Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 15, Issue. 1, No.10 : 2024
ISSN : **1906-9685**

ENHANCING SOLAR PANEL PERFORMANCE WITH LDR-BASED DUST MANAGEMENT SYSTEM

[1]**Mr. B. Divakar,** Assistant Professor, Department of Electrical and Electronics Engineering, Vignan's Institute of Information Technology Visakhapatnam,India.

[2]**Devera Pushpa,** [3]**D. Hemanth Kumar,** [4]**G. Chandra Sekhar,** [5]**K. Mamatha,** [6]**Ch. Uday Kumar,**Students, Department of Electrical and Electronics Engineering, Vignan's Institute of Information Technology Visakhapatnam,India.

ABSTRACT: The Solar panel is sensitive to dust accumulating on the surface of the panel. The dust that accumulates on the panel blocks the light from the sundue to which theefficiencyofthesolarpanel gradually decreases. If these dust-accumulated panels are left uncleaned for a long time, the power output will be reduced nearly by half of the output in normal conditions. So, to clean the solar panels regularly, an automatic dust cleaning system is proposed and designed, which consists of Arduino UNO to control the DC gear motor and LDR sensor to sense the dust and clean the panel automatically. DC motor is used to power the wiper and the cleaning mechanism consists of a wiper to move forward and backward to clean the solar panel. To support the wiper mechanism for cleaning dust off solar panels, we have used bearings mounted on threaded and smooth rods.

Keywords: Solar Panel, DC Motor, Arduino, Wiper.

---

1. INTRODUCTION

Global production of solar panels has expanded in response to the rising demand for solar energy. Solar energy is one of the environmentally friendly energy sources since it can both supply the world's energy needs and reduce its impact on the environment. The essential parts of solar power systems are solar panels, which collect sunlight and turn it into electrical energy. Nevertheless, the buildup of dirt and dust on solar panel surfaces can drastically lower their performance. The amount of sunlight that reaches the photovoltaic cells is reduced by this accumulation, which lowers the panels' energy production.

The idea of automated solar panel cleaning devices has gained traction as a solution to this problem. These systems make use of a variety of methods to clear dust and debris off solar panels, maximizing their efficiency and producing the most energy possible. Light Dependent Resistors (LDR) sensor is one such innovative approach that incorporates them into the cleaning mechanism.

LDR sensors are used in the proposed automated solar panel dust cleaning system to measure the amount of dust collection on the panel surface. The LDR sensors can measure this resistance to

ascertain the level of dust accumulation on the solar panels. When the sensors identify a predetermined value of dust deposition on the panel surface, the system starts up. When the cleaning mechanism is set off, it works to remove the accumulated dust by using the wiper.

There are various benefits associated with the solar panel cleaning system's incorporation of sensors. To maintain optimal panel performance, it first offers real-time monitoring of dust collection, enabling prompt cleaning actions. Secondly, it maximizes the solar power system's overall efficiency by reducing energy usage by only turning on the cleaning process when needed. Furthermore, because the system is automated, less manual intervention is required, which increases convenience and lowers the cost of solar panel maintenance.

These technologies help to maximize the energy production and lifespan of solar panels by enabling accurate detection of dust collection and effective cleaning procedures. This, in turn, promotes the wider adoption of clean and sustainable energy sources.

2. METHODOLOGY

An automatic cleaning method is proposed to remove dust from the solar panel's surface. The system consists of wiper operated by a DC motor through a threaded rod system, depending on the dimensions of the flat plate panel.

A microcontroller generates a signal based on the data from a LDR sensor, which causes the wiper to rotate. This rotational motion is then translated into linear motion via a rod. The purpose of some major components used in the proposed cleaning method are presented in Table I.

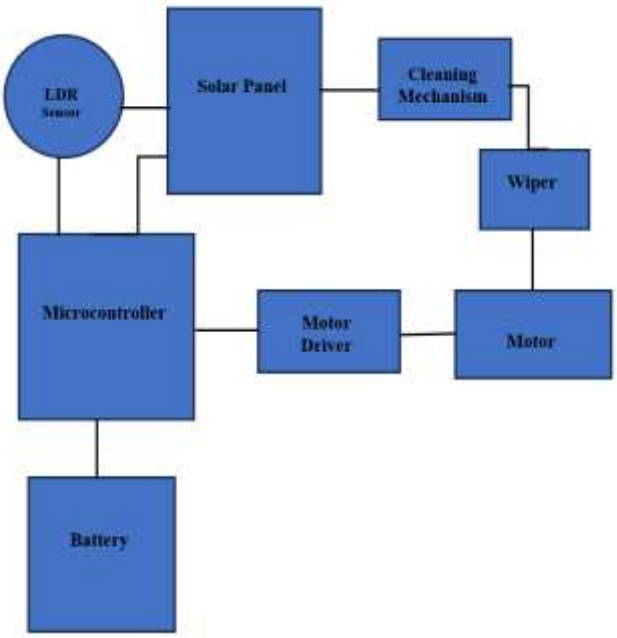
Name	Purpose and Rating
Solar Panel	A 10W solar panel is used in this system.
DC Gear Motor	A dc gear motor is connected to the cleaning shaft to operate it. The operating voltage is 6V.
LDR Sensor	A light dependent resistor (LDR) is used here to track the sunlight.
Battery	A battery of 9V is used.
Threaded Rod	A threaded rod is connected to the motor.
Smooth Rod	Smooth rod is used to make the motion of the wiper linear.

Table 1: Components and its Purpose

3. EXPERIMENTAL SETUP

The experimental setup of automatic dust cleaning system effectively automates the cleaning procedure, maintaining maximum performance of the solar panels by removing dust as needed.

The battery supplies power all the system's components. The solar panel is responsible for generating power from sunlight. The Light Dependent Resistor (LDR) sensor senses the intensity of incident light falling on the solar panel. When the intensity drops due to dust accumulation, the cleaning process begins. The Arduino UNO is the microcontroller that processes the LDR sensor input and controls the motor driver output. The motor driver receives signals from the Arduino Uno and controls the power and direction of the motor. The motor drives the wiper mechanism across the solar panel to remove dust. This is the physical component that contacts the solar panel surface to remove dust. The block diagram of the experimental setup is shown below.



4. COMPONENTS

Arduino UNO

Arduino UNO is a microcontroller board built around the ATmega328P. It contains 14 digital input/output pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB port, a power jack, an ICSP header, and a reset button. It includes everything necessary to support the microcontroller; simply connect it to a computer via USB cable or power it with an AC-to-DC adapter or battery to get started.

SOLAR PANEL

A solar panel, also known as a photovoltaic (PV) module, is a device that transforms sunlight into electricity using the photovoltaic effect. Solar panels are composed of individual solar cells, which are commonly constructed of silicon and other elements. When sunlight reaches solar cells, it excites electrons, resulting in an electrical current. Solar panels are commonly used for both residential as well as commercial applications to generate electricity from sunlight.

LDR Sensor

A light dependent resistor (LDR) is a passive electrical sensor that detects light. It consists of two conductors separated by an insulator that becomes more conducting when exposed to high levels of light intensity, resulting in a variable resistor in the circuit. Here we are using this sensor to detect the sunlight. The cleaning mechanism gets activated in the absence of sunlight.

DC Gear Motor

A DC gear motor is a type of electric motor that uses a gearbox to control the speed and torque of the motor's output shaft. DC gear motors provide a dependable and effective solution for applications that require variable speed control, high torque output, and accurate motion control. Their adaptability and flexibility make them critical components in a wide range of electromechanical systems and devices.

Motor Driver Module

A motor driver module is an electronic component used to control the movement of motors in various applications. It typically consists of a combination of integrated circuits, transistors, and other electronic components designed to provide the necessary power, voltage regulation, and control signals to drive one or more motors.The motor driver receives signal from the Arduino UNO and manages both Power supplied to the motor as well as its direction of rotation.

Wiper

Wiper is used to clean dust on solar panels to maintain their efficiency. A wiper mechanism is mounted on the solar panel frame. When triggered, the wiper slides across the panel's surface.

THREADED AND SMOOTH RODS

To support the wiper mechanism for wiping dust from solar panels, we used bearings installed on threaded and smooth rods.

Component	Specification
Solar Panel	10 watt
Motor Driver Module	4.5 V to 36 V
DC Gear Motor	10 RPM
Battery	9 V
Smooth Rod	8 mm
Threaded Rod	8 mm

Table 2: Components and its Specifications

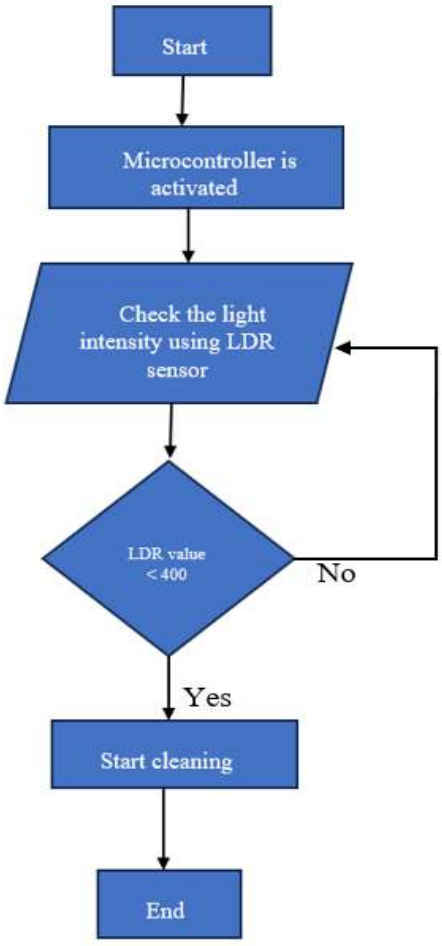
5. RESULTS AND DISCUSSIONS

In automatic dust cleaning system, we have tested the model by taking some sand on the panel. The system effectively monitored the light intensity using the LDR sensor. When the value of the LDR sensor becomes less than the predefined value, the system activates the motor driver. The motor driver then controls the power and direction of the motor. The motor is attached to the cleaning mechanism consisting of form sheets which move forward and backward to clean the dust off the panel. This forward and backward movement of the wiper sweeps away the dust making it suitable to generate optimal power output.

The cleaning process was efficient and automated, ensuring that the solar panels were free of dust and dirt, allowing them to produce the most energy possible. The usage of Arduino allowed for easy programming and operation of the system, making it adaptable to a variety of environments.

The programming of solar panel cleaning system is represented through the flowchart.

The Microcontroller (Arduino UNO) is activated. The light intensity using the LDR sensor is checked. If, the LDR value falls below the predefined threshold value, wiper mechanism is started to clean the solar panel, otherwise, monitoring is continued. After completing the cleaning cycle, the DC gear motor and wiper mechanism is deactivated.



After testing, the solar panel produces an output voltage of 20.27V during normal conditions.

Before cleaning the solar panel, dust accumulation limits the amount of sunlight that reaches the solar cells, lowering the panel's efficiency. This reduces electricity generation because the dust layer acts as a barrier to solar absorption. The obtained output voltage before cleaning is 16.74V.

After installing the dust cleaning system, the solar panel performance improved considerably. When the LDR sensor detects a decline in light intensity, the cleaning mechanism starts the wiper, which removes the dust layer from the panel surface. As a result, the solar panels regain efficiency by enabling more sunlight to enter and be converted into power. The obtained output voltage after cleaning is 19.99V.

6. CONCLUSION

Implementing an Automatic Solar Panel Cleaning System with Light Dependent Resistors (LDR) sensors offers a viable alternative for increasing solar panel efficiency and longevity. Throughout this project, we have looked at how keeping solar panels clean can help maximize energy output and reduce efficiency losses caused by dirt, dust, and other debris accumulation. By including LDR sensors into the cleaning mechanism, we created a sensitive and efficient system capable of sensing changes in light intensity and commencing cleaning operations precisely when needed. We achieved automation by utilizing microcontrollers and motor control systems, which reduces the need for manual intervention and ensures timely cleaning cycles. Finally, creation and implementation of innovative solutions like this help to promote sustainable energy technology, making solar power more widely adopted as a clean and renewable energy source. As we continue to harness the sun's power, projects like the Automatic Solar Panel Cleaning System play an important role in realizing solar energy's full potential and moving toward a greener and sustainable future.

REFERENCES:

1. D. Kumar, A. Kumar, S. Kumar, and R. Bhardwaj, "Design and Development of Automatic Solar Panel Cleaning System using Arduino," International Journal of Engineering and Innovative Technology (IJEIT), vol. 3, no. 12, pp. 127-131, 2014.

2. S. K. Pandey and A. K. Chaturvedi, "Design and Development of Automatic Solar Panel Cleaning System," International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), vol. 6, no. 5, pp. 5262-5266, 2017.

3. R. K. Pandey and R. P. Gupta, "Solar Panel Cleaning Using Arduino and Windscreen Wiper Mechanism," International Journal of Scientific and Research Publications (IJSRP), vol. 8, no. 5, pp. 265-268, 2018.

4. A. Al Amin and M. S. Islam, "Design and Fabrication of an Automatic Solar Panel Cleaning System," International Journal of Scientific & Engineering Research (IJSER), vol. 10, no. 1, pp. 1-5, 2019.

5. H. S. Chaudhary and R. C. Jain, "Solar Panel Cleaning System Using Arduino," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), vol. 8, no. 8, pp. 8098-8104, 2019.

6. R. K. Mishra and A. K. Dubey, "Automatic Solar Panel Cleaning System Using Arduino," International Journal of Advanced Science and Technology, vol. 29, no. 12, pp. 4806-4814, 2020.

7. M. Singh and P. Gupta, "Design and Development of Solar Panel Cleaning System," International Journal of Innovative Science and Research Technology (IJISRT), vol. 5, no. 1, pp. 345-348, 2020.

8. S. Gupta, R. Garg, and A. Bansal, "Automated Solar Panel Cleaning System," International Journal of Recent Technology and Engineering (IJRTE), vol. 9, no. 2, pp. 5471-5476, 2020.

9. S. K. Nanda and S. K. Rout, "Automated Solar Panel Cleaning System with Real Time Monitoring and Control," International Journal of Scientific Research in Computer Science, Engine99ering and Information Technology (IJSRCSEIT), vol. 5, no. 2, pp. 20-25, 2020.

10. M. A. Hossain, M. F. Bhuiyan, and M. S. Islam, "An Automated Solar Panel Cleaning System Using Arduino," International Journal of Engineering Science and Computing (IJESC), vol. 10, no. 7, pp. 24645-24651, 2020.