جامعة الأمير محمد بن فهد
PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Electrical Engineering

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Senior Design Project Report

Project Title: Solar Panels Cleaning System

In partial fulfillment of the requirements for the Degree of Bachelor of Science in Electrical Engineering

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Abstract

The project is about the design and development of a solar panel cleaning system. The main object of this design prototype is to clean the solar panel using an electrical mechanism, such that efficiency or quality of solar panel is not compromised. As a matter of fact, gulf region - especially Saudi Arabia- are facing a lot of dust storms and the solar panels need to be cleaned frequently. If task is performed manually, it will be very costly and time consuming. Water sprinklers and a special wiping material shall be used in the conceived mechanism design to insure quality of cleaning.

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1. Introduction

1.1 Project Definition

There is more than enough solar radiation available around the world to satisfy the demand for solar power systems. The proportion of the sun's rays that reach the earth's surface is enough to provide for global energy consumption 10,000 times over. On average, each square meter of land is exposed to enough sunlight to produce 1,700 kWh of power every year. Solar Panel has a huge effect on our world. It can helps our environment to be better without using other power generation plants that can harm the environment, but solar power plant needs to be cleaned at least every 3 days. It generally depends on the country for example in the Middle East, it needs to be cleaned every day so it will cost so much. There are a lot of techniques for cleaning the solar panels; our idea is to design a smart solar panel that cleans itself automatically and remotely in order to maintain a high level of efficiency of the solar panel.

1.2 Project Objectives

1. Design a solar panel cleaning system which can increase the efficiency of solar panels.
2. Increase the use of solar panels.
3. Make the cleaning of solar panels simple and automated.
4. Minimize human intervention.
5. A cleaning system that does not affect the quality of the original solar panel.
6. An environmentally friendly cleaning system.

1.3 Project Specifications

1. The solar panel cleaning system operates automatically and remotely.
2. Increase the efficiency at least by 10%.
3. Recycle the cleaning water.
4. An autonomous mechanism brush to clean the 100 W solar panel.

1.4 Product Architecture and Components

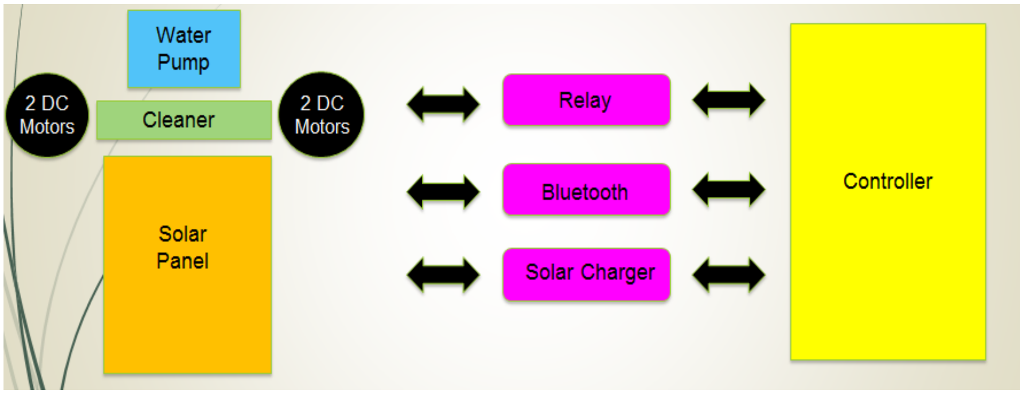


Figure 1

Figure 1 shows the subsystems that we are going to implement in our project. We have two main subsystems which are Mechanical subsystem that is in the left of the block diagram, and the Control subsystem that is shown in the middle and the right of the block diagram. The Mechanical subsystem contains the cleaner along with the DC motors and the stand that holds the solar panel along with the rechargeable battery and the water pump. The Control subsystem contains the relay, solar charger, Bluetooth module and the microcontroller.

1.5 Applications

- In Solar Power Plants.
- In residential houses that use solar power.

2. Literature Review

2.1 Project background

One of the major issues that people face with the installation and the use of solar panels is the cost that is involved in it. But the cost can be drastically reduced by increasing the efficiency of each solar panel and hence reducing the number of solar panels that needs to be installed. Using less number of solar panels in order to get the required electricity will not only be cost efficient but will also help in having a positive impact on the environment. In order to improve the efficiency of the solar panels, there are two main aspects that need to be considered; the first aspect is the amount of light that falls directly on the solar, and the second aspect is how much of this light energy is capable of using effectively in order to generate power. The issue that is faced with the use of solar panels is the dust that forms over it. Dust on the cells of the solar panels reduces the efficiency of the solar panels to a large extent especially in Saudi Arabia where dust and sand storms are very common. Hence there will be an automated system that will periodically clean the solar panels in order to make sure that they perform at peak performance level. The use of right fabrication and controllers will help in making this project possible.

2.2 Previous Work

- Previous Projects 1:

The electrical energy produced by photovoltaic cells depends upon solar irradiance falling on the top of the panel. To maximize the exposure of photovoltaic cells to solar irradiance, solar voltaic cells are installed outdoor. In outdoor environment, dust starts to accumulate on the surface of photovoltaic panels and as a result reduces the effective solar irradiance falling on the surface of photovoltaic panels. Similarly, other bird droppings, ice, and salt layer on photovoltaic panels also obstruct solar irradiances falling on solar panel. To tackle these issues, cleaning systems for photovoltaic cells are used. Surajit et al. (2018) have discussed in detail different types of cleaning systems that used for cleaning solar system. Among different types of technologies used to clean solar panels, autonomous cleaning robots have emerged as a leading technology. Autonomous cleaning robots slide on the surface of the solar panel and clean the solar panel using soft brushes which don't scratch the surface of the panels. The head is attached to motorized trolleys which move it horizontally. The vertical motion of the head is usually controlled by the belt-driven system. Grando et al. (2017) have also surveyed different types of solar cleaning projects and technologies. In their analysis, they have discussed the working of solar brush UAV robot, Ecoppia E4, wash panels, and Nomad cleaning systems. Solar brush robot is a drone that flies very close to the surface of solar panel and cleans the panel through air pressure and by gently rubbing its tail on the surface of the panel. The main advantage of using this type of robot is that very little area of the robot is in direct contact with the panel. This significantly reduces the chances of damage to the panel. The solar brush UAV robot is shown in Figure 2.

Figure 2: Solar Brush UAV Panel.

- Previous Projects 2:

Ecopia solar cleaning robot uses a slightly different technique to clean the solar panel. In this system, a guiding railing is attached over the solar panels as shown in Figure 3. The guiding railing frame work can move horizontally over the surface of the array of panel. For top to down movement, the robot moves on the railing frame work. By sweeping its microfiber brushes connected to the head, Ecopia solar panel cleaning project cleans the surface of the solar array. The system has its own battery which is charged through its own solar cell. This energy storage features allows the system to clean the panels in the night. Furthermore, the system can also be controlled through internet.

Figure 3: Ecopia Solar Cleaning System.

- Previous Projects 3:

Washpanel solar cleaning systems use water and horizontal brush to clean the solar panel. As shown in Figure 4, a horizontal brush is attached to the moveable assembly of the system. This brush remains in contact with the panel. When the assembly of the system moves, water sprinkles through water on panels and brush rub the surface of the panel by removing any mud on the surface of the panel. Nomad cleaning system is very similar to Ecopia system. The primary difference is between the types of brush that revolves on the surface of the panel. In Ecopia system, a small vehicle containing brushes moves on the array. Several pulleys and motors control the movement of solar cleaning robot. Unlike Ecopia system, nomad system doesn't contain many motors, belts, and pulleys. It contains only two motors which are used to move the brush horizontally. The railing on which the brush rolls usually lies behind the solar panels as show in Figure 4. When the assembly moves horizontally, the brush revolves around its axis in a circular motion. By moving in circular motion, the brush sweeps across the surface of the panels, removing any dust and other blockings. The system is fully automated and intelligence system that can be controlled remotely and configured for a variety of cleaning schedules.

Figure 4: Nomad Solar Cleaning System.

- Previous Projects 4:

Sweezey et al. (2009) has produced another kind of robotic solar panel cleaning system which utilizes a support vehicle in addition to the cleaning head and moving trolleys, as shown in Figure 5. Similar to NOMAD and Ecopia systems, cleaning head sweeps the brushes on the surface of the panel. To move the drive system, DC motors of 12 volts are used. The upper and lower trolleys are capable to move in different positions and direction. This feature allows the system to clean the panels in square wave pattern.

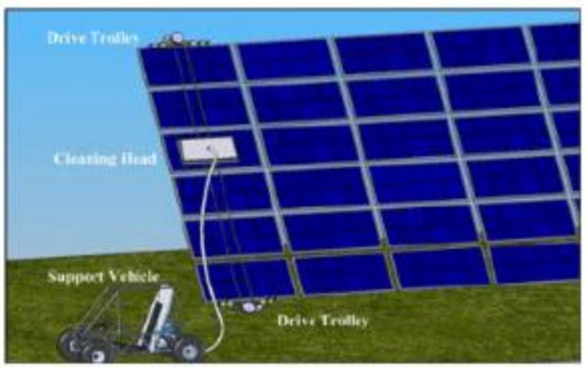


Figure 5: Support Vehicle Based Solar Panel Cleaning System.

2.3 Comparative Study

Looking at the three previous projects, a comparative study was made to determine and quantify the similarities and the differences with our project by observing communication, attached water system and water recycling. As it can be seen in Table 1, our project differs from the three previous projects by using Bluetooth as a communication protocol instead of Wi-Fi. Furthermore, our project has an attached water system in which both the 2nd and the 3rd previous projects have. In fact, the only previous project that uses water recycling system similar to ours is the 2nd previous project. However, our project is distinguished with having all of the three categories.

Table 1: Comparasion Between Three Previous Projects and our Solar Panel Cleaning System.

Projects	1	2	3	Our Project
Collecting Output Power Data				√
Communication			WiFi	Bluetooth
Attached water system		√	√	√
Water Recycling		√		√

3. System Design

3.1 Design Constraints

Design constraints are conditions that need to happen for a project to be successful. In this project, we tried to relate our project to the Engineering Standards as much as we could; and that was through reading and searching about previous research papers that were conducted by expert people, and they have the same idea of our project in general. If we start with the body structure of the system, we can see the materials that we used are suitable for each part. We designed the cleaner with a body that is made from stainless tail to avoid the iron corrosion reactions because the corrosion will affect the cleaning process and the movement of the cleaner itself. Also, we used stainless tail for the water pan for the same reason. We used the aluminum as a stand of the solar panel and at the same time as a rail of the cleaner to keep the wheels running smoothly. The second important constraint is the environmental constraint. The water recollecting process was added in the design for environmental purposes, to save and not waste the water, to reuse the water in the cleaning process or other such as plant irrigations. The water recollecting depends on the engineering design like the angle of the panel and the slope of the water. Based on that, we designed the water pan. In order to increase the reliability of our design, we had to think about something that makes our system more practical. When we brought the idea of the trolley, the trolley is carrying the whole system and it has four wheels with its stoppers just to make sure that it will not move by any condition. We designed the trolley to organize the structure, especially the circuits' wirings and the other mechanical parts in the system.

3.2 Design Methodology

In order to meet all the requirements of the project, it is divided into several stages and phases. The overall aim of the project is to design a smart solar panel that cleans itself automatically and remotely.

Phase 1 (Term 1, Design M.):

- The first stage of the project was to do a primary research in order to check if the project is possible to be made technically.
- The second step that we took is to look into the various sensors, controllers and motors.
- In the next step, we divided the project into categories based on its function. It can be seen that there are two main subsystems on the project and along with this; the project requires some amount of manufacturing and design of mechanical parts to hold the solar panel and the cleaner of the solar panel.
- We started by an AutoCAD sketch of our mechanical structure, so we can build it easily in real life as shown in Figure 6.

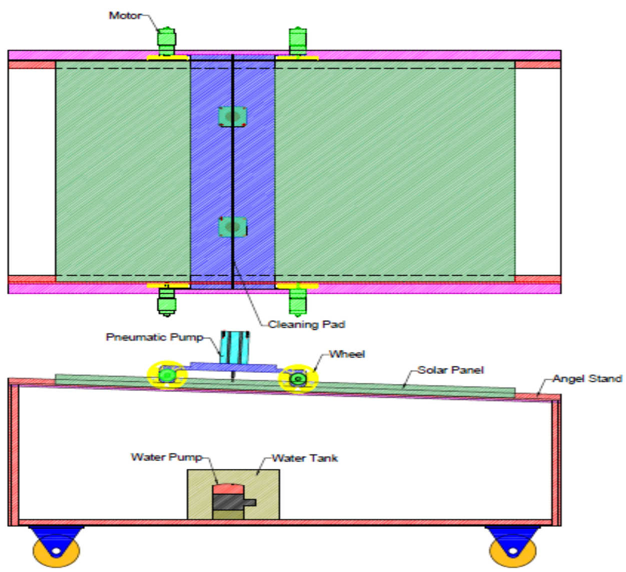


Figure 6: AutoCAD Sketch.

Phase 2 (Term 2, ASSE III):

- We calculated the needed power for our automation system to determine the size of the needed battery for our off-grid system, as shown in Table 2 below:

Table 2: The Daily Energy Usage Calculations of the System.

APPILANCE	DC Motor	Water Pump	Raspberry Pi	Charge Controller	
QUANTITY	4	1	1	1	**Total Watt Hours per Day**
OPERATION (Hours/Day)	0.017	0.017	24	24	
VOTAGE (V)	12	12	5	12	
CURRENT (A)	0.5	1.6	1.8	0.02	
Watts (V*A)	24	19.2	9	0.24	
Watt-Hrs (V*A*Hours/Day)	0.4	0.32	216	5.76	222.48

After calculating the wattage hours per day for the system, we found that it consumes 222.5 W-Hrs per day. Thus, its wattage consumption equals to 9.27 W as shown in Equation 1.

54.48 W-Hrs / 24 Hrs = 9.27 W Equation 1

However, according to the performance characteristics shown in Figure 7, the battery (Solar Gel Acid Battery 12 V 65 AH / 10 HR, 1.8 V / Cell) supplies 10.8 V. So, as it can be seen in Equation 2, the automation system consumes 0.86 A. Therefore, the battery will supply the system with maximum daily consumption for 75.73 Hrs long as shown in Equation 3.

9.27 W / 10.8 V = 0.86 A Equation 2

65 AH / 0.86 A = 75.73 Hrs Equation 3

So, as it can be noticed in Equation 4, the total power consumed by the automation system of the total battery capacity per day equals to 48%.

[(24+24+0.017+0.017) Hrs / 75.73 Hrs] ∗ 100 = 48% Equation 4

Performance Characteristics

Nominal Voltage	12V
Number of cell	6
Design Life	5 years
Nominal Capacity 77ºF(25ºC)	
20 hour rate (3.4A, 10.8V)	68Ah
10 hour rate (6.5A, 10.8V)	65Ah
5 hour rate (11A, 10.5V)	55Ah
1 hour rate (45.1A, 9.6V)	45.1Ah

Figure 7: The Performance Characteristics of the Solar Gel Acid Battery.

- The control system for our project was divided into three subsystems: DC motors control, water pump control and charge tracker control in which each subsystem will be controlled and interfere with each other by Raspberry Pi.
- To control the speed and the direction of the +12V DC motors, Raspberry Pi 3 B+ was coded and then connected to a motor driver. However, we found that the required speed and direction control could be achieved by replacing the motor driver with two relays and connecting the motors in parallel. In fact, this replacement helped us to reduce our project's cost.
- The water pump control was designed by using only one relay. However, the amount of water needed to clean the panel was reached by trial-and-error method. In our control code, we have tried different times until we found that 5 seconds is applicable.
- We have designed a control circuit for both the DC motor and the Water pump by using SRD-05VDC-SL-C 4-channel relay. As shown in Figure 8, two relays were controlled for the four DC motors (forward and backward) and one for the water pump (on or off).

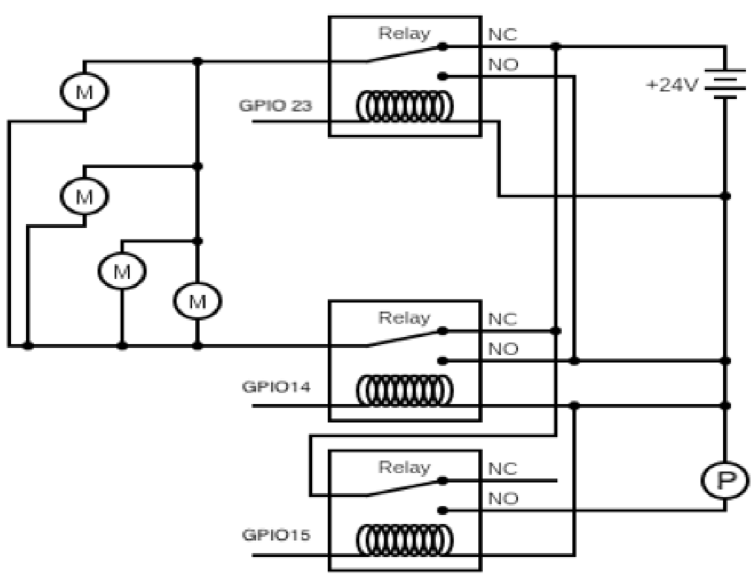


Figure 8: Schematic Diagram of the Dc Motors and Water Pump Control.

- We chose Victron MPPT charge controller for making the cleaning decisions. By mining wattage data from the charge controller to the Raspberry Pi, we will write a python code that will detect the dirt on the panel based on three factors: the determined efficient wattage, time and weather as shown in the following algorithm diagram in Figure 9.

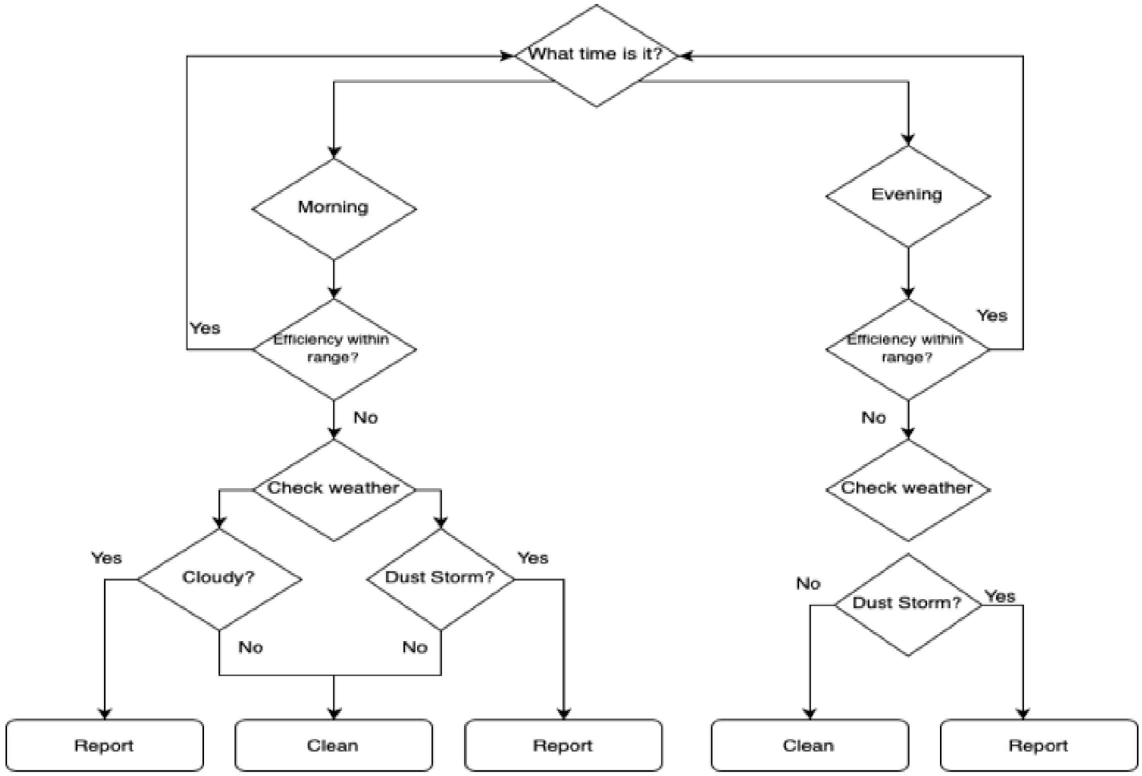


Figure 9: The Cleaning System Algorithm Diagram.

The efficient wattage was founded by calculating an approximate loss then comparing it to our solar specifications. Therefore, for an off-grid solar system, there is 25% loss caused by global incident below threshold, irradiance loss, IAM factor on global, soiling loss factor, temperature, quality and mismatch loss, and ohmic wiring. Thus, by knowing that our solar panel provides 100 W peak power, a clean solar panel will grant 75 W during the useful hours.

- The charge tracker will be connected and tested.
- All the system will be integrated and tested if they function well.
- Add data acquisition system to take measurements.
- Check the system efficiency.
- The final report will be written.

3.3 Product Subsystems and Components

3.3.1 Communication Subsystem: Bluetooth and WIFI to initiate the cleaner manually.

We have chosen Bluetooth over the WIFI to initiate the cleaner manually. Thus, for the connection between the charge controller and the raspberry pi, Bluetooth analog will be used so data can be read from the MPPT controller.

3.3.2 Automatic Control Subsystem: LDR, Dust Sensor and data analysis, to initiate the cleaner automatically.

We chose to use data analysis of the efficiency reading. We will use the raspberry pi to collect the data from the charge controller then make the cleaning decision.

3.3.3 Power Subsystem: 100 W Solar Panel.

The 100W solar panel embedded with the Solar Gel Acid Battery (12V 65AH/10HR, 1.8V/Cell) is sufficient for our project. In fact, the automation system will consume approximately %50 of the battery if continually operated.

3.4 Implementation

We have implemented the AutoCAD sketch that was shown in Figure 6. So at the end of the first semester, we could say that we have finished the Mechanical structure, and we have fitted the Panel on it and we have tested the initial mechanism of the cleaner as shown in Figures 10-12.

Figure 10: Installing the Cleaner that has Four DC Motors and Four Wheels on the Structure.

Figure 11: Fitting the Solar Panel on Board.

Figure 12: Final Sketch.

At the beginning of the second semester, the solar panel position was adjusted on the frame structure to avoid any sunlight blocking that was faced in the initial fabrications. Also, a steel gear track was added for the DC motors to smoothen the dynamics of the wheels as shown in Figures 13 and 14.

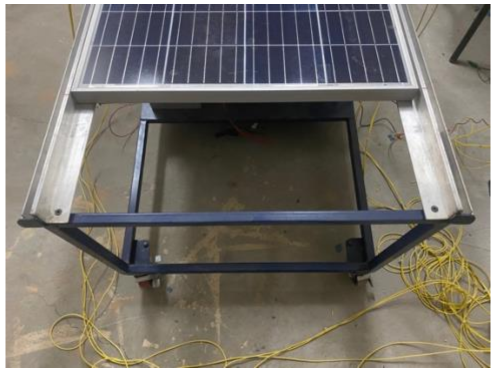


Figure 13: Adjusted Frame.

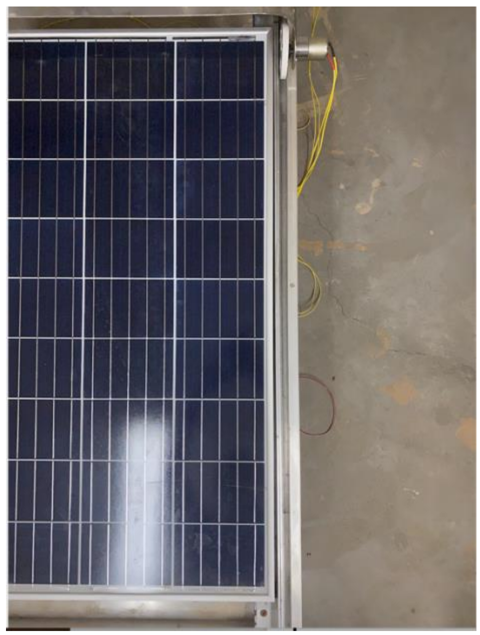


Figure 14: Motor Steel Track.

As it can be seen below in Figure 15, we implemented the control circuit we have designed for the motors and the pump. Figure 16 shows the Raspberry Pi wiring connection of our system.

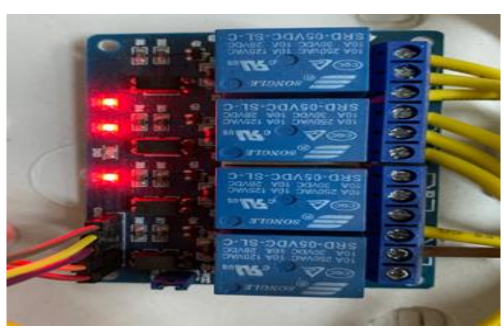


Figure 15: 4-Channel Relay Wiring Termination.

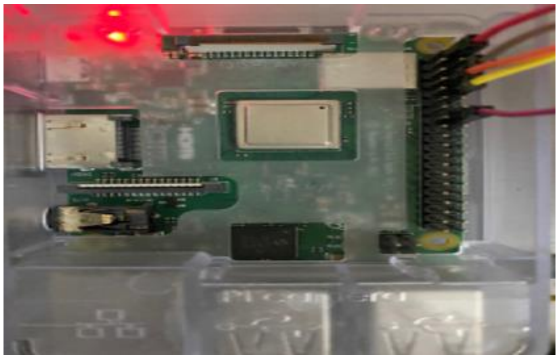


Figure 16: Raspberry Pi Wiring Connection.

Finally, after completing the hardware connections, we wrote the control code in Python by the Raspberry Pi. In fact, the general-purpose input/output (GPIO) number 15 was set up to control the water pump where GPIO 23 and GPIO 14 were chosen for the DC motors. However, we tested that adding 5 Python sleeping time is appropriate for the water pump. Furthermore, 1 Python sleeping time for the motors to move forward and 1.4 to move backward. Thus, the following script was implemented:

```
Import RPi.GPIO as GPIO
Import time

Out1 = 15
Out2 = 23
Out3 = 14

GPIO.setmode(GPIO.BCM)
GPIO.setup(out1,GPIO.OUT)
GPIO.setup(out2,GPIO.OUT)
GPIO.setup(out3,GPIO.OUT)
GPIO.output(out3,GPIO.HIGH)
time.sleep(5)
GPIO.output(out3,GPIO.LOW)
GPIO.output(out1,GPIO.LOW)
GPIO.output(out2,GPIO.HIGH)
time.sleep(1)
GPIO.output(out1,GPIO.HIGH)
GPIO.output(out2,GPIO.LOW)
time.sleep(1.4)
GPIO.output(out1,GPIO.LOW)
GPIO.output(out2,GPIO.LOW)
```

4. System Testing and Analysis

4.1 Subsystem 1: Mechanical Subsystem

The mechanical system was tested and we found that it's applicable to our project and strong enough to hold the solar panel along with the battery and the water pump. Also, the structure is equipped with wheels, and that gives it more flexibility since anyone can move it from one place to another.

4.2 Subsystem 2: DC Motors Control

The DC motors control system was tested and verified, this subsystem is very important since the cleaner will be driven by the motors along the solar panel to clean it. Along with the testings, we found that the four DC motors are enough to drive the cleaner forward to the bottom end of the solar panel then backwards to the top end of the solar panel.

4.3 Subsystem 3: Water Pump Control

The water pump control system was accomplished and verified. The water pump can pump the water on the solar panel through some holes installed in the cleaner, and it can deliver a perfect amount of water to the panel in such a short time. Also, after the cleaning process, the water that we used to clean the panel will fall into a path that was adjusted on the structure to collect the water. From there, recycling techniques will take a place.

5. Future Work and Expected Final Prototype

Our Future work for this project will have three progress stages to reach the final prototype:

1. DC motors speed control
2. Victron Solar Charge Controller complete termination and setup
3. Raspberry Pi complete interference and data mining

5.1 DC Motors' Speed Control

To control the motors speed, we will use Adafruit DC & stepper Motor HAT as shown in Figure 17.

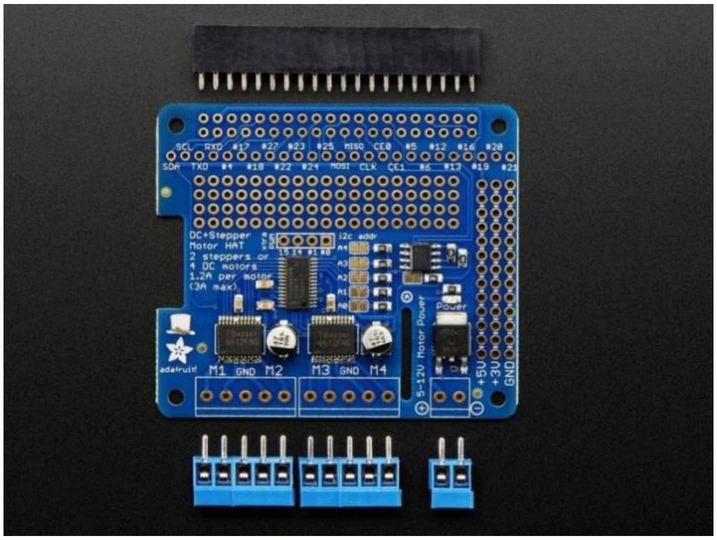


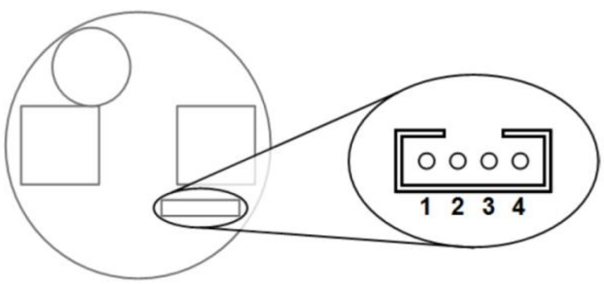
Figure 17: Adafruit DC Motor Driver/HAT.

The Adafruit HAT can drive up to 4 DC or 2 stepper motors with full PWM speed control. The motors are controlled by 4 H-Bridges TB6612 MOSFET drivers with 1.2 A per channel and 3 A peak current capability with thermal shutdown protection, internal kickback protection diodes. The driver can run motors on 4.5 VDC to 13.5 VDC Up to 4 bi-directional DC motors with individual 8-bit speed selection (so, about 0.5% resolution). Therefore, after connecting the 4 DC motors to this driver, a code was written to control the speed and the direction. The code controls the motors. We were able to test it and prove it, by changing duty cycle of the enables to have three different speeds and two directions as will be shown in appendix C.

5.2 Victron Solar Charge Controller

Figure 18: Victron Solar Charge Controller.

The Victron Solar Charge Controller will be used to control the solar panel and the battery while being the source of the data. It features highlights flexible charge algorithm Over-temperature protection and power de-rating when temperature is high. It provides the user with the voltage and the efficiency of the solar panel in the time domain.



Pin	Producer	Consumer
1	GND	GND
2	VE.Direct-RX	VE.Direct-TX
3	VE.Direct-TX	VE.Direct-RX
4	Power +	Power +

Figure 19: Victron Solar Charge Controller Physical Interference.

Also, by adding VE.Direct Bluetooth Dongle, the user can display programming, real-time data and history on phone or tablet. However, these data will be monitored and extracted by the Raspberry Pi.

5.3 Raspberry Pi Complete Interference and Data Mining

To read the data from the charger intro the raspberry, first we need to plug the VE.Direct Bluetooth Dongle. In fact, the data produced by the MPPT controller is Transistor Transistor Logic (TTL) communication that is provided and explained by the manufacturer. Therefore, the future work for this project is to completes this interference between the MPPT controller and the raspberry pi to make the cleaning decision. Finally, to implement the weather factor as was explained in our algorithm earlier, open weather map API has to be used. It is a service that provides weather data, including current weather data, forecasts, and historical data to the developers of web services and mobile applications. It provides an API with JSON, XML and HTML endpoints and a limited free usage tier. Users can request current weather information, extended forecasts and graphical maps (showing cloud cover, wind speed, pressure and precipitation). However, the cleaning decision will be made on the efficiency readings. The following losses percentages were takin from STC and ARAMCO and some other references for the off grid solar system:

Global incident below threshold	-0.04%
Near Shadings: irradiance loss	-0.94%
IAM Factor on global	-1.85%
Soiling loss factor	-11.55%
PV loss due to irradiance level	-0.87%
PV loss due to temperature	-7.97%
Module quality loss	+0.35%
Module mismatch loss	-1.10%
Ohmic wiring loss	-1.03%
Total off-grid system loss	**-25.0%**

However, to calculate the annual solar energy output (E), Equation 5 will be used where A is the surface area of the panel, r is the solar panel efficiency, H is the annual average solar radiation on tilted panel (shading not included) and PR is the performance ratio/coefficient for losses in the off-grid system.

$$E = A*r*H*PR \qquad \text{Equation 5}$$

Our solar panel has a length of 100 cm and a width of 67 cm. Thus, the surface area of the solar panel (A) equals 0.67 meter squared as shown in Equation 6.

$$67 \text{ cm} \times 100 \text{ cm} = 6700 \text{ cm2} = 0.67 \text{ m2} \qquad \text{Equation 6}$$

Then, it is provided by the manufacturer that the solar panel efficiency (r) equals %14.63. Also, it can be noticed from above that the performance ratio/coefficient for losses (PR) is %100 mines the total off-grid system losses in which it equals 0.75. Finally, the annual average solar radiation (H) in AL Khobar city equals approximately 1826 kW/m2 as seen in Figure 20.

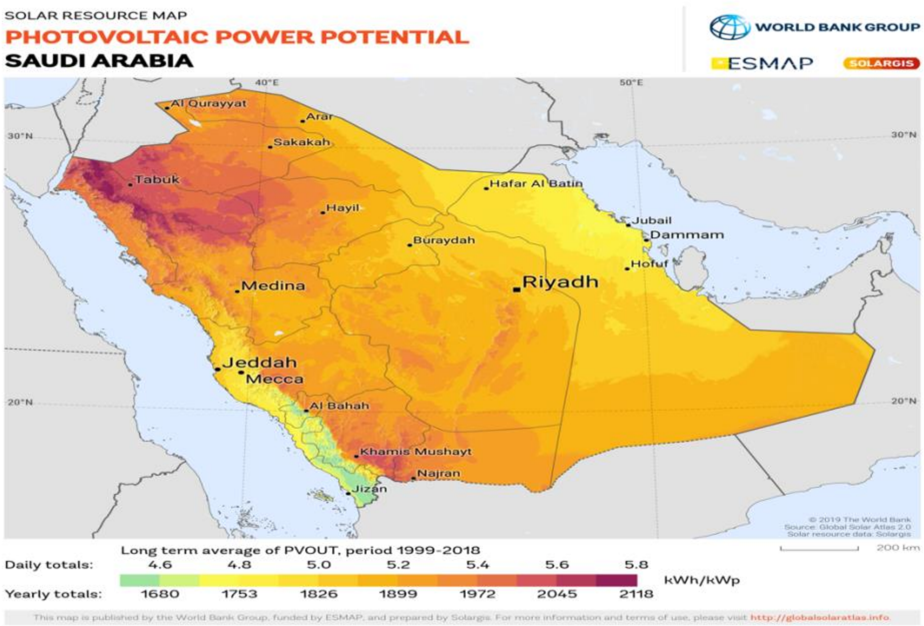


Figure 20: The photovoltaic electricity potential in Saudi Arabia.

So, by substituting Equation 6 and the reached values in Equation 5, the annual solar energy output (E) will equal as shown in Equation 7.

$$E = (0.67\ m2)*(14.63/100)*(1826\ kW/m2)*(0.75) = 134.24\ kW \qquad \text{Equation 5}$$

However, by applying our cleaning system, the soiling loss (11.55%) will not be a factor. Thus, the total off-grid system losses will equal %13.45. Therefore, the performance ratio/coefficient for losses (PR) will increase as well as the annual solar energy output (E) as shown in Equation 6 and 7.

$$PR = 1 - (0.25-0.1155) = 0.87 \qquad \text{Equation 6}$$

$$E = (0.67\ m2)*(14.63/100)*(1826\ kW/m2)*(0.87) = 155.72\ kW \qquad \text{Equation 7}$$

So, our cleaning system can increase the annual solar energy output with 21.48 kW

6. Limitations and Challenges

We faced many challenges in accomplishing our project. The first challenge was the machinery fabrication since we all are electrical engineering students. We faced challenges such as using mechanical software and fabricate the parts then assembly them. Second, to get use to the Raspberry Pi and learn how to write a code in Python language. It is different than Arduino but we were able to do it. However, during this period of time, we faced limitation that kept us from completing our prototype; in which mainly were caused by the COVID-19 pandemic. COVID-19 prevented us to merge the subsystems that were divided by our group members. In fact, it did not allow us to meet as a group and prevented some members from completing their tasks as planned.

7. Conclusion

The Solar Panel Cleaning System project aimed to bring a better solution for maintaining solar efficiency. The main scope was to develop a machine that can clean a solar panel by a proper control system. This project is a developed prototype to expand on a new and increasing market. The project team hit many obstacles along the way.

Designing the control system required learning Raspberry Pi configurations, python coding and its interference with the electrical components. Using soldering boards to implement the designed circuit, hardware wiring, relays and machinery were new experiences. This being said, the project fulfilled the desired design with the planned control and mechanism. The DC motors were controlled by both relays and drivers to accomplish speed and directions control. Also, control code for the DC motors and the water pump were written then implemented in the system. Finally, the MPPT charge controller was connected to the off grid system. However, the prototype was not completed because of the challenges and the limitations that were mentioned earlier.

8. References

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Appendix A:

- **First Progress Report:**

SOLAR PANELS CLEANING SYSTEM

Learning Outcome Asse. III EE | Spring 2020

Project PLAN (1)

Abdulaziz Alshalan (AS) 201400658
Abdulrehman Alghamdi (AR) 201400797
Abdullah Alghamdi (AL) 201401461
Saad Binsalamah (SB) 201403906

Instructor: Dr. Sadiq Alhuwaidi

Project Advisor: Dr.Samir El-Nakla

Period Highlight 1 | Plan | Actual | tual (beyond pla | Complete (beyond pl

Periods (Weeks 1-15): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

ACTIVITY	PLAN START	PLAN DURATION	Assigned To	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Mechanism	1	2	ALL	1	1	100%
Validate mechanism by defining faults and improvements	1	1	AL,AR	1	1	100%
Acquire materials	1	1	AL,AR	1	1	100%
Implementation and testing	1	2	AL,AR	1	1	100%
Search and acquire components (Procurements)	1	5	ALL	1		50%
Subsystem 1 Procurements	1	1	SB,AR	1	1	75%
Subsystem 2 Procurements	1	1	AS,AL	1	1	100%
Subsystem 3 Procurements	1	3	AS,AR			75%
Subsystem 4 Procurements	1	1	AS,SB	1	1	100&
Design subsystem 1: DC Motors Control	4	1	ALL			50%
Learning about basic Raspberry PI programming	1	5	ALL			45%
Learning about DC motors Drivers	1	4	SB,AL			65%
Writing code to implement and test GPIO (General-Purpos Input/Output)	4	1	AR,AS			0%
Implementation, and testing of DC motors Driver Control by Raspberry PI	5	1	ALL			0%
Verifying Complet control of DC motors	5	1	ALL			0%
Design subsystem 2: Water Pump Control	4	1	ALL			0%
Implementation, and testing of water pump by Raspberry PI	5	1	AS,SB			0%
Verefying Complete control of water pump	5	1	AL,AR			0%
Design subsystem 3: Solar Power Regulator	5	3	ALL			0%
Learning about and verefying charge controller specefications	5	1	AR,SB			0%
Implementation, and testing of the solar power regulator	6	2	ALL			0%
Hardware Demo 1	7	1	ALL			0%
Pairing with Raspberry PI and data mining	6	2	AL,AS			0%
Verifying Complete control	8	1	ALL			0%
Prepare midterm Presentation and Report	5	1	ALL			0%
Design subsystem 4: Power System Design (PSD)	9	3	ALL			0%
Defining all electrical equipments and loads calculations	9	1	SB,AR			0%
Implementing power distribution system	10	1	AR,AS			0%
Hardware Demo 2	11	1	ALL			0%
Connecting and testing Solar Power Cleaning system	12	1	AL,SB			0%
Hardware Demo 3	13	1	ALL			0%
Prepare final report	13	2	ALL			0%
Prepare final presentation	13	2	ALL			0%

Progress Details:

The solar panel position was adjusted on the frame structure to avoid any sun light blocking.
Steel gear track was added for the DC motors.
CK20DU solar regulator was subtitude with MPPT75/15 for easier data mining with the raspberry PI.

Issues (delay ...):

We have received a differnet motor driver than the one that we ordered.
e made another request to get the Adafruit motor h that we need along with the MPPT75/15.
so, that may cost us some time

Figure 20: First Progress Report for Assessment III.

- **Last Progress Report:**

SOLAR PANELS CLEANING SYSTEM

Learning Outcome Asse. III EE | Spring 2020

Project PLAN (5)

Instructor: Dr. Sadiq Alhuwaidi

Abdulaziz Alshalian (AS) 201400658
Abdulrahman Alghamdi (AR) 201400797
Abdullah Alghamdi (AL) 201401461
Saad Binsalamah (SB) 201403906

Project Advisor: Dr.Samir El-Nakla

Period Highlight 1 | Plan | Actual | tual (beyond pla | Complete (beyond pl

Periods (Weeks 1-15): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

ACTIVITY	PLAN START	PLAN DURATION	Assigned To	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Design Subsystem 1: Mechanism	1	2	ALL	1	1	100%
Validate mechanism by defining faults and improvements	1	1	AL,AR	1	1	100%
Acquire materials	1	1	AS,SB	1	1	100%
Implementation and testing	1	2	AL,AR	1	1	100%
Search and acquire components (Procurements)	1	5	ALL	1		100%
Design Subsystem 2: DC Motors Control	4	1	ALL			100%
Learning about basic Raspberry PI programming	1	5	ALL			100%
Learning about DC motors Drivers	1	4	SB,AL			100%
Writing code to implement and test GPIO (General-Purpose Input/Output)	4	4	AR,AS			100%
Implementation, and testing of DC motors Driver Control by Raspberry PI	5	4	ALL			100%
Verifying Complete control of DC motors	5	4	ALL			100%
Design Subsystem 3: Water Pump Control	4	1	ALL	5	1	100%
Implementation, and testing of water pump by Raspberry PI	5	1	AS,SB	5	1	100%
Verifying Complete control of water pump	5	1	AL,AR	5	1	100%
Design Subsystem 4: Solar Power Regulator	5	3	ALL			30%
Learning about charge controller specifications	5	1	AR,SB			100%
Implementation, and testing of the solar power regulator	6	2	AS			0%
Pairing with Raspberry PI	6	2	ALL			0%
Prepare midterm Presentation and Report	5	1	ALL			100%
Design Subsystem 5: Power System Design	9	3	ALL			50%
Defining all electrical equipments and loads calculations	9	1	AS,AL			100%
Implementing power distribution system	10	1	SB,AR			0%
Prepare final report	13	2	ALL			50%

Progress Details:

As we are reacheng the end of the semester, we are working on the final report. We are going to finalize what we have done as a progress to update the final report accordingly. Also, we are going to add the two sections that was assigned to us by the instructor of the course; and they are as follows: 1) Future work and expected final prototype. 2) Limitation and challenges.

Figure 21: Last Progress Report for Assessment III.

Appendix B:

- **Bill of Materials:**

Table 3: Budget Estimation of the Project.

Item	Quantity	Unit Cost (SR)	Subtotal (SR)
Microcontroller	1	150	150
Solar Panel	1	220	220
DC Motors	4	150	600
Bluetooth Module	1	100	100
Cleaner and Fabrication	-	2000	2000
Solar Charger	1	250	250
Rechargeable Battery	1	300	300
Water Pump	1	150	150
TOTAL			3770

Appendix C:

- **Control System Code:**

```
Import RPi.GPIO as GPIO
Import time

Out1 = 15
Out2 = 23
Out3 = 14

GPIO.setmode(GPIO.BCM)
GPIO.setup(out1,GPIO.OUT)
GPIO.setup(out2,GPIO.OUT)
GPIO.setup(out3,GPIO.OUT)
GPIO.output(out3,GPIO.HIGH)
time.sleep(5)
GPIO.output(out3,GPIO.LOW)
GPIO.output(out1,GPIO.LOW)
GPIO.output(out2,GPIO.HIGH)
time.sleep(1)
GPIO.output(out1,GPIO.HIGH)
GPIO.output(out2,GPIO.LOW)
time.sleep(1.4)
GPIO.output(out1,GPIO.LOW)
GPIO.output(out2,GPIO.LOW)
```

- **DC Motors Speed Control:**

```
import RPi.GPIO as GPIO
from time import sleep
in1 = 27
in2 = 17
in3 = 24
in4 = 23
en1 = 25
en2 = 22
temp1=1
GPIO.setmode(GPIO.BCM)
GPIO.setup(in1,GPIO.OUT)
```

```
GPIO.setup(in2,GPIO.OUT)
GPIO.setup(in3,GPIO.OUT)
GPIO.setup(in4,GPIO.OUT)
GPIO.setup(en1,GPIO.OUT)
GPIO.setup(en2,GPIO.OUT)
GPIO.output(in1,GPIO.LOW)
GPIO.output(in2,GPIO.LOW)
GPIO.output(in3,GPIO.LOW)
GPIO.output(in4,GPIO.LOW)
p1=GPIO.PWM(en1,100)
p2=GPIO.PWM(en2,100)
p1.start(25)
p2.start(25)
print("\n")
print("The default speed & direction of motor is LOW & Forward.....")
print("r-run s-stop f-forward b-backward l-low m-medium h-high e-exit")
print("\n")
while(1):
    x=input()
    if x=='r':
        print("run")
        if(temp1==1):
         GPIO.output(in1,GPIO.HIGH)
         GPIO.output(in2,GPIO.LOW)
         GPIO.output(in3,GPIO.LOW)
         GPIO.output(in4,GPIO.HIGH)
    elif x=='s':
        print("stop")
        GPIO.output(in1,GPIO.LOW)
        GPIO.output(in2,GPIO.LOW)
        GPIO.output(in3,GPIO.LOW)
        GPIO.output(in4,GPIO.LOW)
        x='z'
    elif x=='f':
        print("forward")
        GPIO.output(in1,GPIO.HIGH)
        GPIO.output(in2,GPIO.LOW)
        GPIO.output(in3,GPIO.LOW)
        GPIO.output(in4,GPIO.HIGH)
        temp1=1
```

```
    x='z'
elif x=='b':
    print("backward")
    GPIO.output(in1,GPIO.LOW)
    GPIO.output(in2,GPIO.HIGH)
    GPIO.output(in3,GPIO.HIGH)
    GPIO.output(in4,GPIO.LOW)
    temp1=0
    x='z'
elif x=='l':
    print("low")
    p1.ChangeDutyCycle(40)
    p2.ChangeDutyCycle(40)
    x='z'
elif x=='m':
    print("medium")
    p1.ChangeDutyCycle(50)
    p2.ChangeDutyCycle(50)
    x='z'
elif x=='h':
    print("high")
    p1.ChangeDutyCycle(75)
    p2.ChangeDutyCycle(75)
    x='z'
elif x=='e':
    GPIO.cleanup()
    print("GPIO Clean up")
    break
else:
    print("<<<  wrong data  >>>")
    print("please enter the defined data to continue.....")      print("forward")
     x='z'
    else:
     GPIO.output(in1,GPIO.LOW)
     GPIO.output(in2,GPIO.HIGH)
     GPIO.output(in3,GPIO.HIGH)
     GPIO.output(in4,GPIO.LOW)
     print("backward")
     x='z'
```

```
elif x=='s':
    print("stop")
    GPIO.output(in1,GPIO.LOW)
    GPIO.output(in2,GPIO.LOW)
    GPIO.output(in3,GPIO.LOW)
    GPIO.output(in4,GPIO.LOW)
    x='z'
elif x=='f':
    print("forward")
    GPIO.output(in1,GPIO.HIGH)
    GPIO.output(in2,GPIO.LOW)
    GPIO.output(in3,GPIO.LOW)
    GPIO.output(in4,GPIO.HIGH)
    temp1=1
    x='z'
elif x=='b':
    print("backward")
    GPIO.output(in1,GPIO.LOW)
    GPIO.output(in2,GPIO.HIGH)
    GPIO.output(in3,GPIO.HIGH)
    GPIO.output(in4,GPIO.LOW)
    temp1=0
    x='z'
elif x=='l':
    print("low")
    p1.ChangeDutyCycle(40)
    p2.ChangeDutyCycle(40)
    x='z'
elif x=='m':
    print("medium")
    p1.ChangeDutyCycle(50)
    p2.ChangeDutyCycle(50)
    x='z'
elif x=='h':
    print("high")
    p1.ChangeDutyCycle(75)
    p2.ChangeDutyCycle(75)
    x='z'
elif x=='e':
    GPIO.cleanup()
```

```
        print("GPIO Clean up")
        break
    else:
        print("<<<  wrong data  >>>")
        print("please enter the defined data to continue.....")
```