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Design &Development of PV Solar Panel Cleaning Mechanism Using Arduino UNO

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Abstract: ***From ancient times the human beings are very aware about the cleanliness of the house and the parts neighbouring to it. The solar PV modules are generally employed in dusty environments which is the case in tropical countries like India. The dust gets accumulated on the front surface of the module and blocks the incident light from the sun. It reduces the power generation capacity of the module. The power output reduces as much as by 50% if the module is not cleaned for a month. In order to regularly clean the dust, a automatic cleaning system has been designed, which senses the dust on the solar panel and also cleans the module automatically. This automated system is implemented using 8051 microcontroller which controls the DC gear motor. This mechanism consists of a sensor (LDR). While for cleaning the PV modules, a mechanism consists of a slidingbrush has been developed.***

A number of environmental factors such as wind speed, humidity, ambient temperature, solar radiation, atmospheric dust and direction influences the power generation process using installed solar photovoltaic modules. Dust build-up on solar module surface is an issue of great worry, particularly in desert provinces where infrequent to regular dust storms do occur. The glass cover transmittance decreases because of accretion of dust on the surface of PV module, which ultimately decreases the amount of solar irradiation reaching the cells. The dust density of the surface, orientation, the tilt angle, exposure period, dominant wind direction, and site climatic conditions determines the reduction in glass transmittance. The density of deposited dust, the composition of the dust and its particle distribution determines the effect of the effect of dust on the power output and current - voltage (I~V) characteristics of PV modules

When PV modules are exposed to real outdoor condition for a long period, it was observed that the performance decreases gradually with dust build-up lest the modules are cleaned by rain or human action. The power output decreases by more than half if no cleaning is accomplished on modules that exceeds six months. Reduction in power output due to dust build-up does not depend only on the length of module exposure, but also on the occurrence and strength of dust. Subsequently, it is suggested that installed PV modules should be cleaned at least once in two weeks. Nevertheless, in the time when sandstorm occurs, immediate cleaning of the solar modules should be performed. It was observed that rainfall improved the power production of dusty solar modules, yet it cannot be trusted upon for cleaning since it is not foreseeable.

Keywords: Automation, Productivity, Microcontroller, Arduino UNO 328

I. INTRODUCTION

Most of the applications nowadays like electricity, agriculture and industrial applications use the solar panels as an electrical power source instead of relying on the generators or the ordinary sources for electricity. The most important part of these systems is the solar panel where the solar energy is converted to heat for water heating or converted to electricity for the others. There are many types of the solar panels. In the countries those have dusty environment accumulation of dust on the solar panels leads to reduction of the transmittance of the panel. Solar desalination plants in some of the middle-east countries like the solar desalination plant of Abu Dhabi suffers from the deposition of dust on its solar plates. The effect of the accumulated dust will be reduced with the increasing of tilt angle, since the tilt angle will affect the exposure time to the sunlight also. But the best way to eliminate the effect of the accumulated dust on the solar panels is to clean the panels. Cleaning the solar panels is normally by washing which is tedious and cumbersome and also expensive in terms of the labour involved and time. In practice cleaning of solar panels should be frequently done which makes the process more laborious and expensive. Hence in this paper an innovative method of automatic cleaning of solar panel has been proposed.

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A. Removal of dust using Mechanical Methods

There are different types of methods that are used to clean solar panel. Few of them are mechanical vibration, ultrasonic cleaning, scrubbing and mopping. When brushing is used for cleaning, it is mainly done with the help of brush or scrubber. In these systems a brush is driven by using a machine, which are similar to automobile wipers. But this cleaning method is not that efficient because of the sticky nature and small size of the dust particle. It is also seen that difficult and harsh working condition of the solar power plant make the maintenance of these machines difficult. Also the solar power plant is present over a very large area which makes this cleaning method expensive and inefficient. The process of blowing of air on the surface of the solar panel is an effective method but it has some negative features such as low efficiency, huge energy usage and difficulty in maintenance of blower arrangement.

II. OBJECTIVE

Objective's of the solar cleaning mechanism is,

1) Design a mechanism to detect obstructions on solar panels causing significant loss of power
2) Design a cleaning mechanism that runs across the length of the panel
3) Improve overall solar panel efficiency. Enables the cleaning mechanism once an obstruction has been detected Is able to distinguish between whether the obstruction is partially shading the panel or not (e.g. complete cloud shading)

III. LITERATURE SERVEY

In this chapter a brief theoretical background will be given in order to define the problem. First the focus will lay on the working of the photovoltaic cell. Next this chapter will go deeper into the mechanisms of soiling and degradation as it is important to know what has to be done for cleaning purposes. Lastly there will be a brief comparison of existing cleaning robots pointing out their weaknesses and strengths.

For solar power to be efficient, elimination of some environmental effects is needed. This section will discuss the PVs' efficiency which is influenced by the environment, especially the effects of dust. The previous automatic cleaning methods that were used have been evaluated with the purpose of developing an i7 cleaning robot which will be efficient at removing dust and pollen from the PV panel's surface. As Thames wants to be a renewable energy township, and as its locality is near the sea, tourism is especially important to the town in the summer months. The map of Thames location on the Coromandel Peninsula is shown in Figure 2-1. There are a lot of renewable energy projects for the township currently being undertaken. The largest renewable energy project is to install PV panels for most houses and businesses. As this project is located in Thames, there are some environmental effects on PVs' output, which are sea salt, bird dropping and pollen, as Thames faces the sea and is surrounded by forest (B. Stanton (personal communication, 6 November 2013)).

IV. PROBLEM STATEMENT

A number of environmental factors such as wind speed, humidity, ambient temperature, solar radiation, atmospheric dust and direction influences the power generation process using installed solar photovoltaic modules. Dust build-up on solar module surface is an issue of great worry, particularly in desert provinces where infrequent to regular dust storms do occur. The glass cover transmittance decreases because of accretion of dust on the surface of PV module, which ultimately decreases the amount of solar irradiation reaching the cells. The dust density of the surface, orientation, the tilt angle, exposure period, dominant wind direction, and site climatic conditions determines the reduction in glass transmittance. The density of deposited dust, the composition of the dust and its particle distribution determines the effect of the effect of dust on the power output and current -voltage (I~V) characteristics of PV modules

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Nevertheless, in the time when sandstorm occurs, immediate cleaning of the solar modules should be performed. It was observed that rainfall improved the power production of dusty solar modules, yet it cannot be trusted upon for cleaning since it is not foreseeable.

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V. WOEKING PRINCIPLE

When a photovoltaic cell is exposed to sunlight it absorbs the photon's hitting the semiconducting materials. Electrons are excited and move up to a higher molecular or atomic orbital. To dissipate the extra energy, the electron can either go back to it's original orbital, converting the excess energy into heat, or it can travel through the material to an electrode, thereby cancelling the potential. Regardless of the size, a cell will generate roughly 0.45 volts DC. This implies that the available power generated by the cell will be strictly dependent on the area of the cell that is irradiated by the sun and the material used for the absorption of the photons. To reach higher voltages, cells are installed in series. The types of cells that are commercially available today can be divided into 3 main groups

1) Crystalline silicon cells: by far the most used bulk material for PV cells.
2) Thin Film cells: heavier but have a smaller ecological footprint.
3) Multijunction cells: still experimental, originally only used in space but terrestrial solar concentrators make them effective on earth now as well.

These three types can all be divided into different subgroups, using different materials and methods dependent on the spectrum available and the cost-effectiveness of the cells. The two most used materials are monocrystalline and polycrystalline silicon cells. The first has a higher efficiency but is also more expensive compared to poly cells. However, due to technological improvement, the price of mono cells has decreased and it's application has grown again. The output power of a cell is the product of the solar intensity (I ≈ 100mW/cm2) and the conversion efficiency of the cell being around 16% for crystalline silicon cells. In 2014, scientists at the University of Cambridge succeeded at making solar cells based on a hybrid material that has an efficiency of 95% proving there is still a serious improvement potential. To protect the cells against the wear and tear of the operational environment, it gets encapsulated with a material (most often glass or polycarbonate) that has both good optical qualities in terms of transmittance and provide protection from impact, humidity, etc. Lastly they get hermetically closed off with silicone.

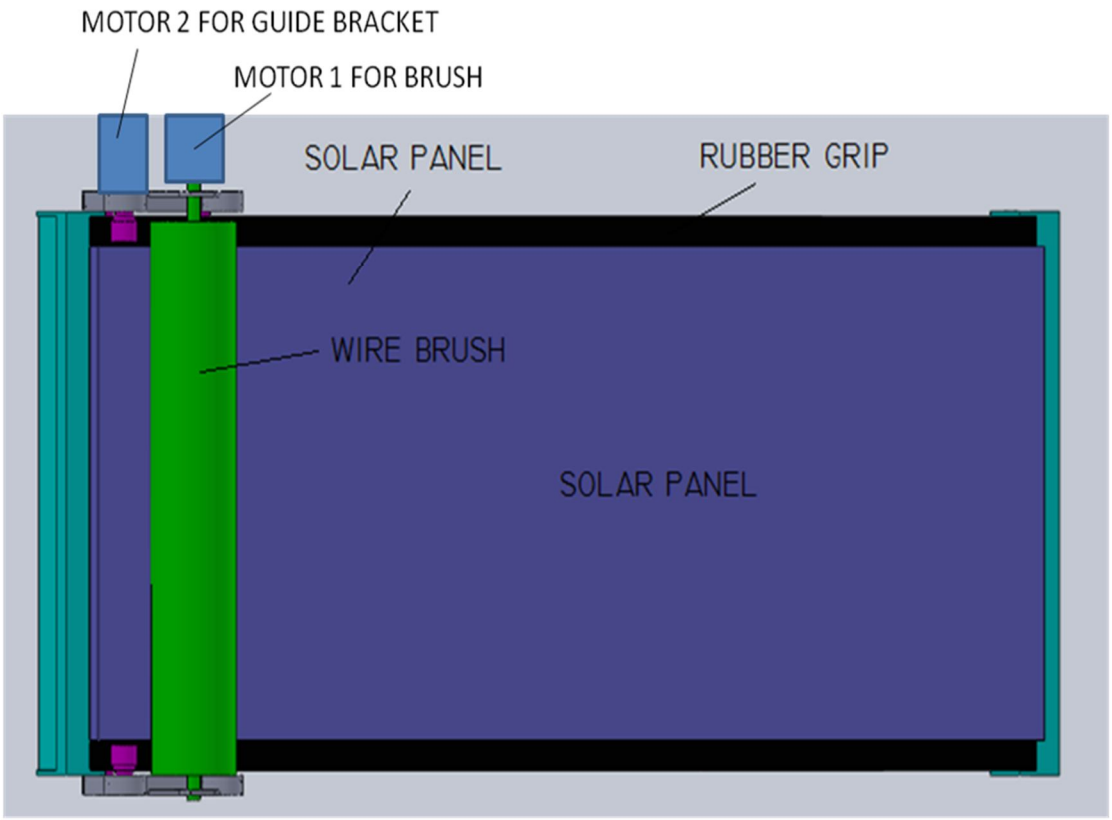

Fig. Schematic diagram of proposed mechanism

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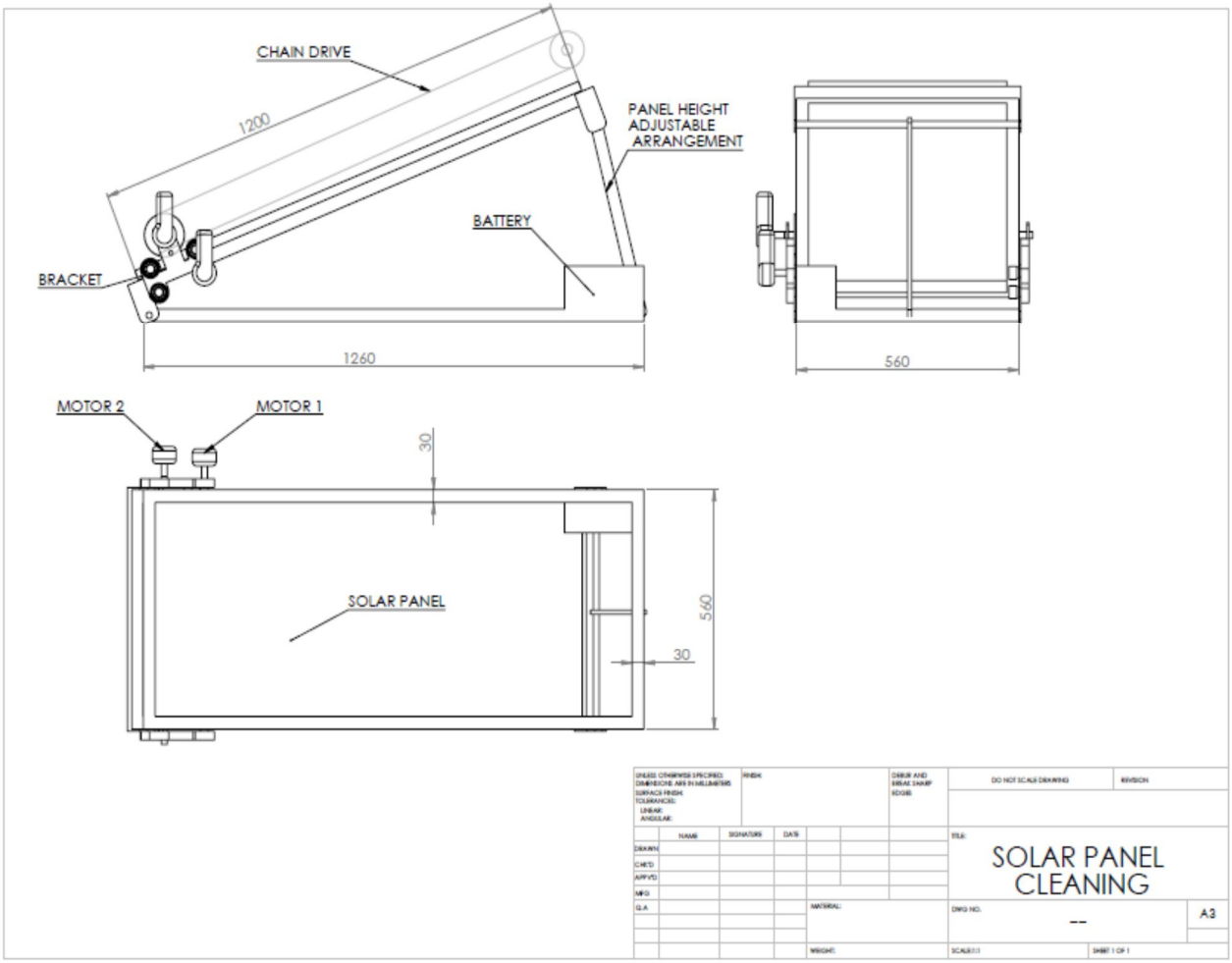

Fig; Diagrammatic representation of mechanism

VI. PRAPOSED WORK IN MECHANISM

A. Design & Development of PV Solar Panel Cleaning Mechanism

Specification of proposed mechanism

These machines are small enough to operate semiautomatic.

1) Function: Clean the solar panel top surface.

2) Specification :

a) Type: Motorised

b) Power:- Solar powered battery.

c) Overall dimensions(Tentative): 600mm x 400mm approx.

d) Job capacity- within 5 min

e) General Information :

The machine consists of a mechanism and chain drive and arduino timer and relay circuit.

3) Analysis of different critical parts of mechanism

4) Selection of materials and drives.

This project will undergo through following six phases.

a) Phase I : Literature Survey

A detailed literature survey will be carried out in the related area. Majorly the selected project is come under industrial field influence, So In this phase we will do small scale industrial visits, Feedbacks and problems faced by vendors.

b) Phase II: Concept Generation

In this phase, we are going to do schematic arrangement design and drawing of major component which we can use for completion of our project. In this phase we will generate the schematic drawing on the basis of problem statement and feedback and suggestion received from end customer and vendors.

c) Phase III: Design calculations

In this phase we are going to do the design calculations by referring the standards, catalogue and reference books. In this work we will finalise the design and components dimensions. We are also select the material according to parts and components fuction and loading conditions. In this phase we will decide the size and shape of components and its position in the assembly. Also we will decide the limit and tolerance between components and alos machining methods required to select to manufacture the components.

d) Phase III: Preparation of Drawings

In this phase we are going to prepare the design. The suitable component and assembly drawings will be prepared which will help visualize the actual project set up. In this phase we will prepare the drawing as per industrial format.

e) Phase IV: Structural Analysis of the Critical Components

In this phase we will do analysis of one components which is under critical loading condition. And by doing analysis we can decide the final dimensions and material of the component.

f) Phase V: Fabrication

(01) Manufacturing of various components and subassemblies will be carried out by using suitable manufacturing processes.
(02) The components will be assembled per the drawing.
(03) Working trials of the project will be conducted to confirm and testing parameters (Time and speed) we will decide for to get best quality of product.

g) Phase VI: Experimental Investigations (Actual Field Trial)

The fabricated mechanism will be tested for the suitability to the intended application. This experimental testing will include the testing of machine at actual site.

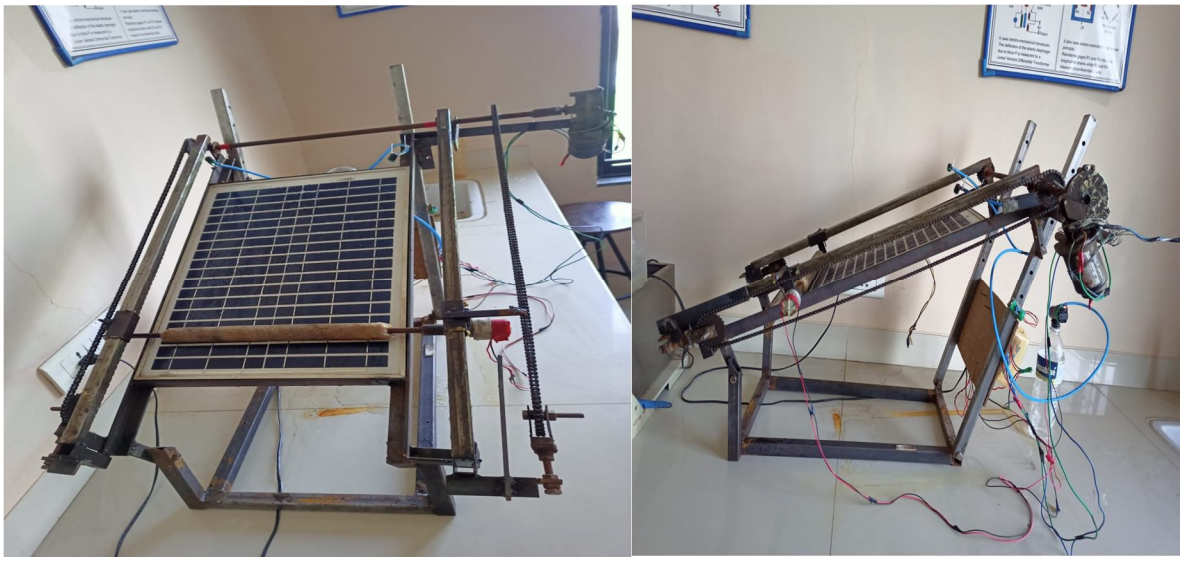

Fig. Prototype Solar Cleaning Mechanism

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VII. CONSTRUCTION & WORKING

A. Arduino Microcontroller

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs – light on a sensor, a finger on a button, or a Twitter message – and turn it into an output – activating a motor, turning on an LED, publishing something online. One can command the board what to do by sending a set of instructions to the microcontroller on the board.

Features Of Arduino Uno Board

- The operating voltage is 5V
- The recommended input voltage will range from 7v to 12V
- The input voltage ranges from 6v to 20V
- Digital input/output pins are 14
- Analog i/p pins are 6
- DC Current for each input/output pin is 40 mA
- DC Current for 3.3V Pin is 50 mA
- Flash Memory is 32 KB

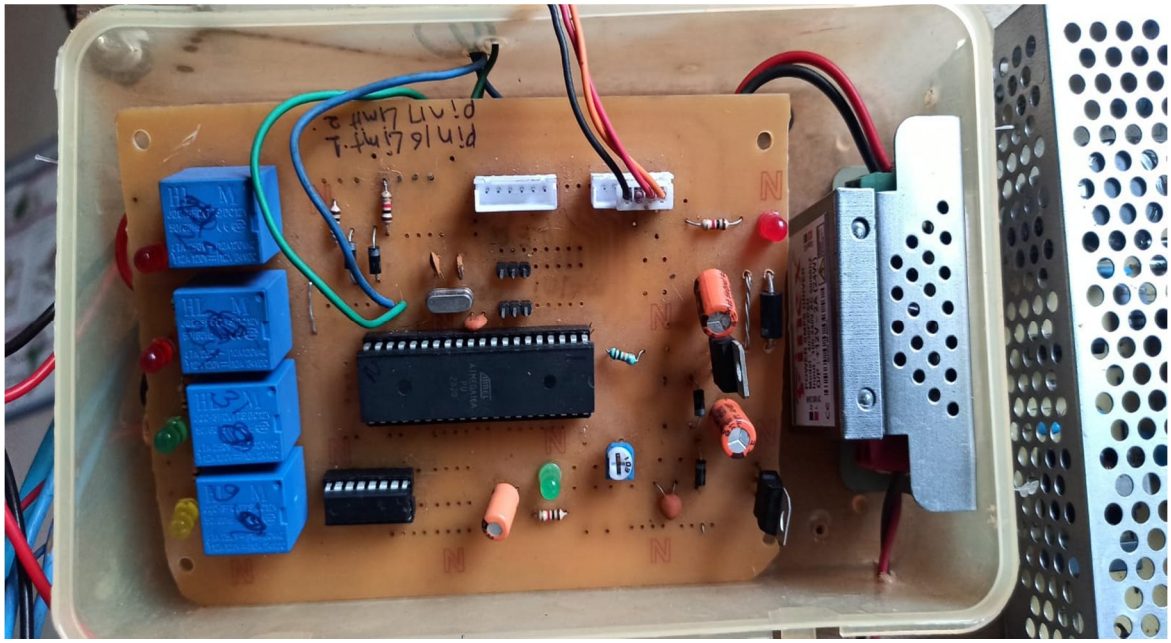

Fig. Arduino UNO circuit

B. Working Code

```
#define ldr 5 //pin2
#define relay1 24//pin
#define relay2 25//pin
#define brush 9 //pin20
#define spray 31//pin21
#define limit2 2//pin16
#define limit3 3//pin17
int count=0;
void setup() {
 pinMode(limit2,INPUT_PULLUP);
 pinMode(limit3,INPUT_PULLUP);
```

```
 pinMode(ldr,INPUT);
pinMode(relay1, OUTPUT);
pinMode(relay2, OUTPUT);
pinMode(brush, OUTPUT);
pinMode(spray, OUTPUT);
digitalWrite(brush, HIGH);
digitalWrite(spray , HIGH); delay(500);
 digitalWrite(spray , LOW) ;

 motorstop();
rest();
}///setup
void loop() {
if (digitalRead(ldr)== LOW)
{
 sprayON();
 cleaning();
 cleaning();
 sprayON();
 cleaning();
 delay(1500);
 digitalWrite(spray , LOW) ;
 digitalWrite(brush, LOW) ;
 while (digitalRead(ldr)== LOW)
{
 digitalWrite(spray , LOW) ;
 digitalWrite(brush, LOW) ;
 delay(1500);

 }
 delay(1500);
 count=0;
 delay(1500);
 }

else
 {
 digitalWrite(spray , LOW) ;
 digitalWrite(brush, LOW) ;
 motorstop();
 }
 }///looop
void motorforward()
 {digitalWrite(relay1, HIGH);
 digitalWrite(relay2, LOW);
 digitalWrite(spray, LOW);
 delay(1000);
 }
void motorreverse()
 {digitalWrite(relay2, HIGH);
```

```
digitalWrite(relay1, LOW);
digitalWrite(spray, LOW);
}
void motorstop()
{digitalWrite(relay1, LOW);
digitalWrite(relay2, LOW);
}
void rest()
{delay(2000);
}
void sprayON()
{digitalWrite(spray,HIGH);
delay(5000);
digitalWrite(spray, LOW);
delay(1000);digitalWrite(spray, LOW);
}
void cleaning()
{ digitalWrite(brush, HIGH);
motorforward( );
delay(3800);
motorstop(); delay(2000);
motorreverse();
delay(5100);
motorstop(); delay(2000);
}
```

VIII. CONCLUSION

It is very important to clean your solar panels. Dirt on the solar panels prevents the entry of light. Moreover, solar panels are made to work by allowing light enters the solar cells. Bird poop, dust or pollen prevent the light from reaching the solar cells which eventually leads to less energy production. Thus, the system developed is very easy to install, it can be used for standalone PV systems. It is fully automated which saves time and human labour. The system can be programmed as per the location of the PV panels, in terms of interval of time of cleaning needed. At the end it would be concluded that don't let the dirty panels contribute to the power loss and economic loss, which may act as a hindrance in the expected contribution in the development and growth of India in long run.

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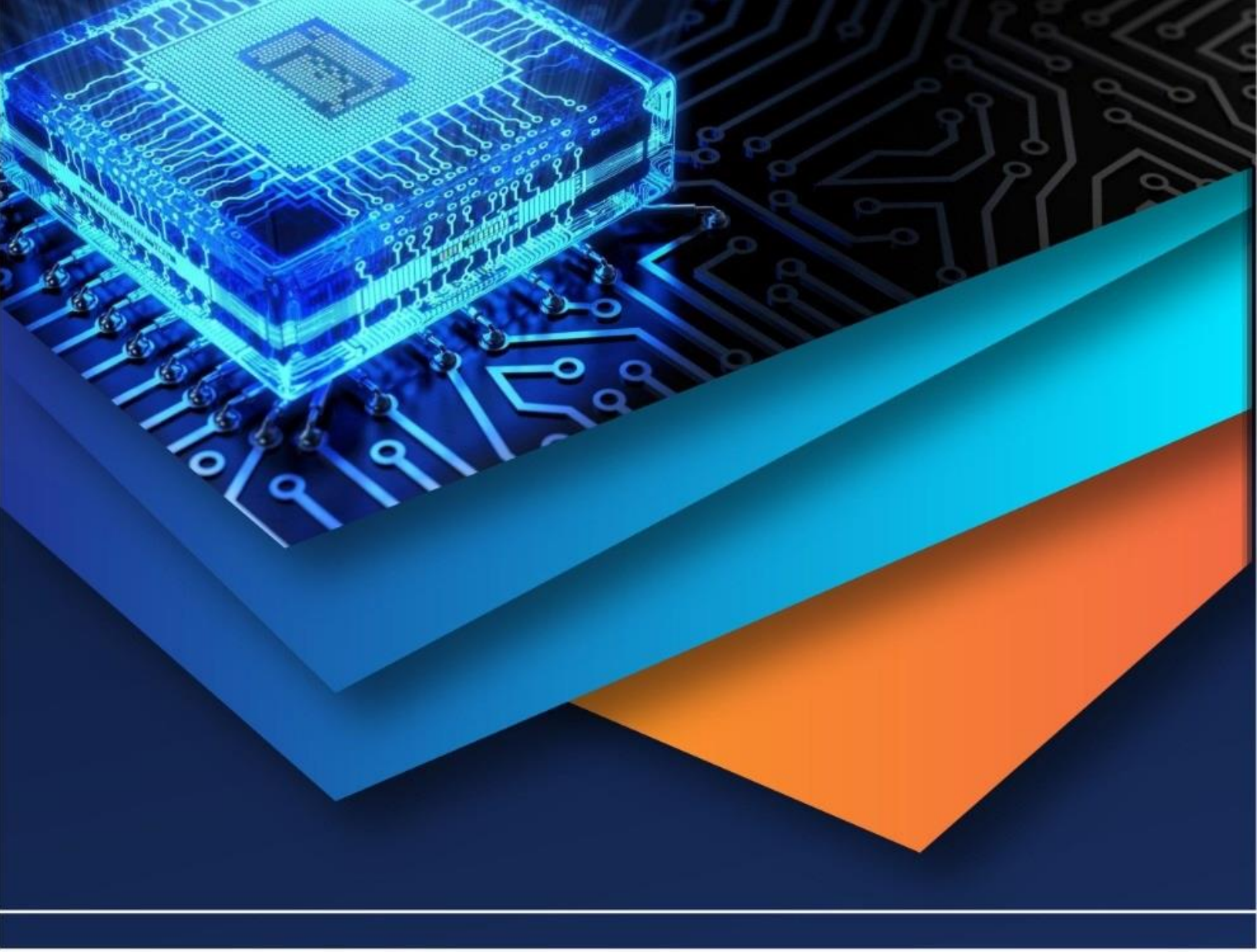

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