Prince Mohammad Bin Fahd University
Department of Engineering
College of Electrical Engineering
Assessment III
Instructor: Dr. Sadiq Alhuwaidi

Solar Panels Cleaning System

Abdulrahman Alghamdi	201400797
Abdulaziz Alshalian	201400658
Abdullah Alghamdi	201401461
Saad Binsalamah	201403906

Advisor: Dr. Samir El-Nakla

Outline

- Project definition
- Project Objectives
- Project Specifications
- Project Architecture
- Background
- Previous Projects
- Summary & Comparison
- Purchased Components
- Design Subsystems
- Budget Estimate
- Project Pan
- References

Project Definition

Design a smart solar panel that cleans itself automatically and remotely in order to maintain a high level of efficiency of the solar panel.

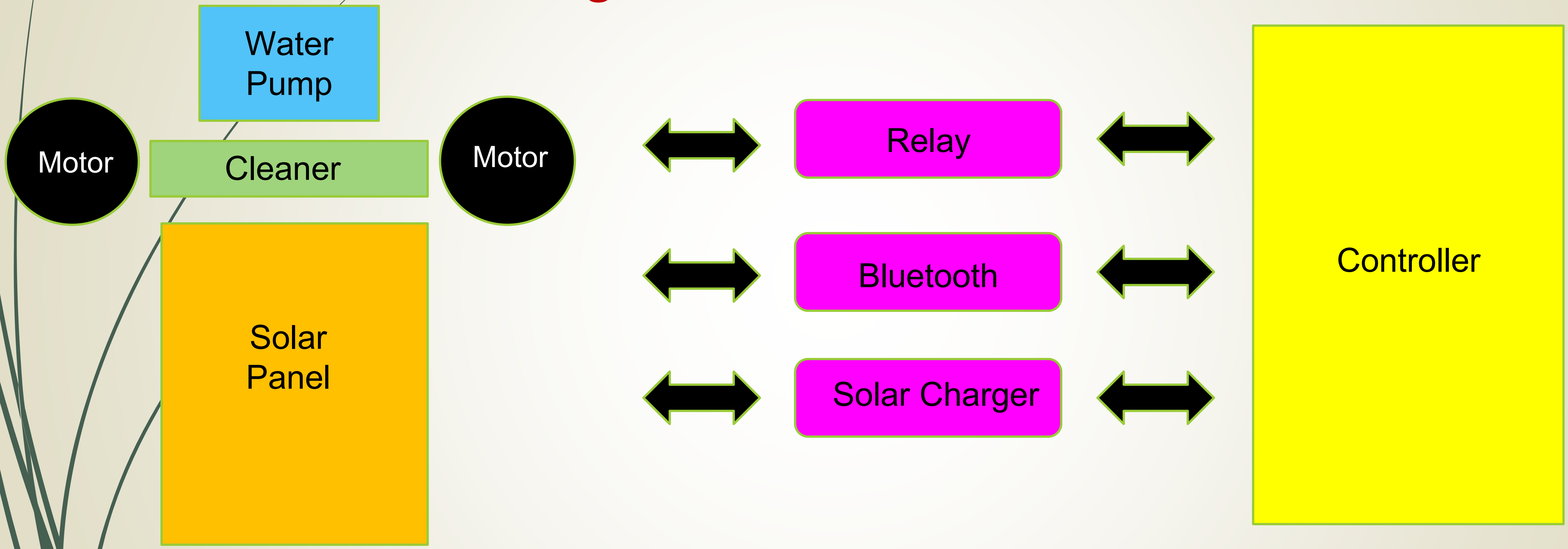
Project Objectives

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.

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.

Project Architecture

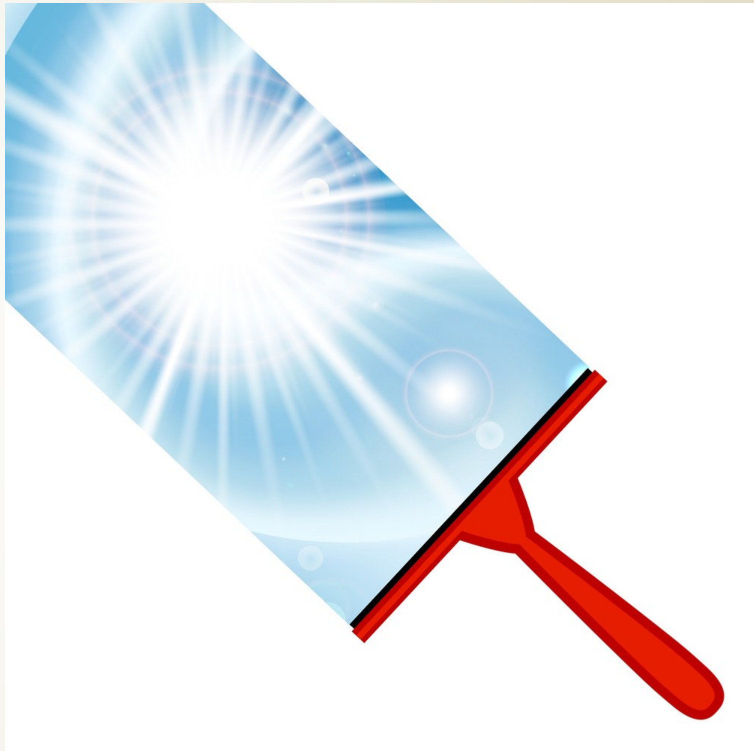


Background: Problem

- The dust and dirt that builds up on solar panels decreases the efficiency of it to a large extent.
- It is not always easy to clean solar panels as they installed high.

Background: Solutions

- Having an automated cleaning system that cleans the solar panel periodically will help in ensuring that solar panel performances well by giving a high output.
- The self cleaning system will also make the process of cleaning the solar panels easy as the cleaner is installed on it, while can also be operated manually.



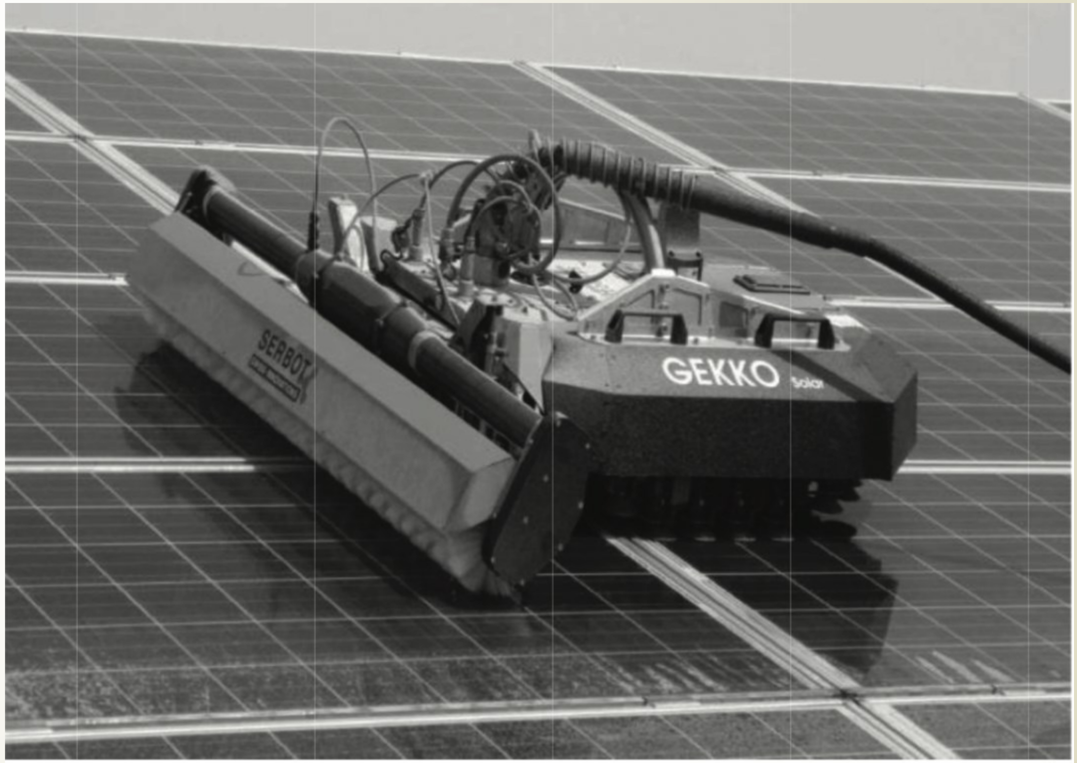
Background: Solutions

- In order to conserve water, that water that is used for cleaning the solar panel will be saved and reused by using recycling techniques.

Previous Projects (1)

An overview of cleaning and prevention processes for enhancing efficiency of solar photovoltaic panels, *CURRENT SCIENCE, VOL. 115, 2018*

- **Electrostatic biasing**: Uses electrical current to clear the panels in a non contact manner.
- **Autonomous Cleaning Techniques:** cleaning robot and Gekko cleaner.
- **Other Autonomous techniques:** WashPanel, HECTOR Robot, solar brush cleaner and Greenbotics Cleaner.



Previous Projects (2)

Solar Panel Automated Cleaning (SPAC) System, *IEEE, 2018*

- **Autonomous** cleaner with squeegee to remove water.
- Has an inbuilt system to recycle the water that is used.
- Manual cleaning of panel is not safe for the cleaners.

Previous Projects (3)

Robots for Cleaning Photovoltaic Panels: State of the Art and Future Prospects, 2017

- Various solutions available in the market were studied in this research.
- Some are attached to the panel as seen in the picture.
- Some are detached like drone and solar brushes.

Previous Projects Summary

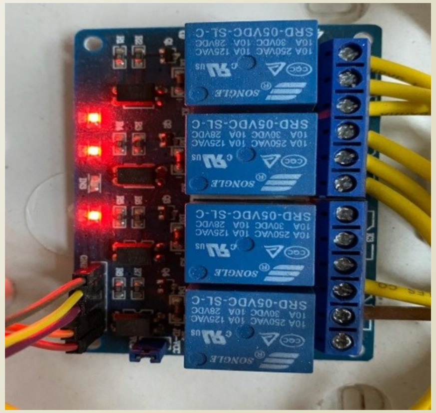
Projects	1	2	3	Our Project
Collecting Efficiency Data				√
Communication			WiFi	Bluetooth
Attached water system		√	√	√
Water Recycling		√		√

Purchased Components

- 100 W Solar Panel.
- Four 12 V DC Motors.
- 65 A Rechargeable Battery.
- Water Pump.
- Solar Charger Controller.
- 5 V Relay.



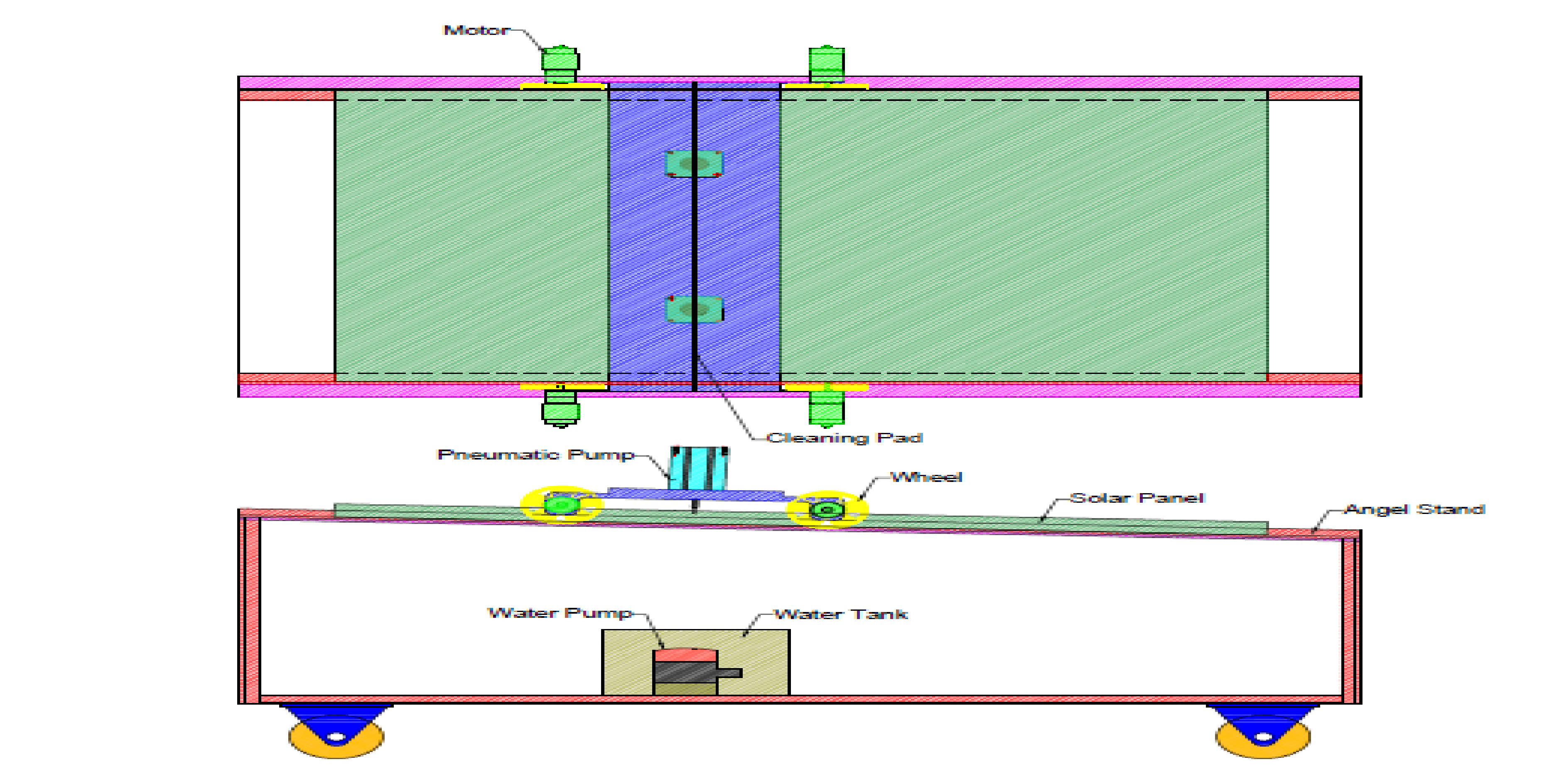




Design Subsystems

1. Mechanical Subsystem.
2. DC Motor Control.
3. Water Pump Control.
4. Solar Power Charger.
5. Power System Design.

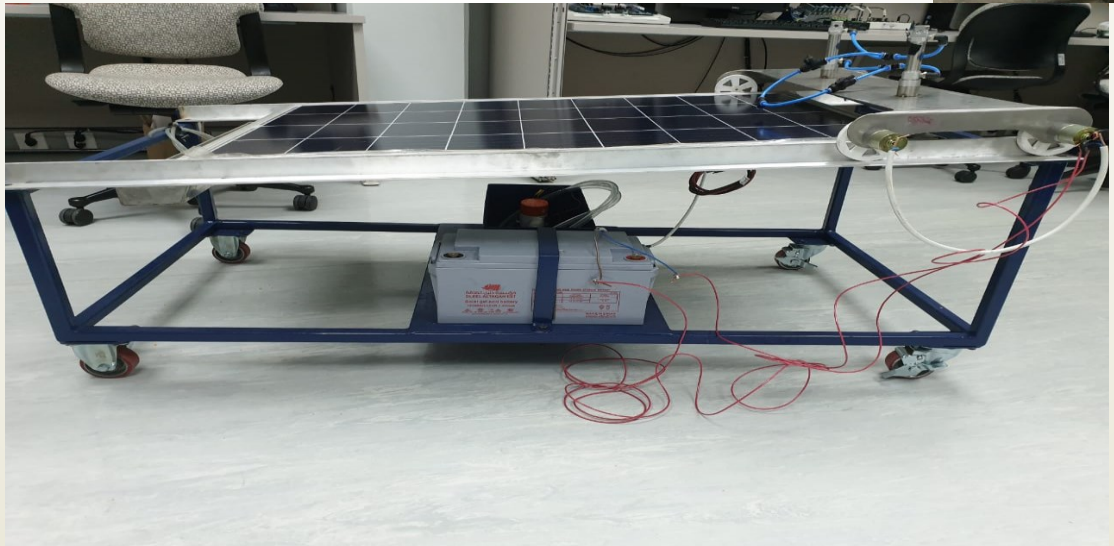
Subsystem 1



AutoCAD Sketch

Subsystem 1

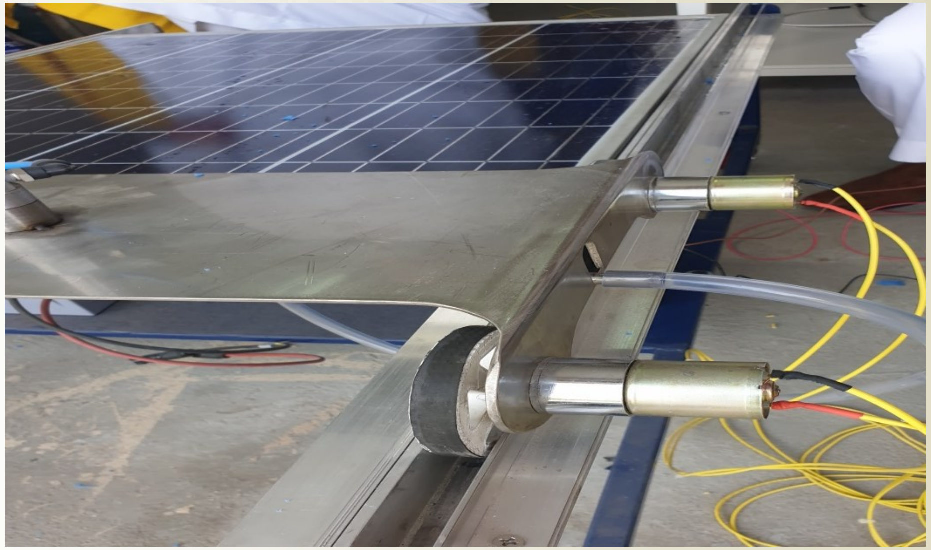


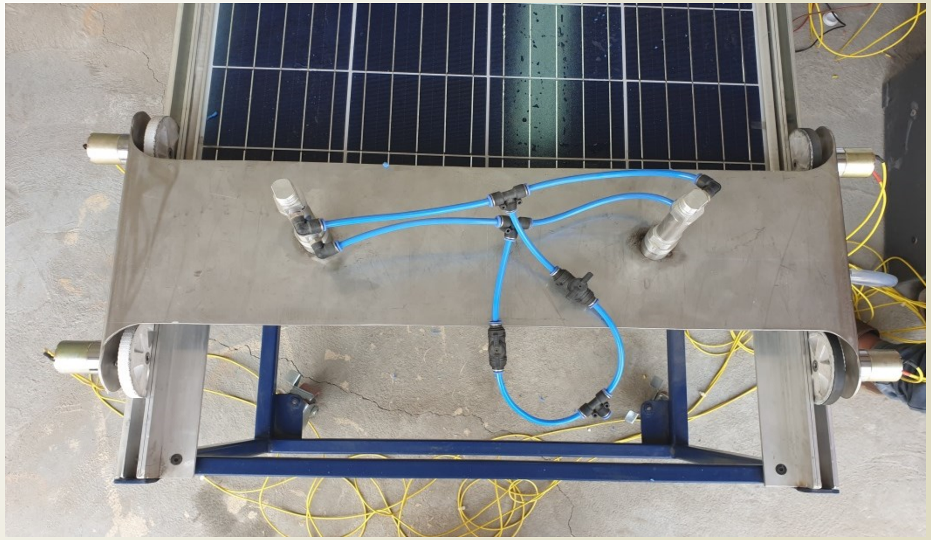



Subsystem 2

DC Motors Control:

1. Direction and Movement.
2. Speed.





Subsystem 3

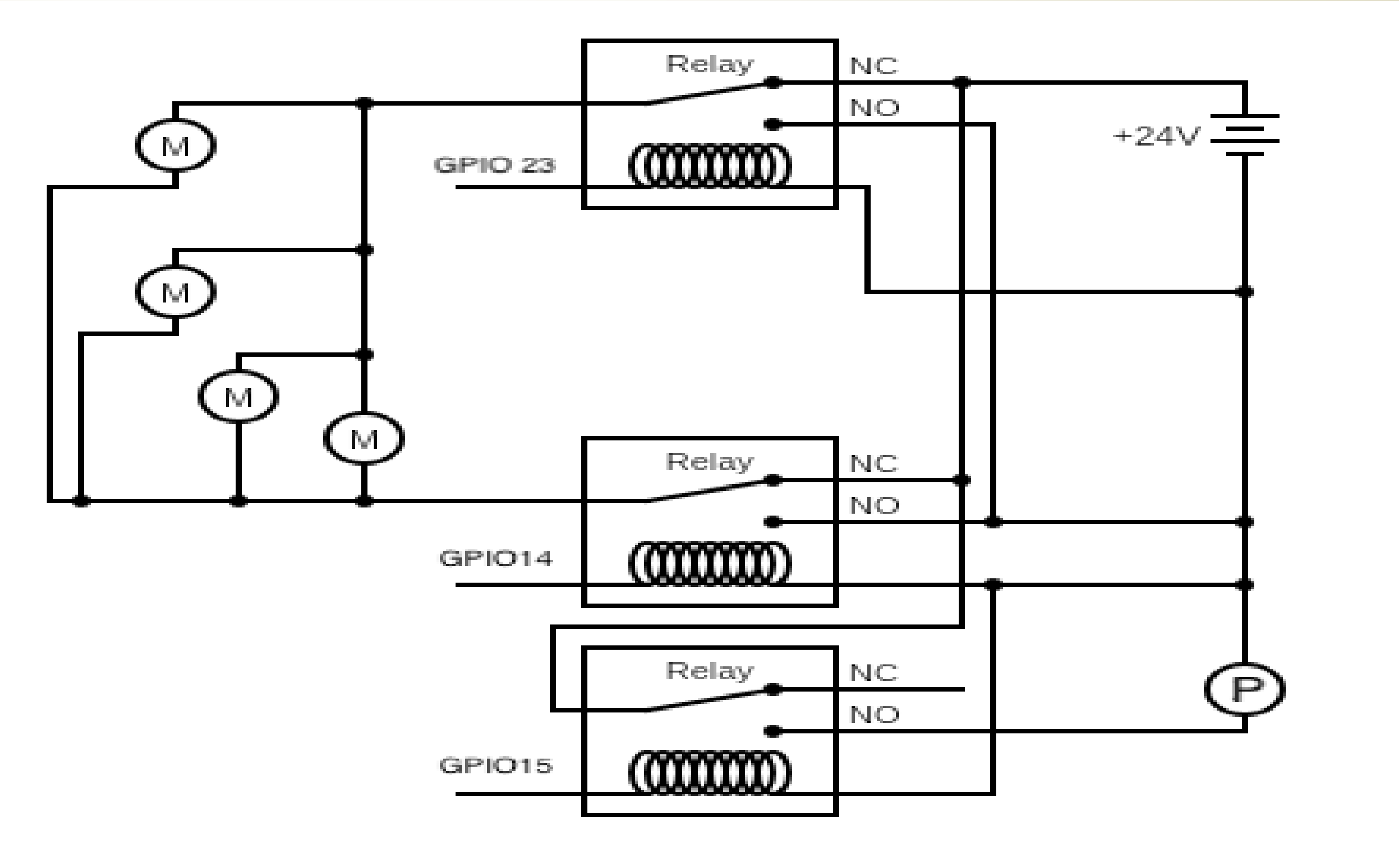
- Water Pump Control accomplished 100%.
- Water Recycling was tested and verified.

DC Motors and Water Pump Control Circuit

```
import RPi.GPIO as GPIO
import time

out1 = 15
out2 = 23
out3 = 14

GPIO.setmode(GPIO.BCM)
GPIO.setup(out3,GPIO.OUT)
GPIO.setup(out1,GPIO.OUT)
GPIO.setup(out2,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)
```



Subsystem 4

- The Charger Controller will charge the battery.
- We can get the efficiency data from the BlueSolar Charge Controller.

Subsystem 5

Calculating Energy Usage:

APPLIANCE	DC Motor	Water Pump	Controller	Solar Charger	
QUANTITY	4	1	1	1	Total Watt Hour per Day
OPERATION (Hours/Day)	0.02	0.02	24	24	
VOLTAGE (V)	12	12	5	12	
CURRENT (A)	0.5	1.6	0.4	0.02	
Power (W)	24	19.2	2	0.24	
Watt-Hours	0.48	0.32	48	5.76	54.56

Subsystem 5

- The automation system consumes 54.56 Watt-Hour per day.
- 54.56 Watt-Hour/24Hour = 2.27 W.
- The battery supplies 10.8 V.
- The automation system consumes 2.27 W/10.8 V = 0.21 A.

Subsystem 5

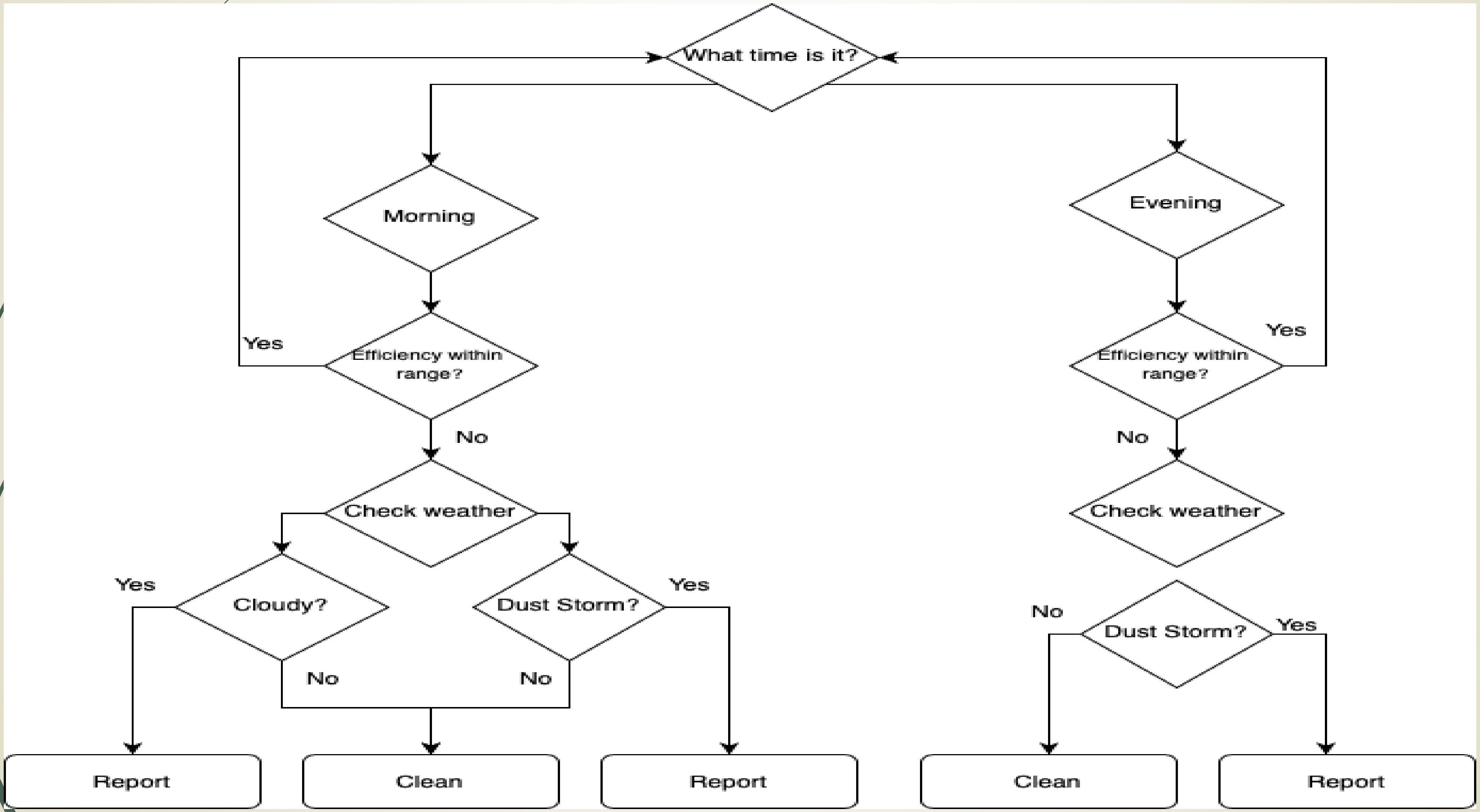
- **Off-Grid System Loss:**

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%**

- Solar Peak power = 100 W
- Instantaneous/granted power =

  100 - (100*25%) W = 75 W

Automation Block Diagram



Project Plan

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

Project Advisor: Dr.Samir El-Nakla

Learning Outcome Asse. III EE | Spring 2020

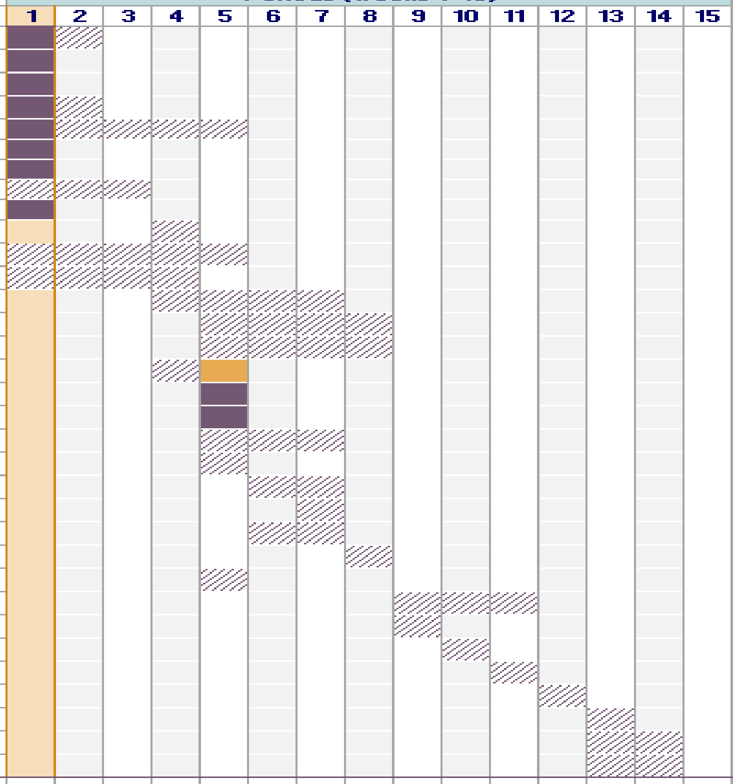
Project PLAN

Instructor: Dr. Sadiq Alhuwaidi

Period Highlight: 1 | Plan | Actual | Actual (beyond plan | % Complete (beyond plan

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		65%
Subsystem 1 Procurements	1	1	AS,AR	1	1	50%
Subsystem 2 Procurements	1	1	SB,AL	1	1	100%
Subsystem 3 Procurements	1	3	SB,AR			50%
Subsystem 4 Procurements	1	1	AS,AL	1	1	75%
Design Subsystem 2: DC Motors Control	4	1	ALL			50%
Learning about basic Raspberry PI programming	1	5	ALL			70%
Learning about DC motors Drivers	1	4	SB,AL			65%
Writing code to implement and test GPIO (General-Purpose In	4	4	AR,AS			0%
Implementation, and testing of DC motors Driver Control by Ra	5	4	ALL			0%
Verifying Complete control of DC motors	5	4	ALL			0%
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			0%
Learning about and verifying charge controller specifications	5	1	AR,SB			0%
Implementation, and testing of the solar power regulator	6	2	AL,AS			0%
Hardware Demo 1	7	1	ALL			0%
Pairing with Raspberry PI and data mining	6	2	ALL			0%
Verifying Complete control	8	1	ALL			0%
Prepare midterm Presentation and Report	5	1	ALL			35%
Design Subsystem 5: Power System Design	9	3	ALL			35%
Defining all electrical equipments and loads calculations	9	1	AS,AL			50%
Implementing power distribution system	10	1	SB,AR			0%
Hardware Demo 2	11	1	ALL			0%
Connecting and testing Solar Power Cleaning system	12	1	ALL			0%
Hardware Demo 3	13	1	ALL			0%
Prepare final report	13	2	ALL			0%
Prepare final presentation	13	2	ALL			0%

Periods (Weeks 1-15)



Progress Details:

Water Pump automation was accomplished. However, water leakage issue was faced then solved by silicon sealant. Design Subsystem 2&3 wasn't started because the motor driver and CK20DU solar charger was not delivered yet. Therefore, subsystem4 (Defining all electrical equipments and loads calculations) was started.

Budget Estimate

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

References

Adinoyi, M. J., & Said, S. A. (2013). Effect of dust accumulation on the power outputs of solar photovoltaic modules. *Renewable energy*, *60*, 633-636.

Shajan K. Thomas, Shelvin Joseph, Sarrop T S, and Sahad Bin Haris, "Solar Panel Automated Cleaning (SPAC) System," in 2018 International Conference on Emerging Trends and Innovations In Engineering And Technological Research (ICETIETR), 2018.

Surajit Mondal, Amit Kumar Mondal, Abhishek Sharma, and Vindhya Devalla, "An overview of cleaning and prevention processes for enhancing efficiency of solar photovoltaic panels," Current Science, vol. 115, no. 6, pp. 1065-1077, September 2018.

Marcel Grando, Elias Renã Maletz, Daniel Martins, and Henrique Simas, "Robots for Celaning Photo Voltaic Panels: State of the Art and Future Prospects," in IX JORNADAS ARGENTINAS DE ROBÓTICA, Cordoba, Argentina, 2017, pp. 29-34.

Andrew Sweezey, Mark Anderson, Ashton Grandy, and Jeremy Hastie, "Robotic Device for Cleaning Photovoltaic Arrays," in International Conference on Climbing and Walking Robots , 2009.

https://www.researchgate.net/publication/275723229_Effect_of_dust_accumulation_on_the_power_outputs_of_solar_photovoltaic_modules