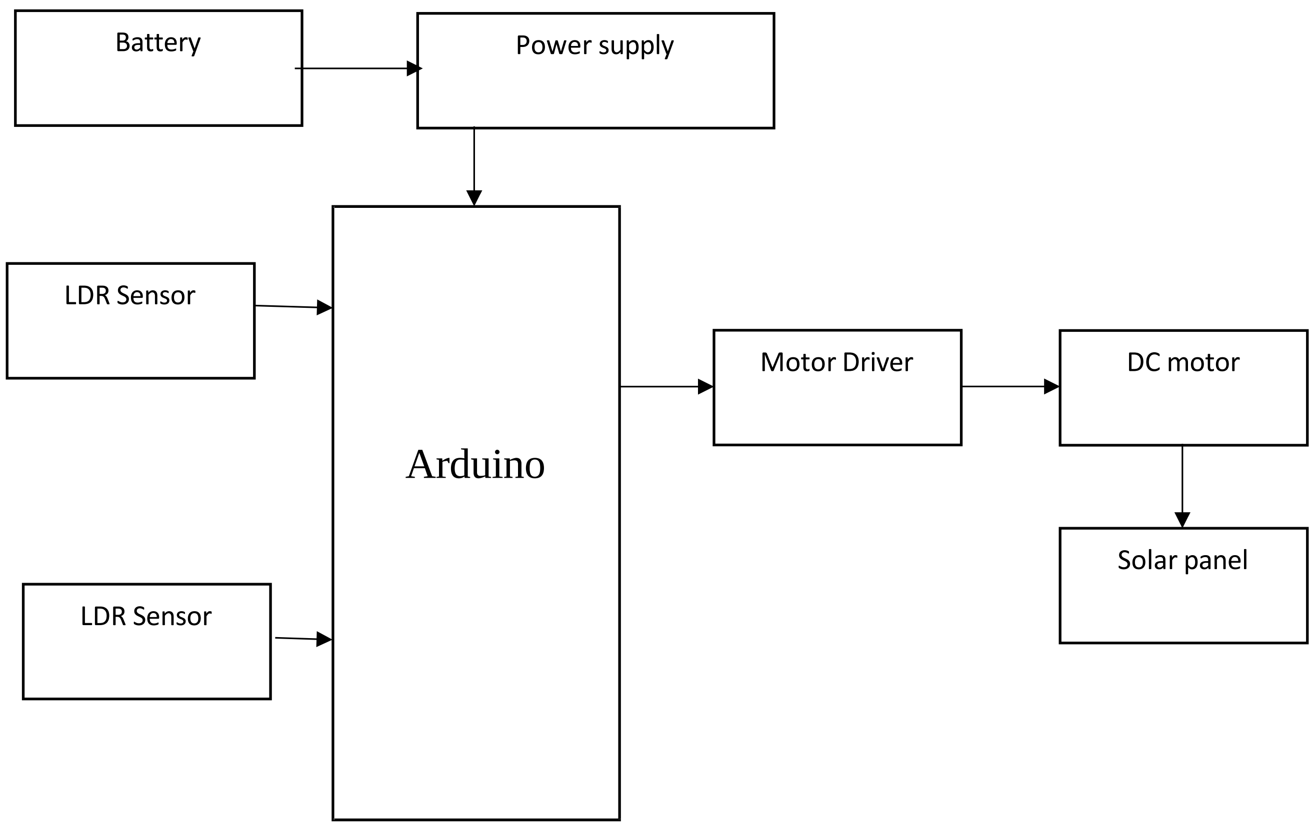


Fig: Block diagram of proposed system

Arduino:

The Arduino is one of the most popular and widely used Arduino boards. It's based on the ATmega328P microcontroller and offers a good balance of features, performance, and affordability, making it suitable for a wide range of projects, from simple to moderately complex.

Most electronic devices involve circuit-making using hardware components. The purpose of introducing Arduino was to make an easy-to-use device that can offer the feature of programming along with circuit making. Therefore, Arduino is a programmable device that is used mostly by artists, designers, engineers, hobbyists, and anyone who wants to explore programming in electronics.

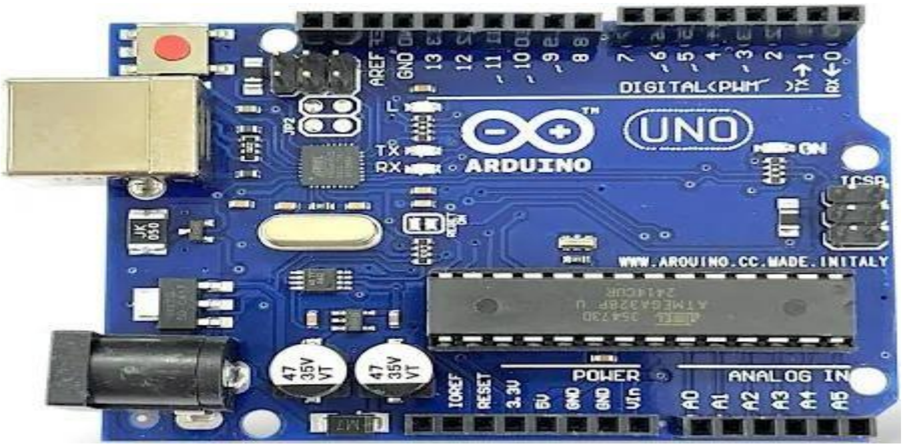


Fig: Arduino hardware

Features of Arduino Uno:

- ✔ Based on **ATmega328P Microcontroller**
- ✔ Input Voltage: **7V to 12V** recommended
- ✔ **14 Digital I/O Pins** (6 with PWM output)
- ✔ **6 Analog Input Pins**
- ✔ **6 PWM Output Pins**
- ✔ Flash Memory: **32 KB** (0.5 KB used by bootloader)
- ✔ SRAM: **2 KB**
- ✔ EEPROM: **1 KB**
- ✔ Clock Speed: **16 MHz**
- ✔ Supports **UART, SPI, I2C** Communication
- ✔ **USB Type B** for programming
- ✔ **Power Jack** for external power supply
- ✔ **ICSP header** for direct microcontroller programming
- ✔ Reset Button included
- ✔ Compatible with various **shields and modules**
- ✔ Ideal for **DIY projects, IoT, Robotics, Automation**

Arduino UNO Pin Description:

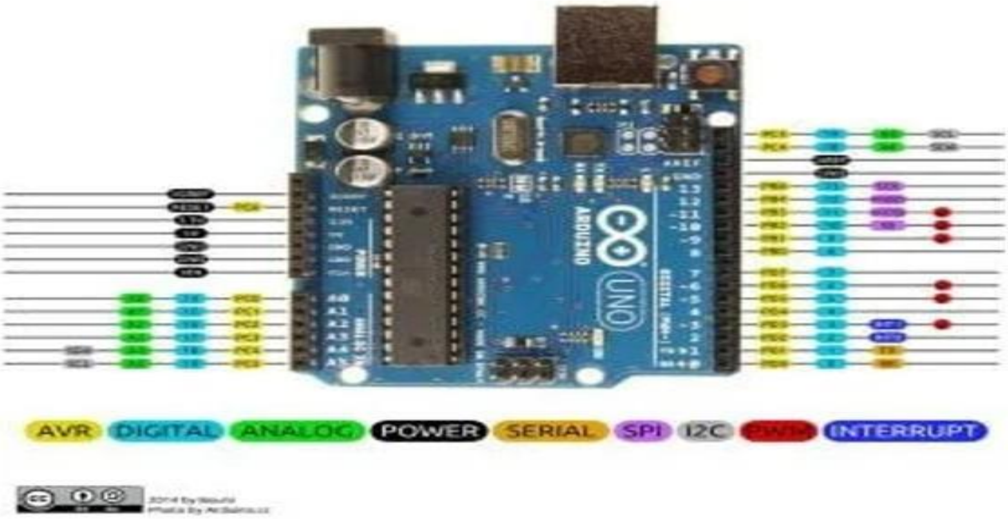
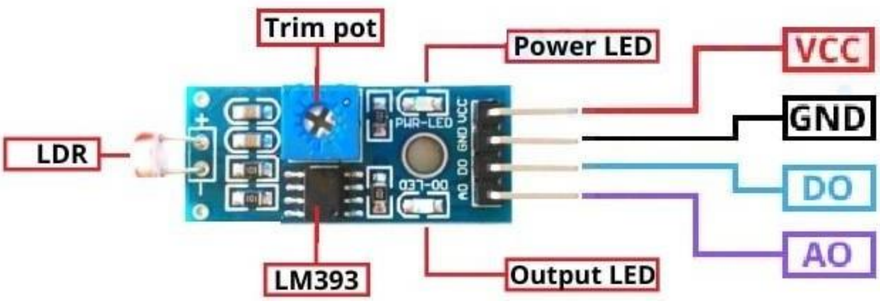


Fig:Arduino UNO Pins

LDR (Light Dependent Resistor) SENSOR:

UltrasoniThe controlling of lights and home appliances is generally operated and maintained manually on several occasions. But the process of appliances controlling may cause wastage of power due to the carelessness of human beings or unusual circumstances. To overcome this problem we can use the light-dependent resistor circuit for controlling the loads based on the intensity of light. An LDR or a photoresistor is a device that is made up of high resistance semiconductor material. This article gives an overview of what is LDR or light-dependent resistor circuit and its working.



An electronic component like LDR or light-dependent resistor is responsive to light. Once light rays drop on it, then immediately the resistance will be changed. The resistance values of an LDR may change over several orders of magnitude. The resistance value will be dropped when the light level increases.

The resistance values of LDR in darkness are several megaohms whereas in bright light it will be dropped to hundred ohms. So due to this change in resistance, these resistors are extremely used in different applications.

The LDR sensitivity also changes through the incident light's wavelength.

The designing of LDRs can be done by using semiconductor materials to allow their light-sensitive properties. The famous material used in this resistor is CdS (cadmium sulfide), even though the utilization of this material is currently restricted in European countries due to some environmental issues while using this material. Likewise, CdSe (cadmium selenide) is also restricted and additional materials that can be employed mainly include PbS (lead sulfide), InS (indium antimonide).

Solar panel:

A **solar panel** is a device that converts sunlight into electricity by using photovoltaic (PV) cells. PV cells are made of materials that produce excited electrons when exposed to light. The electrons flow through a circuit and produce direct current (DC) electricity, which can be used to power various devices or be stored in batteries. Solar panels are also known as **solar cell panels**, **solar electric panels**, or **PV modules**.

Solar panels are usually arranged in groups called **arrays** or **systems**. A photovoltaic system consists of one or more solar panels, an inverter that converts DC electricity to alternating current (AC) electricity, and sometimes other components such as controllers, meters, and trackers. Most panels are in solar farms or rooftop solar panels which supply the electricity grid

Key Components of Solar Panel Systems

1. **Photovoltaic Cells**: The core element that converts sunlight to electricity.
2. **Inverter**: Converts the direct current (DC) generated by the solar panels into alternating current (AC), which is used by most electrical devices.
3. **Battery Storage (optional)**: Stores excess energy for use when sunlight is not available (e.g., during the night or cloudy days).
4. **Charge Controller**: Regulates the flow of electricity from the panels to the batteries and prevents overcharging.
5. **Mounting Systems**: Secure the solar panels to rooftops or the ground, optimizing their orientation to capture the maximum amount of sunlight.

V. Schematic Diagram:

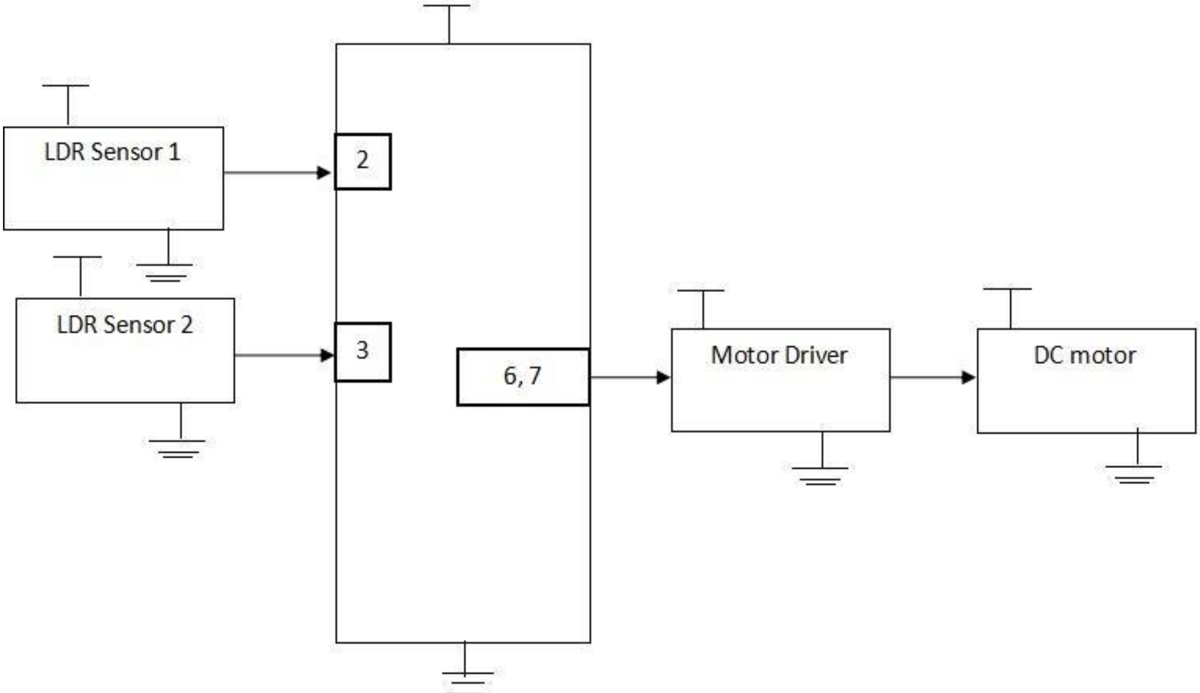
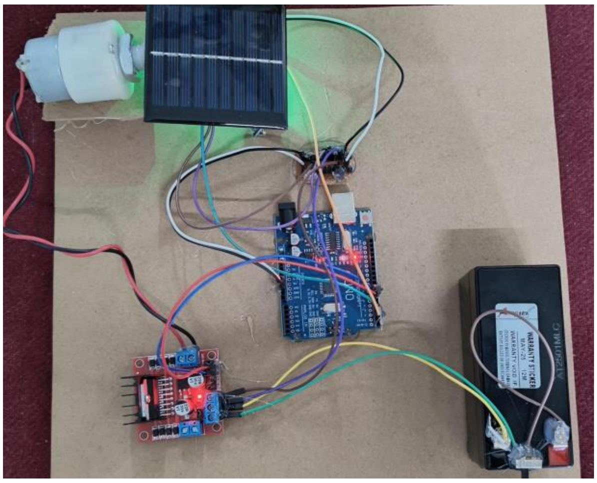


Fig: Schematic diagram of proposed system

VI. Result:



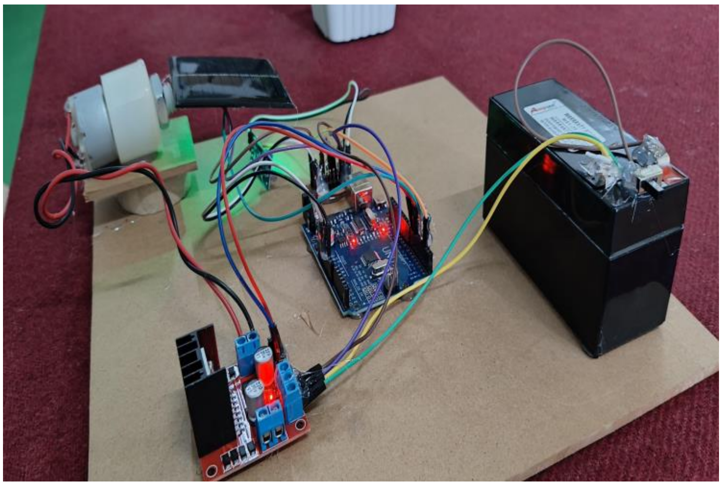
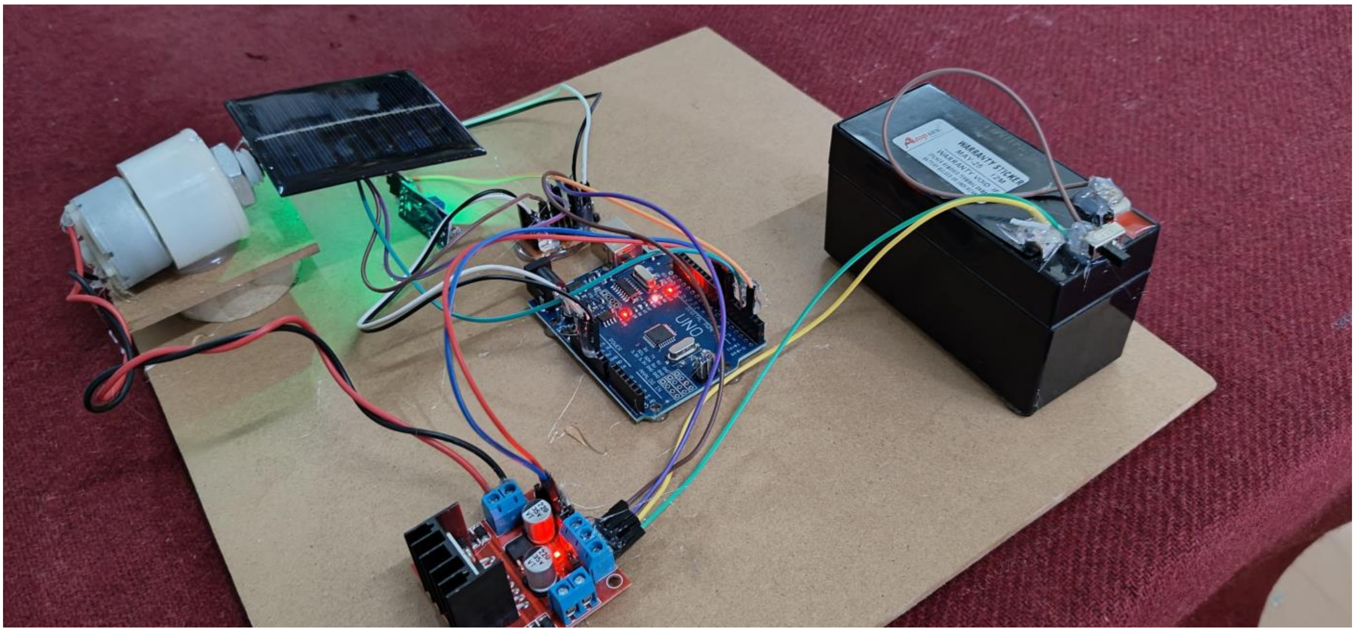


Fig:The Working Model



Results:

The **Solar Panel with Sun Position Tracking System** was designed and successfully implemented to increase the efficiency of solar energy generation by automatically adjusting the orientation of the solar panel according to the sun's position.

During the testing phase, the system demonstrated the following outcomes:

☑ The tracking mechanism accurately followed the sun's movement from east to west throughout the day.

☑ Compared to fixed solar panels, a noticeable increase in energy output was observed, especially during early morning and late afternoon when fixed panels are less effective.

☑ The system utilized sensors (such as LDRs) to detect sunlight intensity and automatically adjust the panel's angle to achieve maximum exposure.

☑ The project showcased real-time responsiveness to the sun's position, ensuring continuous optimization of energy capture.

☑ Experimental data showed a consistent improvement in power generation efficiency, making the system beneficial for both small-scale and large-scale solar installations.

☑ The system operated with minimal human intervention, highlighting its potential for autonomous, low- maintenance operation.

☑ The design was cost-effective, with the potential to further reduce costs with mass production and technological advancements.

VIII. Future Scope:

✔ **Increased Energy Efficiency**

Maximizes solar energy capture by maintaining optimal panel alignment with the sun throughout the day.

✔ **Integration with Smart Grids**

Can be integrated into smart energy systems for real-time monitoring and efficient energy distribution.

✔ **Use of AI & IoT**

Future systems may use Artificial Intelligence and IoT sensors for automatic sun tracking and weather- based adjustments.

✔ **Widespread Adoption in Solar Farms**

Large-scale solar farms are increasingly adopting tracking systems to boost overall power generation.

✔ **Enhanced Applications in Remote Areas**

Ideal for powering rural or remote locations where grid electricity is unavailable.

✔ **Development of Dual-Axis Trackers**

Dual-axis tracking improves efficiency further by adjusting panels both horizontally and vertically.

✔ **Portable & Compact Systems**

Development of portable tracking systems for mobile solar setups in defense, camping, and emergency situations.

✔ **Environmental Benefits**

Helps reduce reliance on fossil fuels by making solar energy more reliable and efficient.

✔ **Cost Reduction with Mass Production**

As technology matures, production costs will decrease, making tracking systems affordable for residential use.

✔ **Contribution to Net Zero Goals**

Plays a key role in achieving renewable energy targets and reducing carbon emissions globally.

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