College of Engineering

Department of Mechanical Engineering

Spring 2018-2019

Senior Design Project Report

Design of a Solar Panel Cleaner Mechanism Team 4

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

Team Members

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Project Advisor:

Advisor Name: Dr. Mohammed Asad

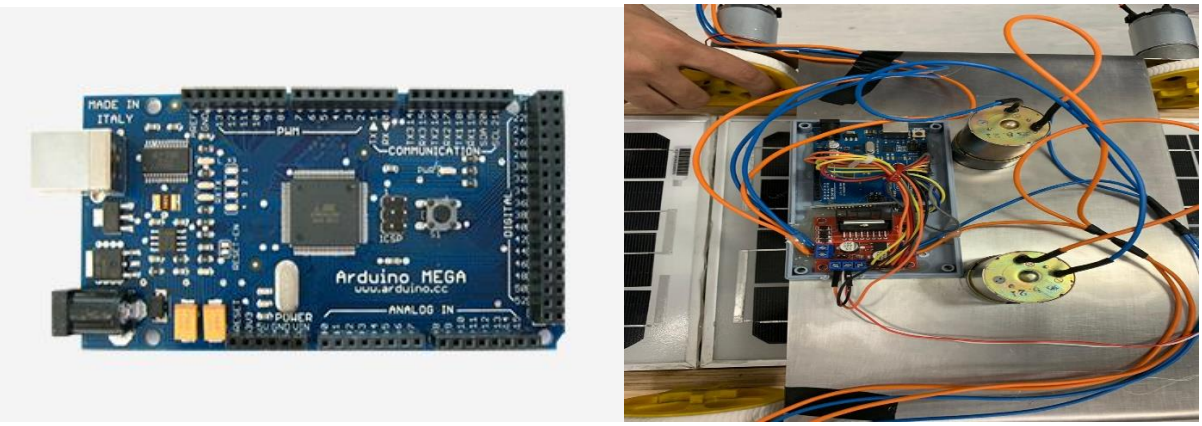
Chapter 4: System Testing and Analysis

4.1 Experimental Setup, Sensors and data acquisition system

4.1.1: Arduino Mega Hardware

What we are using to run our automatic cleaning mechanism is Arduino hard ware, this hardware can keep us away from purchasing a lot of electronics devices. Arduino mega can be simply program it and using it simple we did the programing and also we put a Bluetooth device so we can use the automatic cleaning mechanism from a far distance.

Figure 4.1: Arduino Hardware



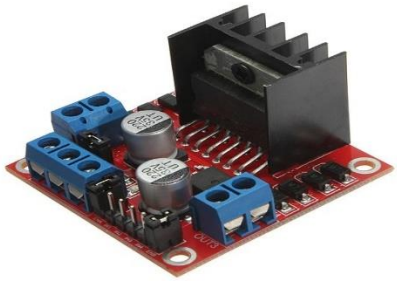
Specifications:

- 12 Volts
- Bluetooth
- AA Battery

4.1.2: H-Bridge

The main objective of the H-bridge that switches the polarity of a voltage applied to a load. It's mainly used in robotics so it can allow the dc motor to move forward and backward.

Figure4.1.2: H-Bridge



4.1.3: Electric Gear Motor

We chose this specific gear motor for a reason the main reason is that it can handle up to 9 kg we did the calculations based on how much is the speed, torque, and power to figure how much it can handle up to. This gear motor has an advantage and disadvantage, the advantage is there are so much torque and power in it but the disadvantage and the problem we faced is that it takes a lot of voltage from the battery so it needs a bigger battery. We put 4 5 rpm electric gear motor in each tire to make sure that it can run the mechanism because it is too heavy also we used 2 300 rpm to rotate the cleaning pads.

- Shaft Size: 14 x 6mm/0.6" x 0.24" (L*D)
- Motor Body Length: 64mm/2.6"
- Motor Body Diameter: 37mm/1.46"
- Torque: 10 Kg.cm
- Rpm: 5
- Voltage: 12v
- Power: 3.67 N-m

Figure 4.1.3: Dc Gear Motor

4.1.4: Voltmeter

The main thing about our mechanism is the power of the electric gear motor we want to calculate the power so that we can get the torque and to see how much each gear motor can handle up to, we found that we can get the voltage and current from the gear motor with the help of the voltmeter so when we get these two main things we finally found the power of the gear motor.

Figure 4.1.4: Voltmeter

Table 4.1: The testing parameters

Testing Parameters	Objective
Arduino Hardware	To program the mechanism
H-Bridge	Is used to control the direction of the motor and to also provide enough current for the motor to run
5 Rpm Gear Motor	To run the mechanism
300 Rpm Gear Motor	To rotate the cleaning pads
Voltmeter	For Calculating the volt and current

4.2 Results, Analysis, and Discussion

In the results we got an important thing which is time we need the time to see the mechanism how much it can go from point a to point b, since we the rpm we can get the omega, so from the omega we got the velocity by the equations down below, and since we have the velocity and the solar panels distance we got the time.

Table 4.2: Data and Results

Symbols	Equations	Results
Omega (ω)	**ω = 2 π 5 / 60 s**	**0.523 rad/sec**
Velocity (V)	**V = R x ω, radius = 0.04 m**	**0.0209 m/s**
Time (t)	**V = d/t, distance = 1.05 m**	**50 s**
Torque (T)	**P = T x ω**	**3.67 N-m**
Force (F)	**T = F x R**	**91 N**
Power (P)_	**P = V x I, V= 12v, I= 0.16 Amps**	**1.92 Watt**

Chapter 5: Project Management

5.1 project Plane

In order to design a specific project, we should plan that project in a proper manner that meets the requirements estimated by the Design Engineers, in other words; we should develop a schedule that is divided into different steps from the start till the end. The other concept is how we control that schedule by explaining the tasks to the group and how we maintain each task and finish them within the estimated time. See table 5.1.1 for tasks & durations and table 5.1.2 for the assigned members.

#	Task		Start	End	Duration
1	Chapter 1: Introduction		04/02/2019	06/02/2019	2
2	Chapter 2: Literature Review	Project Background	08/02/2019	17/02/2019	9
		Previous work			
		Comparative study			
3	Chapter 3: System Design	Design constraint and Design Methodology	18/02/2019	16/03/2019	28
		Engineering Design standards			
		Theory and Theoretical Calculation			
		Product Subsystems and selection of component			

		Manufacturing and assembly			
4	Chapter 4: system Testing & Analysis	Prototype Testing Results, Analysis and Discussion	19/03/2019	24/03/2019	5
5	Chapter 5: Project Management	Project Plan Contribution of Team members Project Execution Monitoring Challenges & Decision Making Project Bill of Material & Budget	24/03/2019	30/03/2019	6
6	Chapter 6: Project Analysis	Life Long Learning Impact of Engineering Solution Contemporary Issues Addressed	30/03/2019	5/04/2019	5
7	Chapter 7: Conclusion & Recommendation	Conclusion Future Recommendation	5/04/2019	9/04/2019	4
8	Design of Prototype	Mechanism Mechanism assembly SolidWorks Design	9/04/2019	15/04/2019	6
9	Parts Purchase	Wood Table Solar panel Raw material Tiers Dc motor & wires Water bump	15/04/2019	20/04/2019	5

10	Manufacturing	Soldering Iron (DC) Screws Manufactring	15/3/2019	20/3/2019	5
11	Testing	Gear Motor Testing Changing Polishing Material Arduino Hardware Testing	4/4/2019	6/4/2019	2

Table 5.1.1: Tasks and their durations

#	Tasks	Assigned Members
1	Chapter 1: Introduction	Mohammed
2	Chapter 2: Literature Review	Ibrahim & Mshary
3	Chapter 3: System Design	Mohammed
4	Chapter 4: System Testing &Analysis	All
5	Chapter 5: Project Management	All
6	Chapter 6: Project Analysis	All
7	Chapter 7: Conclusion & Recommendation	Mshary &Mohammed
8	Design of Prototype	All
9	Parts Purchase	All
10	Manufacturing	All
11	Testing	All

Table 5.1.2: Tasks and Assigned members

5.2 Contribution of Team Members

To accomplish the tasks in a proper manner and during the estimated time we must distribute each task to the group member in order to fulfill the estimated requirements. Table 5.2.1 shows the tasks divided to the members with the percentages of contributing to each member.

#	Tasks		Assigned	Cont. %
1	Chapter 1: Introduction		All	100%
2	Chapter 2: Literature Review	Project Background	Ibrahim	50%
			Mshary	50%
		Previous Work	Mohammed	40%
			Mshary	60%
		Comparative Study	Mshary	33%
			Ibrahim	33%
			Mohammed	34%
3	Chapter 3: System Design	Design Constraints and Design Methodology	Ibrahim	36%
			Mshary	32%
			Mohammed	32%
		Engineering Design standards	All	100%
		Theory and Theoretical Calculations	Ibrahim	50%
			Mohammed	50%
		Product Subsystems and selection of Components	Mshary	25%
			Mohammed	25%
			Ibrahim	50%
		Manufacturing and assembly	Mohammed	50%
			Ibrahim	50%
4	Chapter 4: System Testing &Analysis	Experimental Setup, Sensors and data	All	100%
		Results, Analysis and Discussion	All	100%
5		Project Plan		

	Chapter 5: Project Management	Contribution of Team members	All	100%
		Project Execution Monitoring		
		Challenges & Decision Making		
		Project Bill of Material & Budget		
6	Chapter 6: Project Analysis	Life Long Learning	All	100%
		Impact of Engineering Solution		
		Contemporary Issues Addressed		
7	Chapter 7: Conclusion & Recommendation	Conclusion	All	100%
		Future Recommendation		
8	Design of Prototype	SolidWorks	All	100%
		Frame Design		
		Material		
9	Parts Purchase	Frame Equipments	All	100%
		Solar Panels		
		Frame		
		Table		
		Tires		
		Battery		
10	Testing	Run the mechanism	All	100%
		Retest	All	15%

Table 5.2.1: Tasks the contribution of the members.

5.3 Project Execution Monitoring

During our project, we had many activities which relate to improving our project.

These activities include important meeting and events that related to our senior project.

Table 5.3.1 shows the list of meeting and other events for our project during fallsemester 2019.

Time/Date	Activity/Event
One time a week	Assessment class
Daily	Meeting with group members
Weekly	Meeting with the advisor
14 Mar 2019	Finishing first prototype
21 Mar 2019	Midterm presentation
26 Mar 2019	First test of the system
1 Apr 2019	Finishing final prototype
4 Apr 2019	Test the system
18 Apr 2019	Final Submission of the report
18 Apr 2019	Final presentation

Table 5.3.1: Dates of the activities and events

5.4 Challenges and Decision Making

5.4.1 Chosen a Wrong Workshop

On the way of searching about a workshop, we faced a hard time finding the most suitable one in order to manufacture our project, especially when it comes to modifying a tool and building up a new design. However, after several explorations and investigations, we found a lathe workshop. They have the required tools and machines needed for such a project throughout lesser welding, bending and the raw material. While moving forward, we met the manager of the company and he welcomed us and gave a brief description of his company. On the other hand, we did explain to him the project, also handing over the CAD files we drew, and the work needed to be done from his side. In addition, he did response saying your project will be completed within one week, however, the seven days seemed to be more than one month. Day after day they create excuses by giving a word that this project will finish tomorrow and so on. As a team, we had a decision regarding this matter which was taking us project and start looking for another new workshop. What we faced working with this workshop a definition of non-professionalism and lack of honesty. So, we research again until we find a workshop which we proceed further from there.

5.5 Project Bill of Materials and Budget

Table 5.5 shows the materials that we purchased and their costs in Saudi Riyals (SR). This table includes also the manufacturing and failed part costs.

Table 5.5: Bill of materials

#	Item	Price (SR)
1	Solar panels x3	180 SR
2	Wood table	150 SR
3	DC motor 5 rpm x4	380 SR
4	DC motor 300 rpm x2	150 SR
5	Water pump	75 SR
6	battery	90 SR
7	H bridge x3	105 SR
8	Arduino	200 SR
9	Water Sprinkles	50 SR
10	Stainless steel frame	1500 SR
11	3D Printer tires x4	300 SR
Total		3130 SR

Chapter 6: Project Analysis

6.1 Life-long Learning

In the life-long learning our group learn and got a lot of experience from the begging of our project we got the knowledge of how to deal and manage the problem we faced, our group contains 3 members only and we managed a lot of things the most important thing is time management we did the Gantt chart and we stick with the timing we suppose to finish. In this section we will introduce you what we learned and the experience from our project.

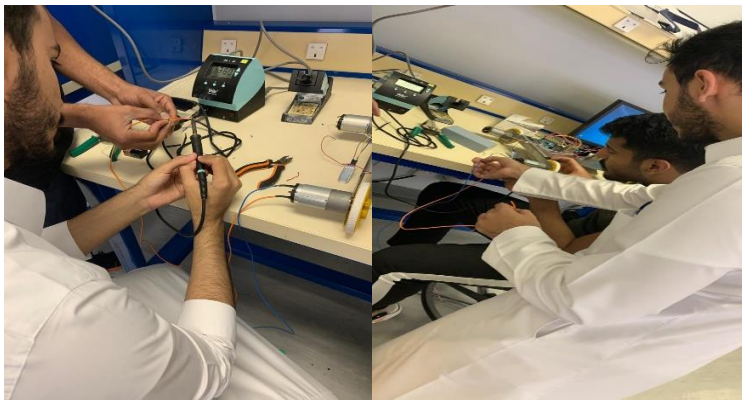
6.1.1: Hardware (Arduino)

In our project Arduino hardware is very important and it needs experts in that field, we got the help from Mr. Antonio from the Electrical Engineering department and he give us a lot of information's about Arduino hardware and what is the steps to connect our mechanism with the Bluetooth. We understand how Arduino hardware can run our mechanism with programing it with the coding, also he gave us some advices about the h-bridge and how to change the polarity of our Dc gear motor to change the direction of the mechanism.

6.1.2: Soldering Iron

While we are connecting the wires from the Dc gear motor to the Arduino hard ware we chose not to knot the wires in the Dc gear motor, so we soldered the wires through the Dc motor polarities so it cannot be removed easily. Soldering iron is a hand tool used in soldering. It supplies heat to melt solder so that it can flow into the joint between two work pieces. A soldering iron is composed of a heated metal tip and an insulated handle to do the soldering the tip needs to be heated up to 380 c.

Figure 6.1.1: Soldering Iron



6.1.3: SolidWorks

As what we learned in the Solidworks in our previous semester we got a lot of knowledge and the perfect skills to design our project in the Solidworks. We managed the problems we faced in our designing part, and also we had a lot of information from the Solidworks which is the engineering standards for the screws we used in our cleaning mechanism also we done some studies on the stainless steel frame that we chose to see the yield strength of the frame.

6.1.4: Time Management Skills

Time management is the most important thing in our project since our group contain three members only, we needed to divide all of the work to us 3 and we worked on it with the help of the gantt chart, by the help of the gannt chart we don't have any late submissions. First we put the important work that needs to be done and after we divided to the three of us.

6.2 Impact of Engineering Solutions

Our project has a huge influent on our society epically in the Middle East, our objective is to do a mechanism can work for small houses and indeed we can maximize our project to be an influent in the industrial environment because of the solar panels that the industries use.

6.2.1: Environment

The functionality of this system has potentially huge implications for environmental preservation efforts. Our system has the potential to boost the production of existing solar panels all around the world. Not only does this improve the current solar energy systems, but it also makes any future investments in solar power a more attractive proposition. This system is a financially viable method of reducing the world's demand for fossil fuels. If fully implemented, this system could prove to be significant in the struggle against climate change.

6.2.2: Economic

The most important part in our project is the economical side, it will the large industrial companies to reduce their labors and more money they will earn from the automatic cleaner. The manufacturing and operational costs of the system cannot exceed the financial savings from the improved solar panel efficiency. If the system cannot save enough money to offset its costs, there is no point to implementing the product in the first place. This system is a significantly larger investment than the use of human laborers for solar panel cleaning. Any cost reductions will improve the chances of this product succeeding financially.

6.2.3: Social

Our project has a huge effect and can be very social, as we see in Saudi Arabia the government start to use solar panels on the lights on the roads and also in traffic signals, so the automatic cleaner mechanism can do a huge effect on the country.

6.3 Contemporary Issues Addressed

In Saudi Arabia epically in the Middle east is that we have a lot of dust storms epically in the summer, and our vision in Saudi Arabia 2030 is to make the majority of the power plants in our country to work by electric power that we get from the sun, so there will be no pollution in our country anymore. So we designed a mechanism that can work automatically and also can maximize the geometrical constraints of our project so it can work in the industrial environments.