Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 3 (2024)

Design and Development of IOT enabled Electronic Circuit for Solar Arrays Cleaning Mechanism

Dr. N. H. Khandare [A], Dr. S. P. Joshi [B], Prof. S. N. Khandare [C]

[A] *Associate Professor, Mechanical Engineering Department, Shri Sant Gajanan Maharaj College of Engineering, Shegaon, India*

[B] *Assistant Professor, Mechanical Engineering Department, Shri Sant Gajanan Maharaj College of Engineering, Shegaon, India*

[C] *Assistant Professor, Information Technology Department, Shri Sant Gajanan Maharaj College of Engineering, Shegaon, India*

Abstract: Using solar energy effectively is essential to reducing the effects of climate change. Photovoltaic (PV) solar panels are the main means of producing power. Nevertheless, a study suggests that the buildup of dust and debris can reduce the efficiency of solar panels by as much as fifty percent. An automated solar panel cleaning system, with or without water, is suggested as a remedy for this problem in order to improve PV panel performance. The project's goal is to install an IOT based Arduino UNO-based microcontroller-based dust cleaning system that will maximize PV panel performance in dusty conditions and boost overall efficiency.

Keywords: Design and Development, Solar Arrays

1.Introduction

The solar industry faces a significant challenge with dust accumulation on solar panels, which can greatly reduce their efficiency. To address this issue, automatic self-cleaning technologies have been developed to overcome the limitations of manual cleaning methods. Various factors like dust, snow, bird droppings, and high temperatures can decrease the efficiency of photovoltaic (PV) energy generation. Joshi, Waghole et.al. describes that dust particles act as barriers, hindering solar energy from reaching the solar cells and reducing overall power production. If left uncleaned, this can lead to a substantial 50% decrease in power output [1]. A solution to this problem lies in robotic devices equipped with programmed coding, offering systematic and efficient cleaning. Compared to traditional methods, these technologies provide advantages such as automated cleaning, inspection, and minimal water usage, making them suitable for both large and small-scale solar PV systems. Implementing these automated systems can ensure cleaner solar panels, enhancing their performance and capacity

2.Methodology

Joshi, Waghole et. al. explains the demand for renewable energy sources grows, solar photovoltaic (PV) panels have become an essential component of the global energy [2]. The efficiency of these panels is significantly impacted by the accumulation of dust, dirt, and other environmental pollutants on their surfaces. To address this challenge, the present project proposes the development of an autonomous solar panel cleaning system

2.1 Components is used to develop the electronic circuit

1. Aurduino UNO: The aurdino UNO is a microcontroller board based on the ATmega328P chip. It has 14 digital input/output pins.

2. Motor driver L298n: The L298n is a popular motor driver IC that allows you to control the speed and direction of two DC motors or one stepper motor, It is 8 pin integrated circuit.

3. Water Pump: A water pump is a electromechanical device that moves water from one place to another by increasing its pressure.

4. DC motor: A DC motor or direct current motor is an electrical machine that converts electrical energy from direct current power source into mechanical energy, specifically rotation.

5. Color sensor: A color sensor is a type of photoelectric sensor that can detect the color of an object ,intead of just measuring intensity, a color sensor analyze the wavelengths of a lights reflected from the objects to determine its color.

6. Jumper wire: Ajumper wire is also known as a jumper or Dupont wire, is a simple electrical wire with connectors pin at each end.

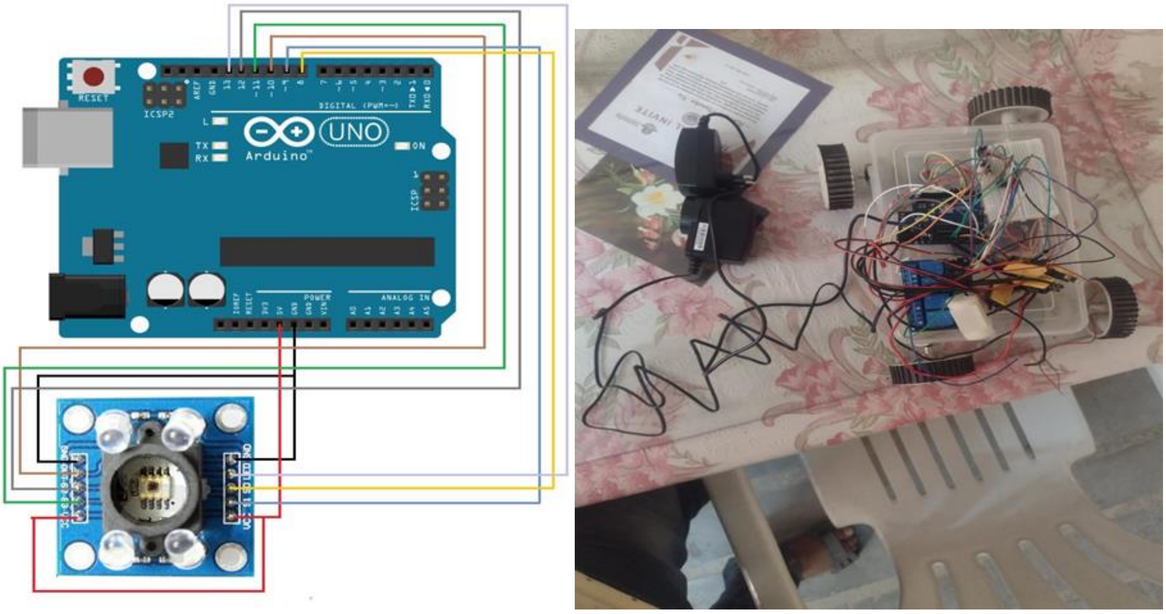


Fig. 01 Arduino kit

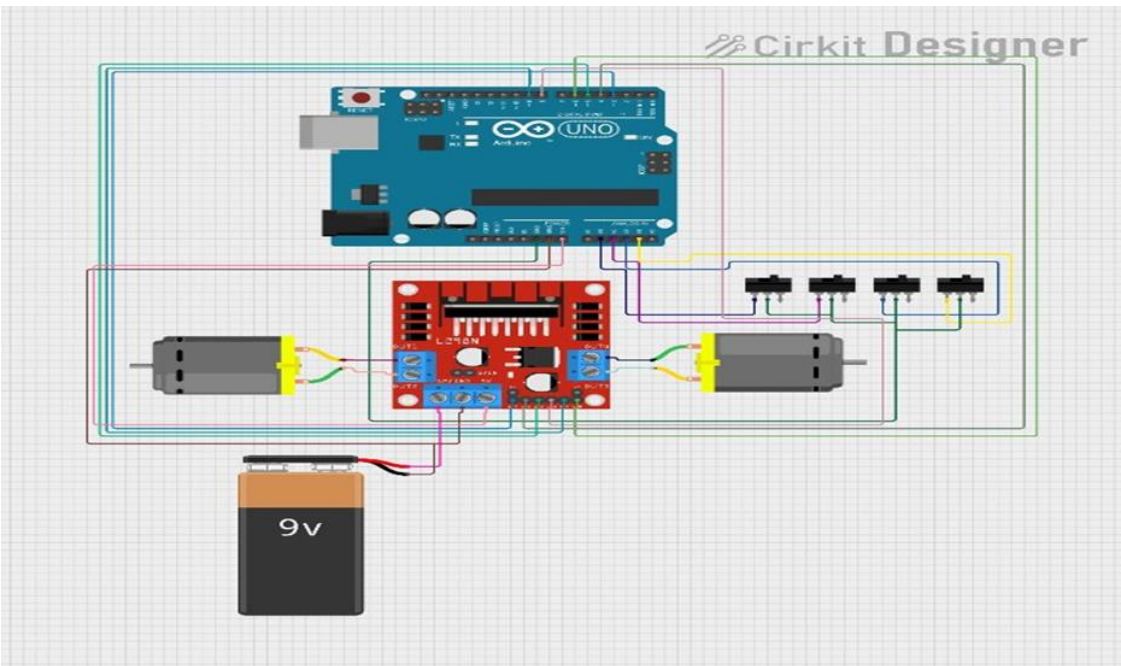


Fig. 02 Block diagram of circuit

Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 3 (2024)

2.3 Code

For Cleaning:

```
#define S0 8
#define S1 8
#define S2 8
#define S3 8
#define sensorOut 9
int Frequency = 0;
int a = 2;
int b = 3;
void setup()
{
  pinMode (S0, OUTPUT);
  pinMode (S1, OUTPUT);
  pinMode (S2, OUTPUT);
  pinMode (S3, OUTPUT);
  pinMode(sensorOut, INPUT);
  pinMode(a, OUTPUT);
  pinMode(b, OUTPUT);
  digitalWrite(S0,HIGH);
  digitalWrite(S1,LOW);
  Serial.begin(9600);
}
void loop(){
 digitalWrite(S2,LOW);
 digitalWrite(S3,HIGH);
 Frequency = pulseIn(sensorOut, LOW);
 Serial.print("  ");
 Serial.println(Frequency);
 if(Frequency < 100){
 digitalWrite(a,0);
 digitalWrite(a,1);
 digitalWrite(b,0);
 digitalWrite(b,1);
 }
```

```
 else{
  digitalWrite(a,0);
 digitalWrite(a,1);
 digitalWrite(b,0);
 digitalWrite(b,1);
 }
}
```

For Movement of X and Y direction:

```
#define ENA 3
#define ENB 5
#define in1 4
#define in2 2
#define in3 6
#define in4 7
 int Frequency = 0;
int speed = 230;
 void setup() {
pinMode(ENA, OUTPUT);
pinMode(ENB, OUTPUT);
pinMode(in1, OUTPUT);
pinMode(in2, OUTPUT);
pinMode(in3, OUTPUT);
pinMode(in4, OUTPUT);
}
void loop() {
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
  analogWrite(ENB, speed);
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
  analogWrite(ENA, speed);
  delay(10000);
  digitalWrite(in3, HIGH);
  digitalWrite(in4, LOW);
  analogWrite(ENB, speed);
```

```
digitalWrite(in1, LOW);
digitalWrite(in2, LOW);
analogWrite(ENA, speed);
delay(5000);
digitalWrite(in1, LOW);
digitalWrite(in2, HIGH);
analogWrite(ENA, speed);
digitalWrite(in3, LOW);
digitalWrite(in4, LOW);
analogWrite(ENB, speed);
delay(10000);
digitalWrite(in1, LOW);
digitalWrite(in2, LOW);
analogWrite(ENA, speed);
digitalWrite(in3, HIGH);
digitalWrite(in4, LOW);
analogWrite(ENB, speed);
delay(5000);
digitalWrite(in3, LOW);
digitalWrite(in4, LOW);
analogWrite(ENB, speed);
digitalWrite(in1, HIGH);
digitalWrite(in2, LOW);
analogWrite(ENA, speed);
delay(10000);
digitalWrite(in3, HIGH);
digitalWrite(in4, LOW);
analogWrite(ENB, speed);
digitalWrite(in1, LOW);
digitalWrite(in2, LOW);
analogWrite(ENA, speed);
delay(5000);
digitalWrite(in1, LOW);
digitalWrite(in2, HIGH);
analogWrite(ENA, speed);
```

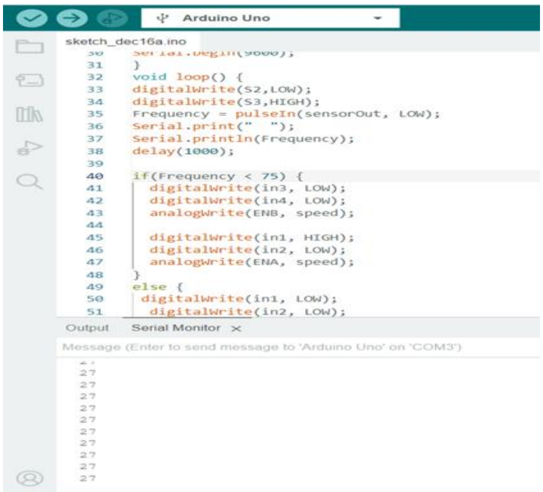
```
digitalWrite(in3, LOW);
digitalWrite(in4, LOW);
analogWrite(ENB, speed);
delay(10000);
digitalWrite(in1, LOW);
digitalWrite(in2, LOW);
analogWrite(ENA, speed);
digitalWrite(in3, HIGH);
digitalWrite(in4, LOW);
analogWrite(ENB, speed);
delay(5000);}
```

Results

If the RGB values are detected by color sensors (TCS230) then following condition are occurs :

If the RGB values of solar panel in serial monitor is > 75 then solar panel is clean (i.e. Wheels motors are on and cleaning pump are off)

If the RGB values of solar panel in serial monitor is < 75 then solar panel is not clean (i.e. Wheels motors are off and cleaning pump are on)



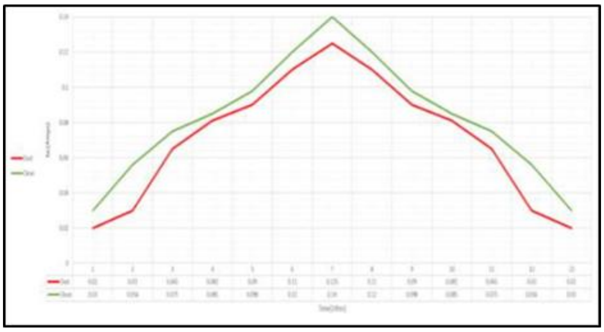


Fig. 03 Actual graphs of experimentation

In this experiment, we aim to compare the electricity generation efficiency between clean and dirty solar panels.

Fig.04 Solar Panel with Dirt

Fig. 05 Solar panel without Dirt

The experiment will be conducted using identical solar panels, with one panel kept clean as a control group, and the other intentionally subjected to simulated dirt accumulation. By following this testing procedure, we can effectively evaluate the performance of clean and dirty solar panels in generating electricity. This information is crucial for optimizing the maintenance schedule and ensuring maximum efficiency and longevity of solar power systems.

Conclusion

The design and fabrication of a solar panel cleaning mechanism is a critical endeavor to ensure optimal energy output and efficiency of solar panels. By addressing factors such as automation, cleaning frequency, and material selection, the mechanism aims to minimize maintenance efforts while maximizing energy generation.

The integration of smart technologies, such as sensors and control systems, further enhances its effectiveness. There are various cleaning methods available, including manual cleaning, automated cleaning systems, and self-cleaning coatings. The choice of mechanism depends on factors such as location, environmental conditions, and cost- effectiveness.

The solar panel cleaning system improves efficiency, durability, and cost- effectiveness. Using things like pulleys, rails, and wire ropes made it a practical and reliable solution for improving solar energy systems.

This innovative approach not only ensures optimal performance but also addresses maintenance challenges, making solar energy more accessible and sustainable.

Acknowledgement

This research work is funded by Maharashtra Government “Rajiv Gandhi Science and Technology Commission, Mumbai". Authors expresses special thanks to RGSTC Team Mumbai (MH) and Sant Gadge Baba Amaravati University for throughout cooperation during the completion of project.

References

1. Joshi, S.P., Waghole, D.R. (2022). Investigations on Efficient Designs of Domestic Cooking Pots. In: Palani, I.A., Sathiya, P., Palanisamy, D. (eds) Recent Advances in Materials and Modern Manufacturing. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-19-0244-4_96
2. S.P. Joshi and Dr.Dnyaneshwar R. Waghole, Experimental investigation on energy efficient design for household cooking utensils, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2022.02.468
3. Parrott, B., Zanini, P. C., Shehri, A., Kotsovos, K., & Gereige, I. (2018). Automated, robotic dry-cleaning of solar panels in Thuwal, Saudi Arabia using a silicone rubber brush. *Solar energy*, *171*, 526-533.
4. Noh, F. H. M., Yaakub, M. F., Nordin, I. N. A. M., Sahari, N., Zambri, N. A., Yi, S. S., & Saibon, M. S. M. (2020). Development of solar panel cleaning robot using Arduino. *Indonesian Journal of Electrical Engineering and Computer Science*, *19*(3), 1245-1250.
5. Habib, M. R., Tanvir, M. S., Suhan, A. Y., Vadher, A., Alam, S., Shawnee, T. T., ... & Alrashed, A. (2021, March). Automatic solar panel cleaning system based on Arduino for dust removal. In *2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS)* (pp. 1555-1558). IEEE.
4. Purohit, N., Meghwal, S., & Bhansali, P. AUTOMATICSOLAR PHOTOVOLTAIC CLEANING BOT.
5. Amin, A., Wang, X., Alroichdi, A., & Ibrahim, A. (2023). Designing and Manufacturing a Robot for Dry-Cleaning PV Solar Panels. *International Journal of Energy Research*, *2023*.
6. Mousavi, S., & Farahani, G. (2022). Introducing a new method of automatic cleaning of the PV array surface using a suction robot. *Mechatronics*, *85*, 102845.
7. Wang, R., Mi, Z., Yu, H., & Yuan, W. (2011). The design of the image processing system is based on SOPC and OV7670. *Procedia Engineering*, *24*, 237-241.
8. Khedaskar, S. V., Rokade, M. A., Patil, B. R., & Tatwadarshi, P. N. (2018). A survey of image processing and identification techniques. *VIVA-Tech International Journal for Research and Innovation*, *1*(1), 1-10.
9. Akyazi, Ö., Şahin, E., Özsoy, T., & Algül, M. (2019). A solar panel cleaning robot design and application. *Avrupa Bilim ve Teknoloji Dergisi*, 343-348.
10. ....Column Break.................Olorunfemi, B. O., Nwulu, N. I., & Ogbolumani, O. A. (2023). Solar panel surface dirt detection and removal based on Arduino color recognition. *MethodsX*, *10*, 101967.
11. Zanjade, B. G., Patel, L. M., Varambhe, K. R., Jambhore, M. T., & Chede, B. DEVELOPMENT OF SOLAR PANEL CLEANING MACHINE.
12. Kumar, R., Ramapraba, P. S., Kishore, S. R., & Jayanthi, S. (2021, July). Automatic Solar Panel Cleaner Robot Using IoT. In *Journal of Physics: Conference Series* (Vol. 1964, No. 6, p. 062084). IOP Publishing.
13. Manju, B., Bari, A., & Pavan, C. M. (2018). Automatic solar panel cleaning system. *International Journal of Advances in Scientific Research and Engineering (ijasre)*, *4*(7).
14. Nikhath Anjum, Keerthana A.S,Meghana. P,Smt. Thilagavathy R. (2018). Automatic cleaning of solar panel system. *International Journal of Research & Techanology ISSN; 2278-0181*