A

PROJECT REPORT ON

"EFFICIENT SOLAR PANELS BY AN AUTOMATIC CLEANING SYSTEM"

SUBMITTED TO THE SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE IN THE PARTIAL FULFILMENT FOR THE AWARD OF THE DEGREE OF

BACHELOR OF ELECTRICAL ENGINEERING

BY

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Academic Year 2020-2021

CERTIFICATE

This is to certify that project report entitled

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Submitted By

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ACKNOWLEDGEMENT

It is our great pleasure in expressing sincere and deep gratitude towards our guide **Mr. V. S. KAMBLE,** Assistant Professor Electrical Engineering Department for his valuable guidance and constant support throughout this work.

We take this opportunity to thank Head of the Department **Dr.Mrs. A. D. Shiralkar –**Head of department and Project coordinator **Mr.S.S. Shingare**-Assistant Prof. Electrical Engineering Dept. and all staff members of department of Electrical Engineering AISSMS IOIT, Pune, for cooperation provided by them in many ways.

The motivation factor for this work is the inspiration given to us by our honorable principal **Dr. P. B. Mane-**Principal, Aissms IOIT**.**

Lastly, we are thankful to those who have directly or indirectly supported for our work.

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ABSTRACT

There are various factors which influence the performance of the solar PV system dust is the one of the significant factor that affects the most. Accumulation of the dust and dirt particles on the surface of the solar panel reduces the performance by blocking the solar radiation and blocks it to reach each solar cell. Therefore this result in reduction of overall power output of the solar panel. In earlier methods human personnel were used to clean the solar panels which could result in injuries or accidents. Also manual cleaning demands extensive labour. These problems are analyzed and as a result an automatic cleaning system has been proposed.

Keywords: Solar Panel, DC motor, Lead Screw mechanism, Wiper, AURDINO, H-Bridge IC L298N, PC Etc.

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1. INTRODUCTION

In energy deficient world, renewable sources of energy are gaining popularity. Solar panels are the most favourite among entire renewable sources because of the abundance of solar energy and its free and easy availability. The awareness regarding global warning, CO2 emission, peaking of most oil reservoirs & impending climate change are critically driving the adoption of solar photovoltaic as a sustainable renewable & eco-friendly alternative, So with the trend and increasing demand of solar panels the efficiency of solar panels is more crucial than ever. Though the technologies are evolving in the modern era, solar panels are still very inefficient. The efficiency to convert solar energy into usable energy is to 21%. Dust and dirt particles gathered on solar panels lower the panel efficiency even further

Figure 1: Dusty solar panel (pc: solarpanelscleaningsystems.com)

Figure 2: Dusty solar panel (pc: precise energy solutions)

Auditing this problem, the project aims to reduce the efficiency losses of existing solar panel cells. The system automatically cleans the surface of solar panels using an Arduino to have the maximum energy generation.

2. LITERATURE SURVEY

Various articles and technical papers have been referred for the project. The literature survey (in brief) has been presented by referring to the articles and technical papers.

1) **Nasibkhadka, AayushBista, BinamraAdhikari, Ashish shrestha, Solar Panel Cleaning Technology: A Review, 5thInternational Conference on Developments in Renewable Energy Technology (ICDRET), April 2018:[1]**

   They analyzed various environmental factors which affects the efficiency of solar panel. They observed that there are so many factors which affect the efficiency of the solar panel. The first and foremost one is dust. Dust accumulation on the PV module surface is the prime factor which affects the efficiency of the solar panel. The fig shows I-V characteristics curve for different dust densities. It explains about decrease in current due to increase in dust densities. Hence as the current decreases consequently efficiency also decreases, Also the best result of curve is for cleaned module. The main problem of the dust accumulation on the solar panel is in the Asia region and mainly in the area where there is more dust than the average dusty area just like UAE, Kuwait, Saudi Arabia and the countries where there are gigantic desert are situated.

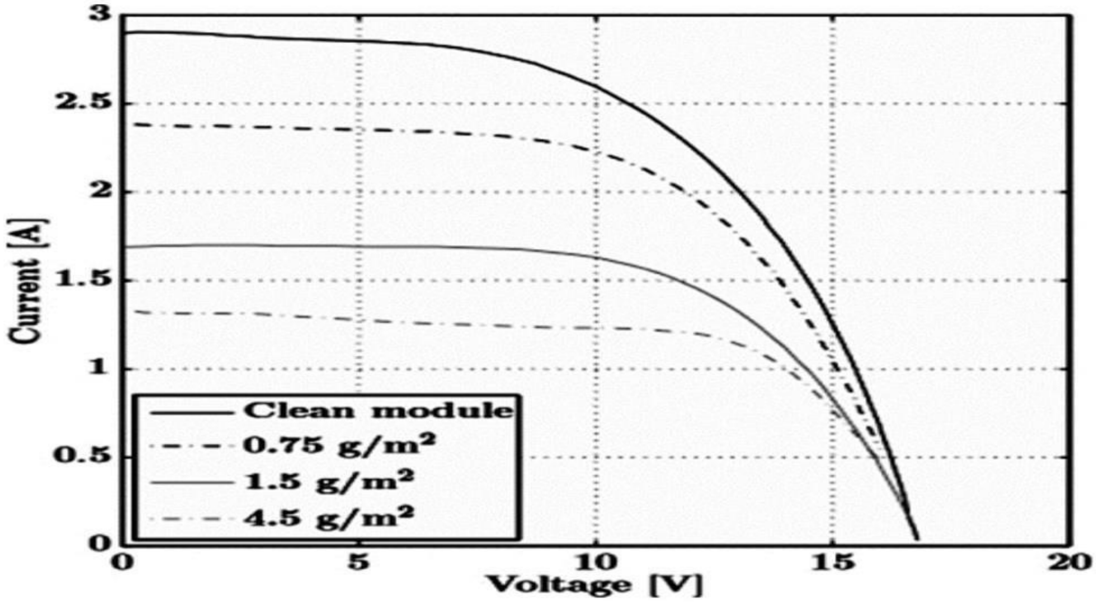

Figure 3: I-V characteristics for different dust densities.

2) Swanand S. Wable, Somashekhar Ganiger, Design & Manufacturing of Solar Panel Cleaning systems[2]:

They observed that in the conventional cleaning of solar panel, there is a lot of wastage of water especially in case of tropical regions where there are a lot of dust accumulation on solar panels. They have created a mechanism consisting of sliding brushes such that the brushes slide on the panel. It was observed that, in terms of daily solar generation, the presented cleaning system provides about 30% more energy output as compared to flat PV plate.

3) **Avipsa Dey, Nishi Shah, Sonali Ghatge, Vaishali Sapkal, solar panel cleaning system Published on 5 March 20.**

An experiment was conducted on a PV panel to study the effect of dust for a time duration of 8 weeks in the month of January to February. As shown in the table, radiation was measured during hours of 11AM to 2PM. Initially at the start power output was 1.98kWh and at the end of week it was 1.49 kWh, the total loss in power was of 0.49kW in duration of 1 hr. Taking some assumptions the losses can range up to 4,292.4kW (approx.) for 1 year, Thus regular cleaning of the installed panel can help us to save the power losses at great extent. This project was sponsored by Government of Gujarat for 10MW canal-top solar plant at Vadodara.

Table-1 : Their Observation:

Week	Dust (g/m^2)	Time	Solar Radiation(kWh)	Power Output (kWh)
2nd Week	1.748	11AM to 2PM	19.90	1.98
4th Week	3.407	11AM to 2PM	19.13	1.78
6th Week	5.421	11AM to 2PM	18.43	1.60
8th Week	7.549	11AM to 2PM	18.03	1.49

3. OBJECTIVES

- Focusing and analyzing renewable sources of energy.
- Studying the parameters which affect solar panel efficiency.
- Use of automatic cleaning system so as reduce manual work.
- Avoiding human accident in high voltage environment by using automatic cleaning system.
- Making economical and low maintenance prototype.

3.1 METHODOLOGY

The working of proposed automatic solar panel cleaning systems mainly depends on Arduino and lead screw mechanism. It consists of 12v DC motor having a rating of 3000rpm 1.2A current. This motor is gathered on the upper most top side of the panel. On the motor shaft Lead Screw Mechanism is connected with that wiper is connected with the help of nut and screw. Motor is connected to the PC through Arduino. Arduino is used to supply the specific function to the motor according to that motor will works.

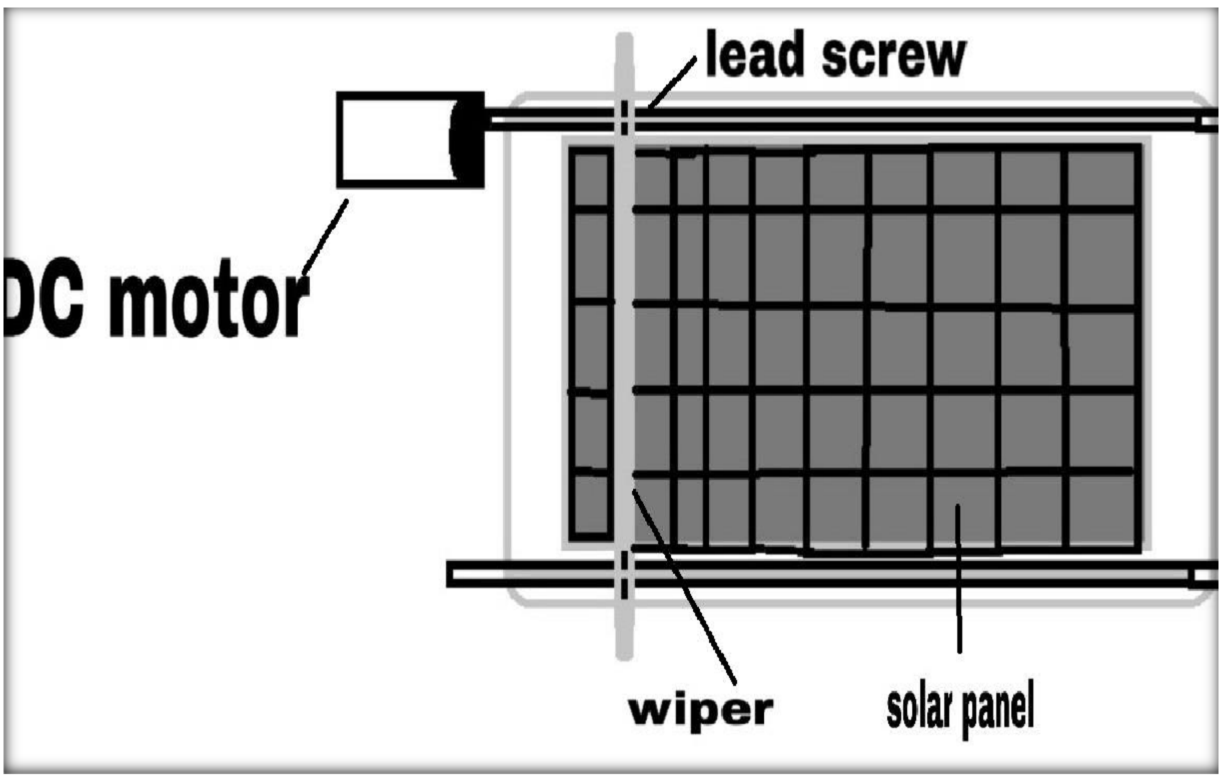

Figure4: working module of solar panel cleaning system.

As the PC gave the instruction to the Arduino to run the motor in clockwise direction as we previously programming will be done. The motor will rotate with that lead screw mechanism is connected to the motor will also rotate with the wiper. As motor rotates in clockwise direction the lead screw rotates in clockwise and wiper moves downwards. The instruction from the PC to Arduino goes for rotation of motor in anticlockwise direction. The motor will rotate in reverse direction that is anticlockwise, with this lead screw mechanism will also rotate in anticlockwise direction and wiper will moves in upwards. Whole setup is controlled with the Arduino through the PC. The set of rotation of wiper is depends on the dusty panels, if the panels was not cleaned since 15 to 20 days 3-4 rotation of wiper we will done.

COMPONENTS AND ITS SPECIFICATIONS

Solar panel

A **solar panel** (also **solar module**, **photovoltaic module** or **photovoltaic panel**) is a packaged, connected assembly of photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each panel is rated by its DC output power under standard test conditions, and typically ranges from 100 to 320 watts. The efficiency of a panel determines the area of a panel given the same rated output - an 8% efficient 230watt panel will have twice the area of a 16% efficient 230watt panel. Because a single solar panel can produce only a limited amount of power, most installations contain multiple panels. A photovoltaic system typically includes an array of solar panels, an inverter, and sometimes a battery and or solar tracker and interconnecting wires.

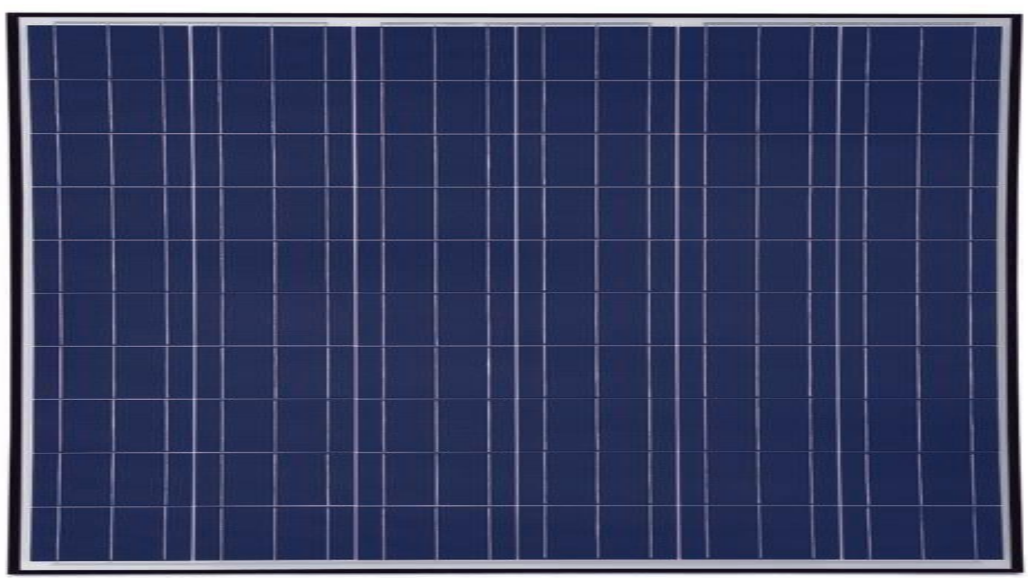

Figure 5: Solar panel

SPECIFICAIONS

- Output power : 10watts
- operating voltage : 12 volt
- Panel technology : poly crystalline
- Cell conversion efficiency >16%
- Weight : 1.00Kg
- Dimensions : L x W x H

  285 x 350 x 22mm

3.3.2 Arduino

The Arduino Uno is the most common version of Arduino family. The Arduino Uno is a micro controller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. The Arduino Uno is great choice for beginners.

It contains everything needed to support the micro controller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Arduino Uno is a good choice for beginners since it is easy to start with.

USB: The USB port is used to power the board from the computer's USB port and also to transfer the program code from computer into the Arduino microcontroller.

External Power: It is used to power the board if the USB connector is not used. An AC adapter (9 volts, 2.1mm barrel tip, enter positive) could be used for providing external power. If there is no power at the power socket, then the Arduino will use power form the USB socket. But it is safe to have power at both the power socket and USB socket.

Digital Pins (I/O): The Arduino Uno has 14 digital pins (0 to 13) of which the 6 are PWM (~).This pins can be either inputs or outputs. But we need to mention it in the Arduino sketch (Arduino programming).The PWM (Pulse Width Modulated) pins acts as normal digital pins and also used to control some functions. Say for example, control the dimming of LED and control the direction of servo motor. Both digital inputs and digital outputs can read one of the two values either HIGH or LOW.

Analog Pins: The Analog pins (0 to 5) acts as inputs which is used to read the voltage in analog sensors such as temperature sensor, gas sensor, etc. Unlike digital pins which can only read one of the two values (HIGH or LOW), the analog inputs can measure 1024 different voltage levels.

A T mega Microcontroller: The Arduino uses ATmega328 microcontroller. It is a single chip microcontroller created by Atmel. This chip works well with Arduino IDE if damaged its controller can be easily replaced. The Atmega328 has 32 KB of flash memory for storing code (of which 0, 5 KB is used for the boot loader). It has also 2 KB of SRAM and 1 KB of EEPROM.

3.3V Pin: A 3.3volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

5V Pin: The regulated power supply used to power the microcontroller and other components on the board. This can come either from an on-board regulator, or be supplied by USB or another regulated 5V supply. **Reset Button:** It is used to reset the microcontroller. Pushing this button will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino.

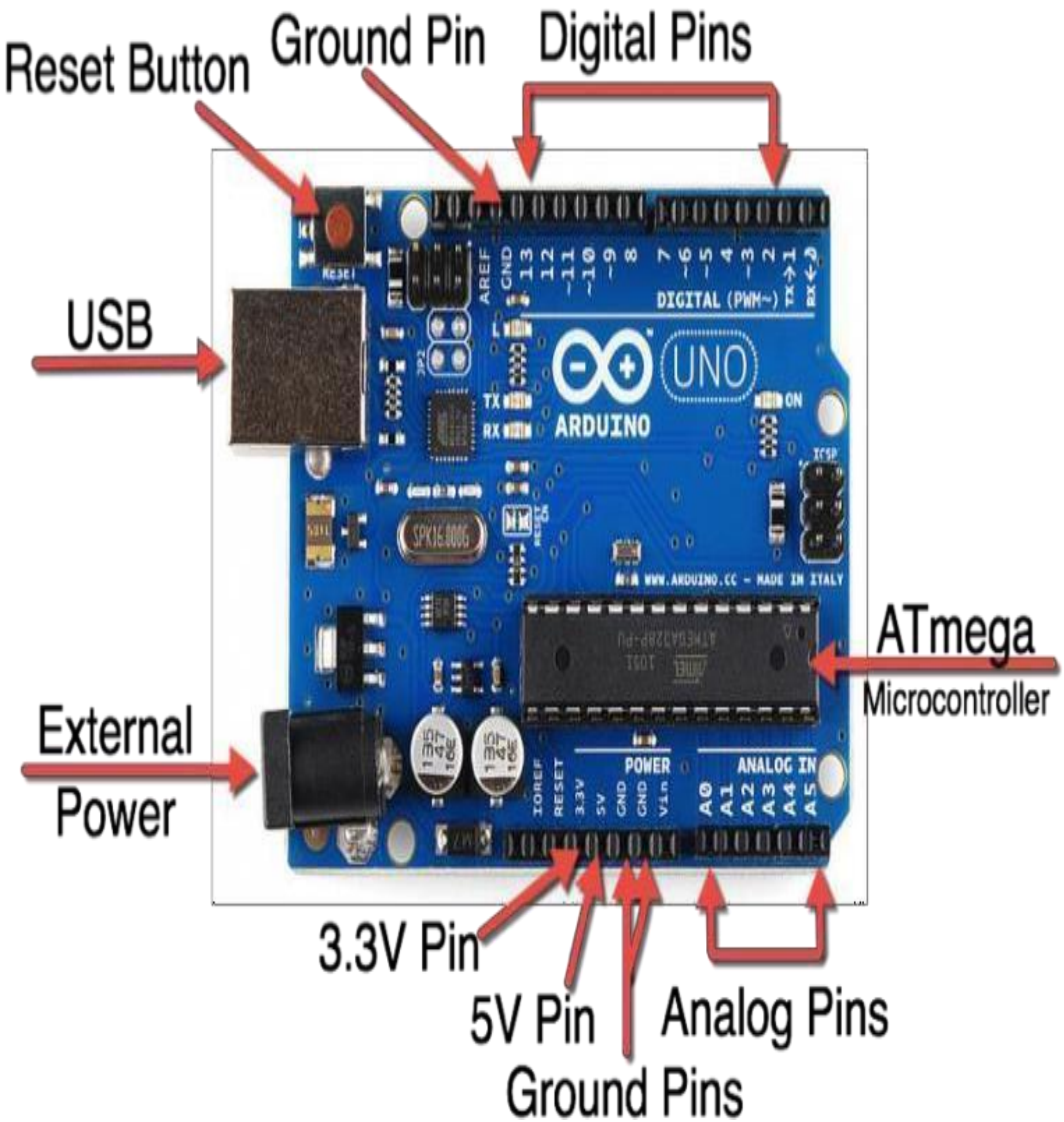

Figure 6: ARDUINO

TECHNICAL SPECIFICTION:

Microcontroller: AT mega 328

- Operating voltage: 5v
- Input Voltage (limit): 6to20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3VPin: 50 mA
- Flash Memory: 32 KB (ATmega328) of which 0.5 KB used by boot loader SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

3.3.3 H-bridge IC L298

Dual Motor Controller Module 2A with Arduino. This allows you to control the speed and direction of two DC motors, or control one bipolar stepper motor with ease. The L298N H- bridge module can be used with motors that have a voltage of between 5 and 35V DC.

There is also an onboard 5V regulator, so if your supply voltage is up to 12V you can also source 5V from the board.

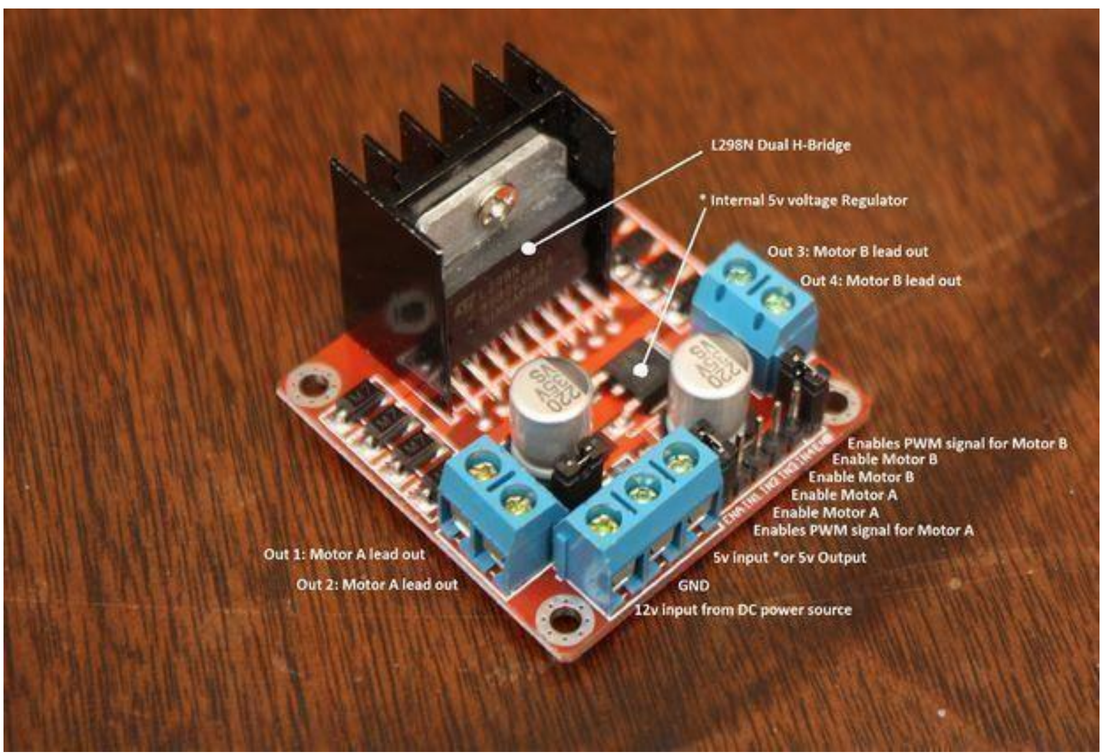

Figure 7: L298 motor driver module

Pin Configuration:

1. DC motor 1 "+" or stepper motor A+
2. DC motor 1 "-" or stepper motor A-
3. 12V jumper - remove this if using a supply voltage greater than 12V DC. This enables power to the on board 5V regulator
4. Connect your motor supply voltage here, maximum of 35V DC. Remove 12V jumper if >12V DC
5. GND
6. 5V output if 12V jumper in place, ideal for powering your Arduino etc.
7. DC motor 1 enable jumper. Leave this in place when using a stepper motor.

Connect to PWM output for DC motor speed control.

8. IN1
9. IN2
10. IN3
11. IN4
12. DC motor 2 enable jumper. Leave this in place when using a stepper motor. Connect to PWM output for DC motor speed control

Controlling DC Motors:

To control one or two DC motors is quite easy. First connect each motor to the A and B connections on the L298N module. If you're using two motors for a robot etc. ensure that the polarity of the motors is the same on both inputs, Otherwise you may need to swap them over when you set both motors to forward and one goes backwards!

Next, connect your power supply - the positive to pin 4 on the module and negative/GND to pin

5. If you supply is up to 12V you can leave in the 12V jumper (point 3 in the image above) and 5V will be available from pin 6 on the module. This can be fed to your Arduino's 5V pin to power it from the motors' power supply. Don't forget to connect Arduino GND to pin 5 on the module as well to complete the circuit.

Now you will need six digital output pins on your Arduino, two of which need to be PWM (pulse-width modulation) pins. PWM pins are denoted by the tilde ("~") next to the pin number, for example:

Finally, connect the Arduino digital output pins to the driver module. In our example we have two DC motors, so digital pins D9, D8, D7 and D6 will be connected to pins IN1, IN2, IN3 and IN4 respectively. Then connect D10 to module pin 7 (remove the jumper first) and D5 to module pin 12 (again, remove the jumper).

The motor direction is controlled by sending a HIGH or LOW signal to the drive for each motor (or channel). For example for motor one, a HIGH to IN1 and a LOW to IN2 will cause it to turn in one direction, and a LOW and HIGH will cause it to turn in the other direction.

However the motors will not turn until a HIGH is set to the enable pin (7 for motor one, 12 for motor two). And they can be turned off with a LOW to the same pin(s), However if you need to control the speed of the motors, the PWM signal from the digital pin connected to the enable pin can take care of it.

DC MOTOR

Specifications

- Operating voltage: 5v dc
- Operating current: 1.2 A
- Speed : 3000 rpm

Figure 8: DC Motor

The motor is very easy to use and available in standard size. Also, you don't have to spend a lot of money to control motors with an Arduino or compatible board.

3.3.5 Wiper

Length of wiper is used according to size of solar panel. As the size of solar panel is 285 * 350 according to that size of wiper is 280mm in length. When motor rotates so the lead screw and according to the direction of linear motion wiper moves which cleans the solar panel surface.

Figure9: Wiper

The most widely used and effective way for cleaning glass surface is wiping it, by using wiper system. The automobiles have been using the wiper system since more than a century and various improvements have been made in the design till now. It is robust in construction, simple in design, cheap to manufacture, quick in operation as compared to the other glass cleaning systems. Simple wipers clean the surface along the circular path but the solar panel has a rectangular glass surface to be cleaned.

So, in order to cover the maximum area under the wiper cleaning system, the arrangement consisting two wipers, each at the diagonally opposite end of the solar panel was used. The area of panel surface cleaned, of the total surface area of the panel depends on the length to width ratio of the solar panel. The percentage of the total area of the PV module surface cleaned by the cleaning system increases as the length to width ratio of the PV panel.

<u>Selection:</u>

The wipers used in the automobiles with the curved windscreen have the claw type construction. This design helps in distributing the load evenly along the entire blade and also keeps the blade in contact with the windscreen along the entire length. As the solar panels will have flat glass, the requirement of the claw design is not so crucial, which will eliminate the use of bulky wiper blades by using simple straight wiper blades. These wipers are also cheaper

to manufacture due to their simple design. Typical automobile wipers have 100000 cycle of life, which shows their durability for the purpose. The wiper blades have complex relations between the coefficient of friction, normal load and sliding velocities because of the intricate nature of rubber blade and glass contact for different value of parameters.

As the interface of the wiper blade increases the coefficient of friction reduces. The coefficient of friction varies from 0.7 to 2.3 for the variation of the interference between 0.6 to 2.4 mm in a 4mm specimen of the wiper blade in the dry condition as per the test carried in labs.

The test results also proves that the coefficient of friction decreases with the increase in the velocity in the wet conditions. The variation of the normal force with the friction force is linear for low value of normal force, but for the higher values the curve changes significantly and the increment in the friction force with respect to the increment in the normal force reduces. The coefficient of friction reduces with the increment in the normal force as a result of rise in the interference. So, the value of coefficient of friction is taken as 2 for the calculations considering that the wiper may be required to be operated in the dry condition.

The standard value of normal force applied on the wiper blades for the flat wipers in the automobiles as per the wiper selection catalogue is between 10 to 15 Newtons per meter of the blade length. So, considering 10N/m normal force for the blades, as there are no shocks or vibrations while operating the wiper on the solar panel, as that are faced by the automobile wiper system, which demands higher amount of force to cling to the glass surface.

$\mu = 2$

fiN= 10 N/m

L = 1 m

So, total normal force acting on the wiper blade is

FN = fN × L (1)

= 10 × 1

= 10 N

Hence, the torque required to drive one wiper is

$T = \mu \times FN \times (L/2)$ (2)

$= 2 \times 10 \times 0.5$

$T = 10$ Nm

Here, μ is coefficient of friction, fN is normal force per unit length of the wiper blade, FN is the total normal force on the wiper blade, T is the torque required to drive a wiper.

Lead screw mechanism

A lead screw also known as power screw is a screw used as a linkage in a machine to translate rotatory motion into linear motion. It has a larger area of sliding contact between their male and female members(threads). As the size of solar panel 285 * 350 according to that size of lead screw mechanism is 290*20.

Figure 10: Lead Screw Mechanism

Choosing of lead screw for best linear application:

Before choosing the lead screw mechanism work on the linear motion application is needed. These includes Thrust, speed, accuracy, repeatability and resolution.

Thrust:

The more thrust an application requires, the larger the diameter screw will be needed. That's because the screw is similar to a column subject to compression and tension. During compression, the screw should not bow or deflect. And during tension, the screw must support the load without failing.

The strength depends on

$$Pcr = (14.03 \times 106 \times FC \times d4)/L2$$

where Pcr = maximum load; Fc = end fixity factor (this is 0.25 for one end fixed, one end free; 1.0 for both ends supported; 2.0 for one end fixed, one end simple; and 4.0 for both ends rigid); d = root diameter of screw; and L = the distance between nut and load-carrying bearing.

Speed:

The second most important factor is speed. All screw mechanisms have a critical velocity — the rotational velocity limit of the screw after which vibrations develop due to the shaft's natural harmonic frequency.

This is also commonly called “screw whip” and depends on the diameter and length of the screw between supports. It is important to note that a screw’s critical velocity is not a function of orientation (horizontal, vertical, etc).

Speed can be calculated by,

N = (4.76 × 106 × d × Fc)/L2

Where,

N = critical speed, d = root diameter of screw, Fc is end fixity factor (0.36 for one end rigidly fixed, one end free; 1.00 for both ends supported; 1.47 for one end rigidly fixed, one end supported; and 2.23 for both ends rigidly fixed), and L = the length between bearing supports.

Accuracy and repeatability:

The third most important thing is accuracy and repeatability. Accuracy measures how well an assembly can move a load to a desired location within a tolerance level. Accuracy depends on the accuracy of the leadscrew. The most accurate screws will almost always be the most expensive. Repeatability measures how well a screw assembly can consistently move a load to the same location. Many applications don’t need a high level of accuracy but will likely require a high level of repeatability. It is possible for ball and other types of leadscrews to have repeatability but not accuracy. Ball and roller nuts, because they do not wear like Acme nuts, maintain higher levels of repeatability. Backlash, the next area of discussion, is also important for bidirectional repeatability.

4. BLOCK DIAGRAM & FLOW CHART

Block Diagram:

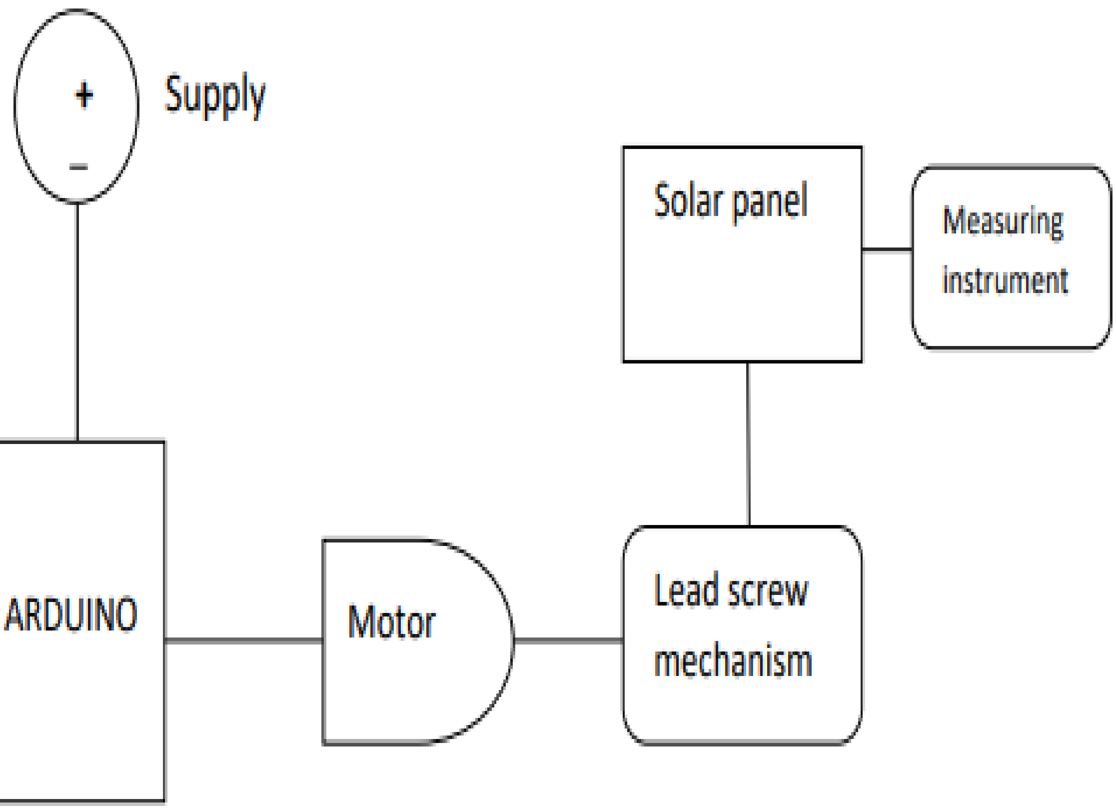

Figure11: Block Diagram

Here is the block diagram of the project. The supply is nothing but PC is connected to the Arduino through the connecting wires. The Arduino takes the instruction from PC to operation of rotates in clockwise or in anticlockwise direction. Arduino send the Instruction to the motor and motor rotate, if the motor moves with that lead screw mechanism is also rotates which is connected to the motor shaft. There is the movement of lead screw mechanism with that wiper is also move and clean the solar panel. Output measuring before cleaning and after cleaning is done by measuring instrument which is connected to solar panel.

FLOW CHART:

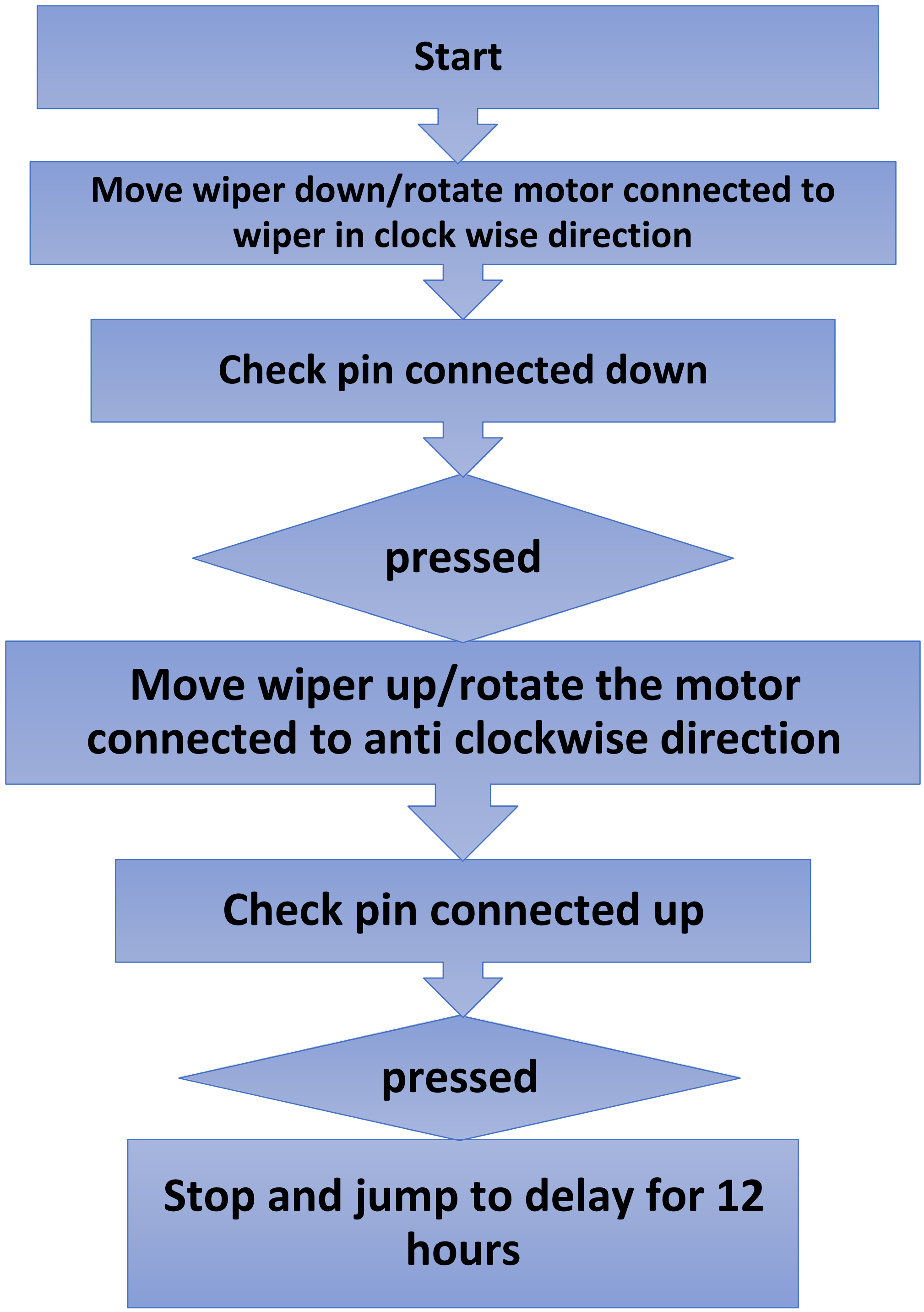

Figure12: Flow Chart

5. PROGRAMMING

```
#include<reg51.h>

void delay(unsigned int value)
{
int i,j;
for(i=0;i< value;i++)
for(j=0;j< 10;j++);
}

void main()
{
while(1)
{
delay(50000);
P1=0x00;
delay(50000);
P1=0x01;      //Motor rotate in clockwise direction
delay(50000);
P1=0x00;      //Delay to stable motor for changing direction
delay(50000);
P1=0x02;     //Motor rotate in anti clockwise direction
}
}
```

6. COST ANALYSIS

Sr.no.	Components	Quantity	Price	Total
1	Solar Panel	1	750.00	750
2	Lead Screw Mechanism	1	1200.00	1200
3	12v DC motor	1	150.00	150
4	Arduino-UNO	1	1500.00	1500
5	Connecting wires	1	50.00	50
6	Motor Driven L298N	1	500.00	500
7	Wiper	1	150.00	150
			Total	4300/-

Table 2: Cost of different components.

The Total cost required for the implementation of Automatic Solar Panel Cleaning System is Rs.

4300/-

7. TEST AND OBSERVATIONS

Sr. no.	Time	Volt. (V)	Current (Amp)	Power (W)
1	7 am	12.98	0.08	1.038
2	9 am	13.14	0.12	1.576
3	11 am	14.95	0.21	3.139
4	1 pm	14.3	0.32	4.576
5	3 pm	13.92	0.3	4.176
6	5 pm	13.08	0.19	2.485
7	7 pm	12.75	0.07	0.894

Table 3: Dusty Solar Panel Readings.

Sr.no.	Time	Volt. (V)	Current (Amp)	Power (W)
1	7 am	13.58	0.38	5.160
2	9 am	18.65	0.4	5.86
3	11 am	15.68	0.42	6.585
4	1 pm	15.85	0.45	7.132
5	3 pm	15.72	0.44	6.916
6	5 pm	14.38	0.37	5.320
7	7 pm	13.28	0.32	4.249

Table 4: Clean Solar Panels Readings.

Output Difference Between Clean & Dusty Panel:

There are two panels and their observation are taken.

In first panel which are dusty panel, so this panel there are some time which are taken from observation At the time of morning 7am the voltage and current are shown and power also shown.

In this time power not actually getting which required as compared to clean panel. Take another example as the time 3pm from dusty panel energy from sun fall much better as compared to morning, evenly the sun radiation fall better on panel and thus the power not get which required and this thing happens due to dusty panel and life of panel will get reduced.

So, to overcome this problem our project is decided to clean this panel and increase efficiency of this panel. In second observation the cleaned panel shows following readings. Similarly the time takes from clean panel comparatively of dusty panel. The time takes 7am and in this time the power gets more as compared to dusty panel, due to clean mechanism the panel's efficiency will also increases.

Takes another example of time at 11am the power gets increase due to the cleaned panel and also gets increase efficiency.

8. SIGNIFICANCE

Advantages:

- The system is not complex.
- Easy to control and usable.
- Usable for distress area.
- Very low maintenance.
- Easy to operate and user friendly.
- Better efficiency.
- Fast and good performance.

Disadvantages:

- High initial cost.
- Need power source for operation.

9. CONCLUSION AND FUTURE SCOPE

Conclusion:

- The result shows that cleaned panel has about 36% more power than dusty panel. Hence more power
- indicates improved utilization rate of solar panel.
- Therefore, By cleaning mechanism more efficient solar panels are demonstrated. Also, due to the
- automatic system manual work and human accident are avoided

Future Scope:

This project highlights the effect of dust, dirt, pollen, sea salt, and bird droppings on the Photo voltaic systems efficiency. However, the development of the cleaning system can solve above those problems. The automatic cleaning system is an innovative technology used to clean the accumulated dust, dirt, pollen, sea salt and bird dropping on the solar panel. It reduces the human interference and in future it may have scope to detect more obstacles

i.e, oil, snow fog, soil etc.

Future Works:

- We are planning to assemble this project fully automatic, by using a sensor. For example our solar panel is a 325 watt rating and normally its output is 300watt. If a solar panel in a dusty condition and gives as a 150watt output power. We settle a rating for sensors as below 160watts its gate automatic cleaning if a output power of solar panels is going below 160 watts.

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