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DESIGN AND DEVELOPMENT OF NEW SOLAR TRACKING SYSTEM

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Abstract

In this project photovoltaic conversion panel is expected to be used in an automatic microcontroller based solar tracker system. Our aim is to design a single axis solar tracker as well dual axis solar tracker system. The sun is tracked by the tracker and its position is changed in such a way that it maximises the power output. The solar panel is moved by two geared DC motors so that sun's light is able to remain aligned with the solar panel. The operation of experimental model of the device is based on a DC motor which is intelligently controlled by a dedicated drive until that moves a mini photovoltaic panel, the presence of the two simple but efficient light sensors receive signals by a microcontroller. The performance and characteristics of the solar tracker device are experimentally analysed.

Acknowledgment

First of all, we would mention that we are very thankful to Almighty Allah who has blessed us with wisdom, knowledge and courage to achieve what we had promised and provided us the opportunity to fulfil our ambition.

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Chapter # 1: Introduction

1.1 Project Definition

Sustainable power source gather by solar panel in form of sunlight is converted in to power which would then be able to be utilized to give capacity to electric loads. Several individual solar cells are contained by solar panels which are themselves made out of layers of silicon, phosphorous which gives the negative charge, and boron which gives the positive charge. Solar panels ingest the photons and in doing as such start an electric flow. The subsequent energy produced from photons striking the outside of the solar panel enables electrons to be struck out of their nuclear circles and discharged into the electric field created by solar cells which at that point move these free electrons into a directional flow and this procedure is called Photovoltaic effect.

The aim of this project is to ensure the sunlight rays are falling perpendicularly on the solar panel to give the maximum solar energy. Normally a solar panel converts only 30 to 40 per cent of the incident solar radiation in to electrical energy. An automated system is required to get a constant output, which should be capable to constantly rotate the solar panel. The sun tracking system was made as a prototype to solve the problem. It will be automatic and keeps the panel in forward-facing of sun until that is visible. The unique characteristic of this system is that instead of taking the earth as its reference, it takes the sun as a guiding source. The sunlight is monitored by the active sensors and rotates the panel towards the direction where the intensity of sunlight is maximums.

1.1 Project Objectives

Our project is based on the following objectives:

- Ability to manually rotate the tracker with the usage of a controller alongside the overall ecliptic.
- The solar panel tracks the sun from east to west mechanically for maximum intensity of light.

- To consume maximum solar energy through solar tacking panel.
- Design and improve a solar panel
- High performance and efficiency of Solar panel.

1.2 Project Specifications

Table #1.1: The system dimensions

Item	Size
System Length	1 m
System width	1.3 m
Refrigeration Body	1 * 0.48 m
Solar panel Length	1.480 m
Solar Panel width	0.670 m
Coil Length	23 m

Table # 1.2: The system measurements

Item	Measurements
Battery	1000 Ah
Solar output current	8.75A
Solar output Voltage	18 V
Inverter	1000Ure

1.4 Project Applications

The main applications for this project are;

- It could be fabricated and increased in dimensions to be used during camping for several purposes.

- It can be modified to make a concentrated solar-hybrid form which can save almost all the cost of running it.
- It can be use domestically and on largest scales.
- It gives better efficiency comparing with general systems.
- It can implement on large PV panels.

Chapter # 2: Literature Review

2.1 Project Background

Fossil fuels have been facing reduction with passing time and generation of power is becoming a bigger challenge. Talking about renewable sources, the conversion of solar energy into electrical energy by using photovoltaic panels is prioritized. The watts delivered by the solar panel are directly proportional to the relative angle of the sun in reference to the earth. Thus, the delivery of the watts is reduced when tis relative angle changes. In this regard the efficiency of the PV panel can be increased by using solar tracking system. The pay load is moved towards the sun by solar trackers throughout the day.

This project highlights different forms of tracking system as well as their pros. The main types of tracking systems are either a single axis solar tracker or a dual axis solar tracker. The single axis system depends on a single horizontal or vertical axis. The direction of the axis is based on the location of the system where it is going to be placed. The dual axis is a system that includes both a horizontal and vertical axle. This type of tracking system can track the motion of the sun exactly around the world in any location.

2.2 Previous Work

Haneih (2009) conducted a study in Amman Jordan focusing on the demand of the sun tracking for solar panels. This study basically discussed about increasing efficiency of PV panels in dessert regions. The author explained that by using part of the power output of the solar panel two degrees of freedom orientation can be achieved. If we consider the symmetry of the system, the kinematics of the system can be controlled using astronomic calculation. Solar tracking sensors and feedback control loops can be used to add close loop control to the system. This solves the problem of cloudy days. The author further explained that special consideration should be given to the grid arrangement of panels in the collecting plants.

In another study conducted by Rao et al (2012) a project using ARM7 TDMI processor was explained. The processor did the task of gather input from sensor and giving command to the motor to track the sun. ARM7 TDMI processor was used to design and implement closed loop algorithm which form the bases of monitoring controller. This resulted in maximum current from solar panel to increase the energy production.

A difference between solar tracking device and a stationary collector was noted by Kancevica et al (2012). The author discussed that n a solar tracking device the solar radiation struck flat plate collector perpendicularly as compare to stationary collector of same size. This produced average 1.4 times more heat energy.

Abdallah (2008) introduced a computerized sun tracking device to rotate the solar still with reference to the movement of sun. The researcher demonstrated the comparison between fixed and sun tracked solar stills. The productivity was increased around 22 percent with use of sun tracking because there was 2 percent increase in efficiency. There is an increase in water temperature and decrease in thermal capacity of the water by using the sun tracker. This leads to an increase in evaporation rate as well as in distillation rate.

2.3 Comparative Work

Balabel et al., (2013) used a mathematical analysis to achieve optimal operational efficiency of solar photovoltaic module. He focused on design and testing of control system. The study was based on calculated data of the altitude angle at Taif city, Saudi Arabia. The researcher showed that the sun tracking algorithm can be divided into closed-loop and open-loop systems depending on its controlled.

The literature on tracking process for the dual axis sun tracker by a sliding mode control law was reviewed by Rhif et al (2010). The power production can be increased up to 40 percent by using this autonomic dual axis sun tracker. The result showed the usefulness of the sliding mode control in the tracking process, its strength and the high quality of the sliding mode observer.

It was stated by Madhu et al (2012) that the sun is tracked from east to west by single axis tracker whereas the daily east to west movement of the sun and the seasonal declination movement was tracked by two axis tracker. A large area of sunlight is focused into a small beam by using lenses or mirror. Sunlight is converted into electric current using the photo electric current by PV. Test results suggest that the increase in electricity efficiency of monitoring solar plate in everyday days is 26 to 38% compared to fixed plate. And during cloudy or rainy days it's varies at any degree

Generally, solar panels are motionless and do not monitor the movement of the sun. In this project a solar tracker device that tracks the movement of sun throughout the sky and tries to maintain the solar panel perpendicular to the rays, ensuring that the maximum quantity of sunlight is incident on the panel during the day. The solar tracking system starts following the sun right from sunrise, in the course of the day until night, and starts all over again from the dawn next day. The solar panels are powerful means of storing energy, their performance at doing so is immediately associated with their perspective with the sun. Because PV cells get the maximum power from facing the solar, a stationary solar panel collects less sunlight one which follows the sun throughout the sky. In this project the dual axis system is used that includes both a horizontal and vertical axis. In this project the tracking system can track the motion of sun exactly around the world at any location.

Chapter # 3: System Design

3.1 Design Constraints and Design Methodology

3.1.1: Geometrical Constraints:

The second we decided to design the dual axis solar tracker system for the project there are some constraints that should be taken under consideration. First of all the major problem was to create solar tracker system of suitable size that will be easy to handle. The main point which was creating hurdle was that the size of the dual axis solar tracker should not affect the performance and efficiency of panel. For that, lots of studies were performed to get well-balanced final product.

3.1.2: Sustainability:

As an entire system design should be capable of preserve it self physically and functionally and it is simple not fragile system apart from the solar panels as they require special care. To make up the expense of the device the system needs to work for quite a while. The unique characteristic of this system is that instead of taking the earth as its reference, it takes the sun as a guiding source. The sunlight is monitored by the active sensors and rotates the panel towards the direction where the intensity of sunlight is maximums.

3.1.3: Environmental Concern:

There will be abundant availability of solar energy in the nature because the sun emits energy at an extremely large rate. The world's energy demand could be fulfilled if all the solar energy is converted in to useable forms. Solar energy can be converted to more usable energy forms through solar tracking solar panel. There is unprecedented interest in renewable energy, particularly solar energy. Our project solar tracking solar panel highlights the use of abundant source of energy particularly in Saudi Arabia which is going wasted unused.

3.1.4: Social Impact:

On one hand we can see that the world's energy resources depletion will be one of the major problems and on other hand we know that global warming is major concern of the world. But solar energy which we can gain from solar panel, we can gain maximum energy which is clean and green and improving its efficiency by using sun trackers is a great option in near future.

3.1.5: Economic:

The major constraint of the project was the financial concerns related with the creation of the system. Solar energy can reduce the electricity bills of households since solar energy can be used to supplement other resources of energy. One might install a solar tracking system with a solar panel considering the advantages like the efficiency increases by 20-60% that is equivalent to more money. The space requirement is reduced for solar park and they sustain the same output the profit time of the investment is reduced. Long-term maintenance concerns for tracking systems are drastically reduced by advancement in technology and reliability in electronics and mechanism.

3.1.6: Safety:

Our design has also been planned to sustain safety at all times during its functional lifespan. The solar tracking solar panel system is securely mounted to prevent it from becoming a failing hazard.

3.1.7: Ethics:

Solar tracking solar panel designs and models are already in use in markets and in our daily life but we intend to present this solar tracking solar panel system with some modifications in it. The aim of this project is to ensure the sunlight rays are falling perpendicularly on the solar panel to give the maximum solar energy. An automated system is required to get a constant output, which should be capable to constantly rotate the solar panel. The solar tracking system was made as a prototype to solve the problem. It will be automatic and keeps the panel in forward-facing of sun until that is visible.

3.2 Engineering Design Standards

For any project to have strong standing in the engineering world engineering standards should be applied in it. The components used in solar tracking solar panel are listed below with their engineering standards and details.

Figure # 3.1: Technical specs of servo motor MG90S

Table # 3.1: Components and Weight

Weight	**13.4g**
Dimension	22.8×12.2×28.5mm
Stall torque	1.8kg/cm (4.8V); 2.2kg/cm (6.6V)
Operating speed	0.10sec/60degree (4.8V); 0.08sec/60degree (6.0V)
Operating voltage	4.8V~ 6.6V
servo wire length	25 cm

Table # 3.2: Specifications of Hardware

Hardware	Specification
4 M3 Screws	2.9 mm diameter
Nuts	14-16 mm length
1 Screw	6-32 diameter
2 Wood Screw	Size 2

3.3 Product Subsystems and selection of Components

3.3.1 Tools

- Wire Stripper/ Cutter
- Several Small Screw Drivers
- Rubber Feet Cable Wrap or Twist Ties highly recommended

3.3.2 Electronics:

- 5.5V Solar Cell
- Arduino Uno + USB Cable
- Arduino Sensor Shield
- x 9g Metal Gear Servos
- 1 x 5 Port Terminal Block
- 1 x 4 Port Terminal Block (or 3 port will do)
- x 10K Ohm Resistors
- x Light Detecting Resistors
- x JST Socket Connector Cables
- Jumper Wires

Figure # 3.2: Arduino Uno

3.3.3 Optional Electronics

- LED Volt Meter Hardware

3.4 Theory and Theoretical Calculations

3.4.1 Coding Arduino

For our solar tracker system to be functional very important step is to code the Arduino. Only after the coding of the arduino which is attached to the system, solar panel will act as solar tracker. For this purpose we will be installing arduino on the mobile phone which will be attached via USB. While programming we will make sure to set our board type to Uno. We will be able to modify and manage the speed and range of the servos and the sensitivity of the sensors with the coding.

#include // include Servo library

// 180 horizontal MAX

Servo horizontal; // horizontal servo

```
int servoh = 180; // 90; // stand horizontal servo

int servohLimitHigh = 180;

int servohLimitLow = 65;

// 65 degrees MAX

Servo vertical; // vertical servo

int servov = 45; // 90; // stand vertical servo

int servovLimitHigh = 80;

int servovLimitLow = 15;

// LDR pin connections

// name = analogpin;

int ldrlt = 0; //LDR top left - BOTTOM LEFT <--- BDG

int ldrrt = 1; //LDR top rigt - BOTTOM RIGHT

int ldrld = 2; //LDR down left - TOP LEFT

int ldrrd = 3; //ldr down rigt - TOP RIGHT

void setup()

{ Serial.begin(9600);

// servo connections

// name.attacht(pin);

horizontal.attach(9);

vertical.attach(10);
```

```
horizontal.write(180);

vertical.write(45);

delay(3000);

}

void loop()

{ int lt = analogRead(ldrlt); // top left

int rt = analogRead(ldrrt); // top right

int ld = analogRead(ldrld); // down left

http://www.instructables.com/id/Simple-Dual-Axis-Solar-Tracker/

int rd = analogRead(ldrrd); // down right

// int dtime = analogRead(4)/20; // read potentiometers

// int tol = analogRead(5)/4;

int dtime = 10; int tol = 50;

int avt = (lt + rt) / 2; // average value top

int avd = (ld + rd) / 2; // average value down

int avl = (lt + ld) / 2; // average value left

int avr = (rt + rd) / 2; // average value right

int dvert = avt - avd; // check the diffirence of up and down

int dhoriz = avl - avr;// check the diffirence og left and rigt

Serial.print(avt);
```

```
Serial.print(" ");

Serial.print(avd);

Serial.print(" ");

Serial.print(avl);

Serial.print(" ");

Serial.print(avr);

Serial.print(" ");

Serial.print(dtime);

Serial.print(" ");

Serial.print(tol);

Serial.println(" ");

if (-1*tol > dvert || dvert > tol) // check if the diffirence is in the tolerance else change vertical angle

{

if (avt > avd)

{

servov = ++servov;

if (servov > servovLimitHigh)

{

servov = servovLimitHigh;
```

```
}

}

else if (avt < avd)

{

servov= --servov;

if (servov < servovLimitLow)

{

servov = servovLimitLow;

}

}

vertical.write(servov);

}

if (-1*tol > dhoriz || dhoriz > tol) // check if the diffirence is in the tolerance else change horizontal angle

{

if (avl > avr)

http://www.instructables.com/id/Simple-Dual-Axis-Solar-Tracker/

{

servoh = --servoh;

if (servoh < servohLimitLow)
```

```
{
servoh = servohLimitLow;
}
}
else if (avl < avr)
{
servoh = ++servoh;
if (servoh > servohLimitHigh)
{
servoh = servohLimitHigh;
}
}
else if (avl = avr)
{
// nothing
}
horizontal.write(servoh);
}
delay(dtime);
}
```

3.4.2 Efficiency of solar tracking system

The success of our project depends on the output of the solar tracking system. Now to determine the desired output of the system we will find the efficiency of the solar tracking system. To calculate the efficiency we will multiply the amount of the sunlight that hits the earth surface in our area also known as incident radiation flux by the area of our panel(square meters).

The efficiency of solar tracking system will be proved if the following condition given in equation is achieved:

$$\varepsilon = (E_T - E_F) - E_C > 0$$

Where;

$E_{T=}$ the electric energy produced by the solar panel with tracker

$E_{F=}$ the electric energy produced by the same solar panel without tracker or when fixed

$E_{C=}$ the energy consumption for orienting the panel

For the economical and energetic justification of the solar tracking system the efficiency parameter is included in the field of the values corresponding to 20-25% of the electricity generated by the solar panel without tracker. For solar system to be efficient the values we get should be higher as it is not possible because this is practically the maximum impact of incident solar radiation which can be achieved by the sun and on the other hand lower values will not justify the efficiency of the solar tracking system.

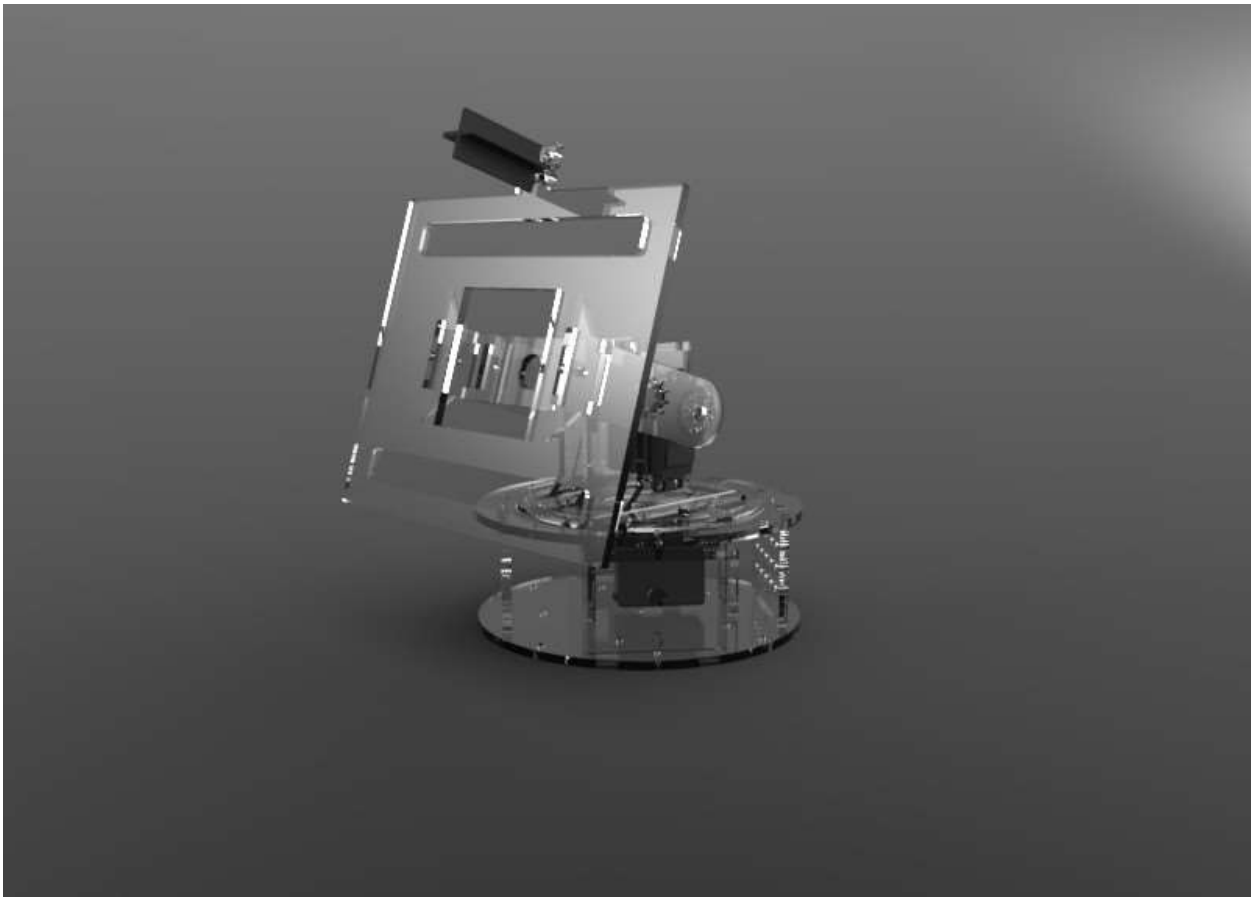

Fig # 3: CAD model of solar tracker

3.5 Manufacturing and Assembling (Implementation)

The current project is based on tracking solar panels. These panels change their orientation in relation to solar radiation. This orientation helps in getting full benefit of optimal angle between solar panels and solar radiations. This increases the efficiency and results in maximum production of energy. A custom Arduino shield, sensor holder and code have been used in this project. Initially, declaration of both servos is done and creation of object. This serves to control the servo motors. To secure the reference servo positions, the variables posx and posy have been used. The working of the motors has been established by selecting a tolerance or a constant value. On the servo object, the servos are attached on digital pins. Pin Mode in used to select analog pins as input. The setting of servos is made to mid-point or

original position. This is set with a 1000 ms or 1sec delay. This is helpful in catching up with the user. To read the analog values, three variables are selected. These variables are mapped into integer's value from 0 to 1023. It will stay on its original location if the difference between the two variables is less then tolerance value. Otherwise a movement is shown towards the direction of maximum intensity of light. This is done by increasing or decreasing the values of posx and posy. The loop is repeated. This takes place till a value is achieved which is greater than the minimum tolerance. Position is set to150° if the value becomes greater than 150° and it is kept at 30° if the value is less than 30°. These angles are chosen as lower and upper limit angles.

Chapter 4: System Testing and Analysis

4.1 Experimental Setup, Sensors and data acquisition system

4.1.1: Multimeter

In order to collect data from our project solar tracking solar panel we need to calculate and evaluate all the important parameters. To asses our systems performance need to require. For this purpose, we took the help of our lab technician for the data collection with multimeter. Multimeter is used in our project to find the voltage being produced by the solar panels at many different stages, when solar panel was incident by sunlight. First the voltage checked when sunlight was perpendicular to the solar panel. Second time voltage checked when solar panel was tracking the sunlight. We repeated this process throughout the day time.

Additionally, we are also required to obtain the amount of power it produces which we did it using the $\boldsymbol{P_{OUT} = VI}$ formula. This formula gave us the power output, the power being produced and then we found the power input using$\boldsymbol{P_{IN} = DNI.}$ Then we calculated the efficiency of the system using both of these formulas.

Furthermore, the multimeter used to measure the data in the table below has following specifications;

Specifications:

- Manufacturer: B & K Precision
- DC Voltage: 200mV/2V/20V/200V+-(0.5%+2) 600V+-(0.8%+2)
- AC Voltage: 2V/20V/200V+-(0.9%+3) 600V+-(1.2%+3)
- DC Current: 200uA/2000uA/20mA/200mA/10A+-(1.5%+3)
- AC Current: 200uA/2000uA/20mA/200mA/10A+-(1.5%+4)
- Resistance: 200ohm/2Kohm/20Kohm/200Kohm+-(0.8%+2) 2Mohm/20Mohm+-(1.0%+2)
- Frequency: 200kHz
- Capacitance: 2000uF
- Diode check: Resolution: 0.001V, Will display the forward drop voltage

- Continuity check: If measured resistance less than 100Ω, will buzzer is sounded. Sound loudly ,Easily to hear
- Power Supply: 9V Battery(6F22)

Figure # 4.1 : Multimeter

4.2 Results, Analysis and Discussion

4.2.1 Performance of Solar Panel without Tracking

The below table shows the performance of the solar panel without tracker

Table# 4.2(a) Solar panel without tracking

Time (Hrs)	Voltage (V)	Current(A)	Power (W)
9am	5.5	0.11	0.605

10am	9	0.19	1.71
11am	10.5	0.2	2.1
12 pm	12.5	0.28	3.5
1 pm	14	0.32	4.49
2 pm	13.5	0.3	4.05
3 pm	11	0.26	2.86
4 pm	8	0.16	1.28
5 pm	6	0.12	0.72

4.2.2 Performance of Solar Panel with Tracking

The table given below shows the efficiency and performance of the solar panel with tracking.

Table# 4.2(b) Solar Panel with tracking

Time (Hrs)	Voltage (V)	Current(A)	Power (W)
9am	12.2	0.23	2.8
10am	13.5	0.25	3.4
11am	14	0.28	3.92
12 pm	14	0.3	4.2

1 pm	15	0.3	4.5
2 pm	14	0.3	4.2
3 pm	13	0.26	3.38
4 pm	10	0.25	2.5
5 pm	7	0.2	1.4

2.134watts is the average power obtained from solar panel without tracking and 3.18watts power is obtained from solar panel with tracking.

41.64% is the improved efficiency neglecting the power consumption of motor. So the proposed dual axis tracking system presents efficient system to connect solar energy which ensures that consumption of energy is more than the fixed solar panel.

In our project the hardware of solar tracking solar panel design and the implementation of the design has been proposed. Our result shows that the solar tracking system increases the efficiency of the solar panel. Solar tracking solar panel is completely automatic and it ensures the minimum low cost. So, it is a dual axis system which maximizes the efficiency and can be obtained over a period of time. Normally a solar panel converts only 30 to 40 per cent of the incident solar radiation in to electrical energy. An automated system is required to get a constant output, which should be capable to constantly rotate the solar panel. The sun tracking system was made as a prototype to solve the problem. It will be automatic and keeps the panel in forward-facing of sun until that is visible.

Chapter 5: Project Management

5.1 Project Plan

We In order to be successful in delivering our project on time we needed a good project plan. The project had a lot of different tasks which needed to be done in a timely manner so they were divided amongst the team members equally. The following table shows our project plan.

Table # 5.1: Project Plan

S. No.	Tasks		Start	End	Duration
1.	Chapter # 1: Introduction		09/09/19	19/09/19	10
2.	Chapter # 2: Literature Review	Project Background	20/09/19	30/09/19	10
		Previous work			
		Comparative Study			
3.	Chapter # 3: System Design	Design Constraints and Design Methodology	02/10/19	10/10/19	09
		Engineering Design Standards			
		Theory & Theoretical Calculations			
		Product Subsystems & Selection of Components			
		Manufacturing &			

		Assembly			
4.	Chapter # 4: System Testing & Analysis	Experimental Setup, Sensors and Data Results, Analysis & Discussions	01/11/19	12/10/19	11
5.	Chapter # 5: Project Management	Contribution of team Members Project Execution Monitoring Challenges and Decision Making Project Bill of Materials and Budget	15/11/19	19/11/19	4
6.	Chapter # 6: Project Analysis	Impact of Engineering Solution Contemporary Issues Addressed.	26/11/19	28/11/19	2
7.	Chapter # 7: Conclusion & Recommendation	Conclusion Future Recommendation	28/11/19	29/11/19	1
8.	Design of Prototype		05/11/19	11/11/19	6
9.	Parts Purchase		20/09/19	05/10/19	15

10.	Manufacturing	05/10/19	19104/19	14
11.	Testing	20/10/19	22/10/19	2

Table# 5.1 (a): Assigned Members for Tasks

S. No.	Task	Assigned Members
1.	Chapter # 1: Introduction	Saeed & Nasser
2.	Chapter # 2: Literature Review	Nawwaf & Foaud
3.	Chapter # 3: System Design	Saeed Nasser Foaud Nawwaf
4.	Chapter # 4: System Testing & Analysis	Saeed Nasser Foaud Nawwaf
5.	Chapter # 5: Project Management	Saeed Nasser Foaud Nawwaf
6.	Chapter # 6: Project Analysis	Saeed Nasser Foaud Nawwaf

7.	Chapter # 7: Conclusion & Recommendation	Nawwaf & Foaud
8.	Design of Prototype	Saeed & Foaud
9.	Parts Purchased	Saeed & Nasser
10.	Manufacturing	Everyone
11.	Testing	Everyone

5.2 Contribution of Team Members

To complete the project within the allocated time we have divided the complete project in to sub tasks. The table below shows the contribution of team member.

Table # 5.2: Contribution of Members

S. No.	Tasks		Assigned Member	Contribution
1.	Chapter # 1: Introduction		Everone	100 %
2.	Chapter # 2: Literature Review	Project Background	Saeed Nasser Foaud Nawwaf	25% 25% 25% 25%
		Previous work	Saeed Nasser Foaud Nawwaf	25% 25% 25% 25%
3.	Chapter # 3: System Design	Design Constraints and Design Methodology	Saeed	20%
		Engineering Design Standards	Saeed	20%
		Theory & Theoretical	Nasser	20 %

		Calculations		
		Product Subsystems & Selection of Components	Nawwaf	20 %
		Manufacturing & Assembly	Foaud	20 %
4.	Chapter # 4: System Testing & Analysis	Experimental Setup, Sensors and Data	Saeed Nasser	50%
		Results, Analysis & Discussions	Foaud Nawwaf	50%
5.	Chapter # 5: Project Management	Contribution of team Members	Saeed	25%
		Project Execution Monitoring	Nawwaf	25%
		Challenges and Decision Making	Foaud	25%
		Project Bill of Materials and Budget	Nasser	25%
6.	Chapter # 6: Project Analysis	Impact of Engineering Solution	Saeed	50%
		Contemporary Issues Addressed.	Nasser	50%
7.	Chapter # 7: Conclusion & Recommendation	Conclusion	Nawwaf	50%
		Future Recommendation	Foaud	50%
8.	Design of Prototype		Saeed & Foaud	100%

9.	Parts Purchase	Saeed & Nasser	100%
10.	Manufacturing	Saeed Nasser Foaud Nawwaf	100%
11.	Testing	Everyone	100%

5.3 Project Execution Monitoring

In order to keep our project and ourselves on right path it was necessary to organize our work through team meetings and setting suitable and professional schedule for operating the different parts in the project. The table below depicts how we use to execute and manage each of our meetings.

Table # 5.3: Dates of Activities & Events

Time/Date	Activities/Events
Once in week	Assessment Class
Bi-Weekly	Meeting with the group members
Bi-Weekly	Meeting with the Advisor
20 September, 2019	Ordering parts
14 November, 2019	Midterm Presentation
20 October, 2019	First Test of System
21 November , 2019	Finishing Final Prototype
4 December, 2019	Test of the System
5 December, 2019	Final Submission of Report

12 December, 2019	Final Presentation

5.4 Challenges and Decision Making

Throughout the project we faced a lot of challenges and problems which needed to be resolved and rectified in order to deliver a successful project. We had to take lot of decisions while working on our project. How to manage time was of the biggest problem which was faced throughout the project. However, we were able to resolve all of these problems efficiently with teamwork. The problems which we faced are as follows.

5.4.1: Equipment and Device Problems

- **Servo Motor**

  A custom arduino shield, sensor holder and code have been used in this project. Initially, declaration of both servos is done and creation of object. This serves to control the servo motors. To secure the reference servo positions, the variables posx and posy have been used. The working of the motors has been established by selecting a tolerance or a constant value. On the servo object, the servos are attached on digital pins

- **Coding Arduino**

  For our solar tracker system to be functional very important step is to code the Arduino. Only after the coding of the arduino which is attached to the system, solar panel will act as solar tracker. For this purpose installed arduino on the mobile phone which then attached via USB. After several trials we were able to code the arduino.

5.4.2: Testing & Safety Issues

The test that we run on our project was done in day light. When the sun rays were on their peak to run and charge its battery. The aim was to ensure the sunlight rays are falling perpendicularly on the solar panel to give the maximum solar energy. An automated system was set to get a constant output, which should be capable to constantly rotate the solar panel. The sun tracking system was made as a prototype to solve the problem

5.4.3: Design Problems

The problem which we faced after completing the solar tracking system was that it was not moving with the rays of sun. Our project was based on tracking system so to ensure the sunlight rays are falling perpendicularly on the solar panel to give the maximum solar energy, we have done several experiments. After three attempts we were able to design an automated system, an automated was set to get a constant output, which should be capable to constantly rotate the solar panel. Another problem that was faced was coding the arduino. For our solar tracker system to be functional very important step is to code the Arduino. Only after the coding of the arduino which is attached to the system, solar panel will act as solar tracker. For this purpose we will be installing arduino on the mobile phone which will be attached via USB. While programming we will make sure to set our board type to Uno.

5.5 Project Bill of Materials & Budget

The table below shows the parts we purchased order and fabricated from the market. It includes the total amount spent on our project in Saudi Riyals (SAR).

Table # 5.5: Project Bill of Materials

Materials	Cost (SAR)
Solar panel	100
Servos	80
Coil Screw Small other parts	100
Manufacturing	300
Total Sum	**580**

Chapter 6: Project Analysis

6.1 Life-Long Learning

Through our working with the project it is significant to have many effective learning, which reflects lots of benefits and advantages in our life learning. This project was started as a team and to set out achievable goals was our first priority. Before starting a project proper research was conducted regarding the implementation of the plan. We ensured that each member of team had ostensible information on the subject. Proper equipment was utilized for the research. We learned a lot form our blunders throughout the project and tried to work on trial and error basis.

6.1.1: Software Skills:

In order to achieve our objective in a professional manner it is very important to use technological advances and skills. At the point when we started our project we alluded to online websites to familiarize ourselves that which designs are in market and how can we improve. Then we designed our project by finding all constraints and started doing simulations. In addition, it is significant to get viable use for working up project's design utilizing the various kinds of software skills and to program technical connections depending on the mechanical and technical powers. With the help of these softwares we were able to solve all the problems smoothly and quickly.

6.1.2: Hardware Skills:

We used very simple and straightforward hardware skills for our project. All parts which are best suitable for our engineering standards were purchased for manufacturing purpose. However, multimeter is used for calculation and evaluation of system performance that gave us the values of current and voltage. To support the hardware system in operating system the team was professionally provided with database.

6.1.3: Time Management:

One of the main challenges in the beginning for the team was to manage the time during working on project. We had less than four months to complete our project; we managed our time in such a manner that we were able to finish our project and to do testing beforehand. It was necessary to organize our work through team meetings and setting suitable and professional schedule for operating the different parts in the project. Gantt chart plays an important role in helping us managing our time in respect to the different tasks. Team ideas were shared for making the best in suitable assigned time.

6.1.4: Project Management:

To fulfill any task in a proper manner and on time project management is one of the most important factors. The first thing we did before working on our project was to make Gantt chart. Gantt chart is a kind of project management plan. In that we had specified all the tasks, their due dates and who was responsible for doing those tasks. The task was divided equally among each member and each group member was responsible for his task. It is necessary for each member in the team to focus on the task and give enough time for previewing and reviewing the missions according to the work plan which shows the responsibilities and procedures in all stages.

6.2 Impact of Engineering Solutions

6.2.1: Society:

The use of solar tracking system is increasing with advancement of technology. The efficiency of solar panels is more important than ever because of the increasing demand for solar energy. The aim of this project is to ensure the sunlight rays are falling perpendicularly on the solar panel to give the maximum solar energy. An automated system is required to get a constant output, which should be capable to constantly rotate the solar panel; it will help society to make use of more reliable energy.

6.2.2: Economy:

We used simpler and less expensive parts because the cost of manufacturing was a big concern for us during the project. We have used Arduino sensor shield, nut and screws which are economically affordable material. This has too fold benefits, less manufacturing and maintenance cost. A simple system has fewer chances of breaking down and therefore leading to less maintenance cost. There is no use of implementing the project if it cannot pay more than its manufacturing cost.

6.2.3: Environment:

The main implication of this solar tracking system functionality is to ensure environmental preservation. Globally, the production of existing solar panel can be increased by the execution of simple machinery. The idea of investing in solar tracking system is sure to become a promising idea with successful results. This system can assist in struggle against climate change if implemented successfully. Moreover, this economy friendly system can reduce the demand of fossil fuel around the globe.

6.3: Contemporary Issues Addressed

The issue of global warming has led to the use of scientific technologies that do not promote global warming. Solar tracking systems come under the category of good energy resource. The efficiency of solar tracking system depends on the angle of the axis. This system ensures the maximum accumulation of sunlight by tracking it and motioning along the movement of sun. The solar panel tracks the sun from east to west mechanically for maximum intensity of light. Furthermore, it deals with the issue of modification to make a concentrated solar-hybrid form which can save almost all the cost of running it. It addresses the issue of cost expenses and design of the solar energy panel was also major concern. It must also be taken in consideration that how assembling of every nut, bolt and screw must be done.

Chapter 7: Conclusion & Future Recommendations

7.1 Conclusion

The current project is based on tracking solar panels. These panels change their orientation in relation to solar radiation to increase the efficiency and results in maximum production of energy and helps in getting full benefit of optimal angle between solar panels and solar radiations. The execution of solar tracking system was made clear because of our sufficient research and preplanning of our goals and objectives. The main agenda of this project was to make simple machinery on low cost basis. Trial and error method help us in achieving our goal. We made use of our engineering knowledge in this three month project and were successful in developing and designing low cost solar tracking system. Because the issue of global warming must be controlled by making use of alternatives that are environmental friendly.

7.2 Future Recommendations

The goals of this project were outlined keeping in mind the timeline and resources that were attainable. However this initial design can be subjected to many improvements. Initially this design represents a miniature scale model which can be modified into a much larger scale. Easy to bend cables can be used which do not apply any force on the motor when it is rotating the solar panel. To get a better tracking precision, a photo transistor with and amplification circuit can be used. Furthermore accuracy can also be increased by utilizing dual axis design versus single axis design. Future projects can make use of microcontroller. This microcontroller can serve as standalone unit in the fabricated circuit.

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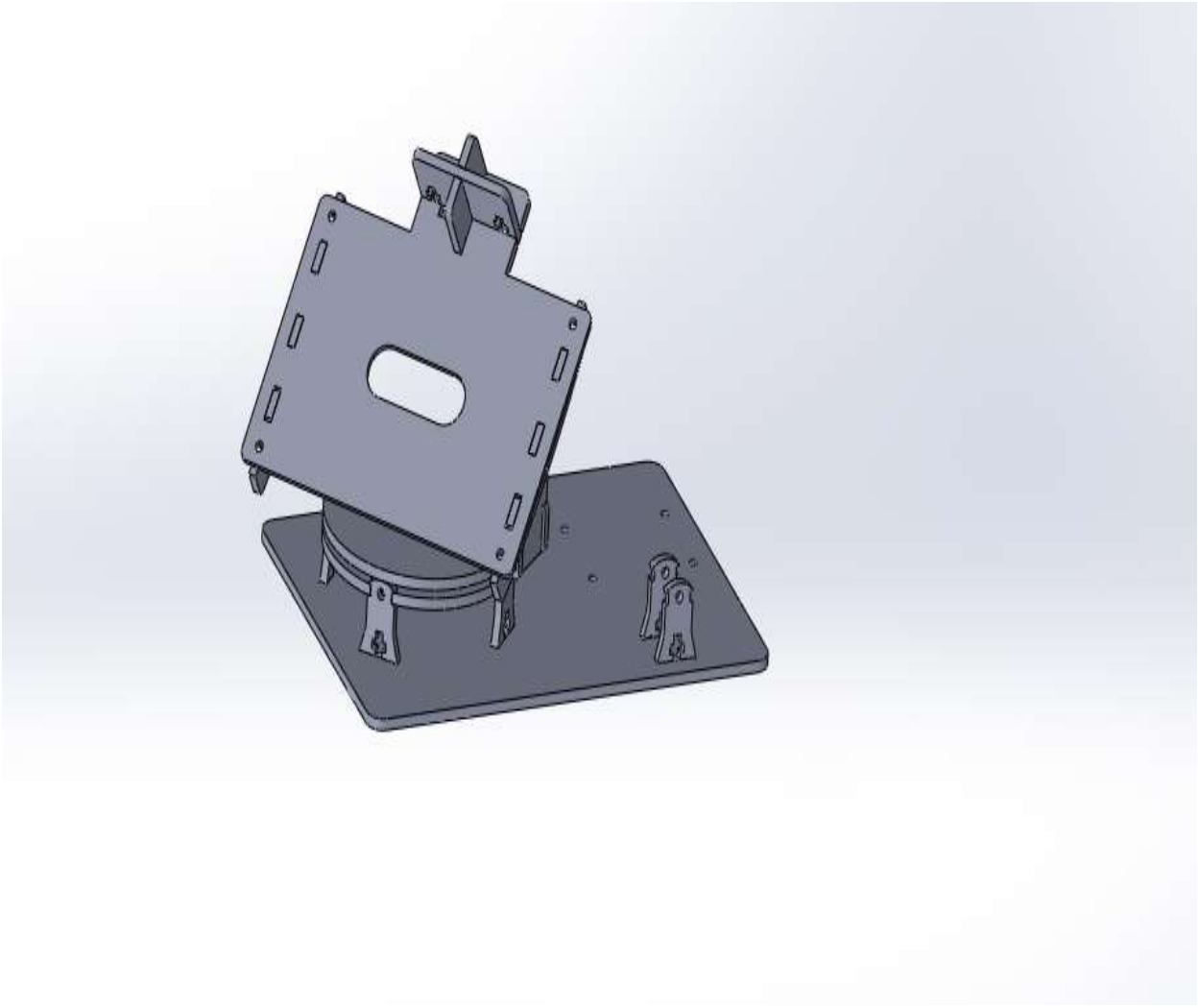
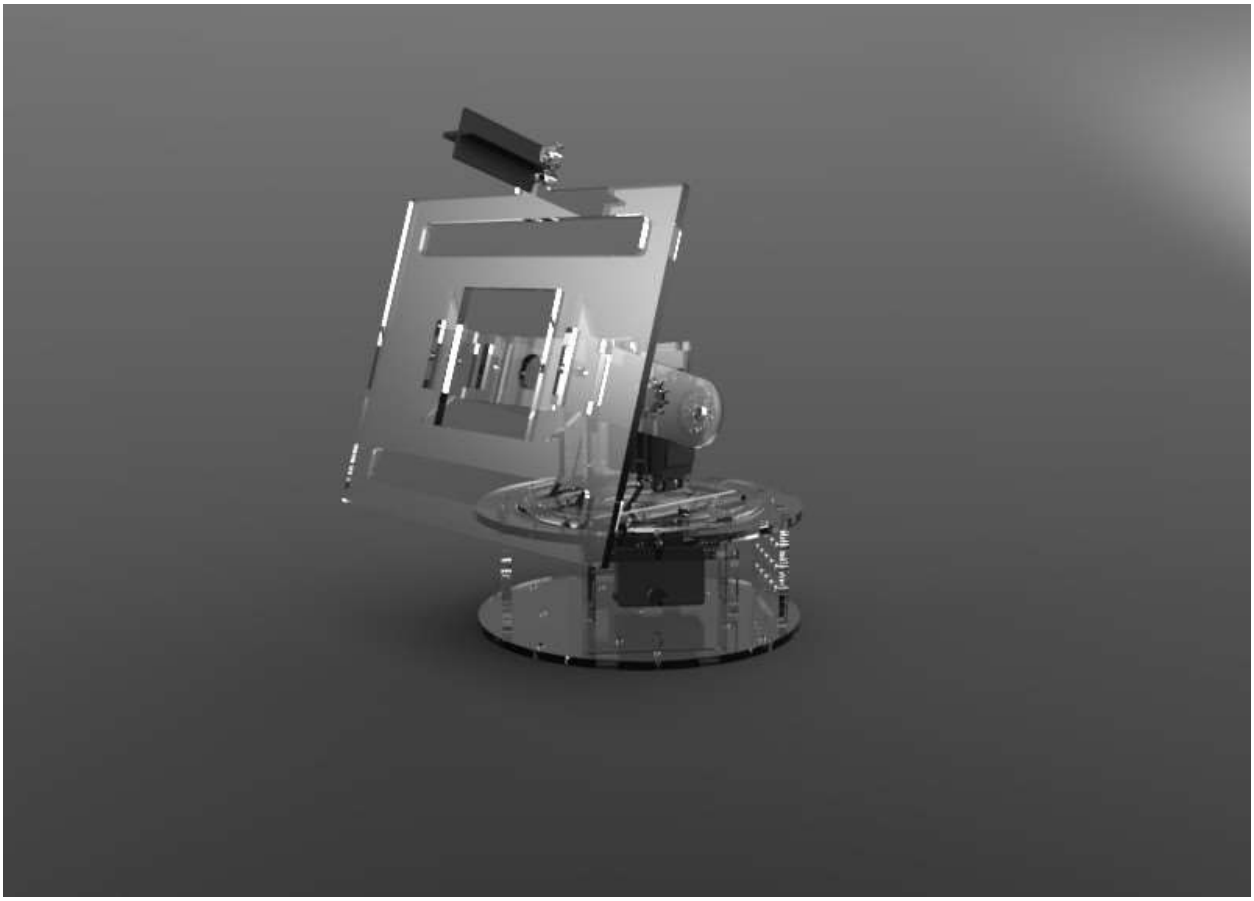
Appendix A: Progress Report

Appendix B: Engineering Standards

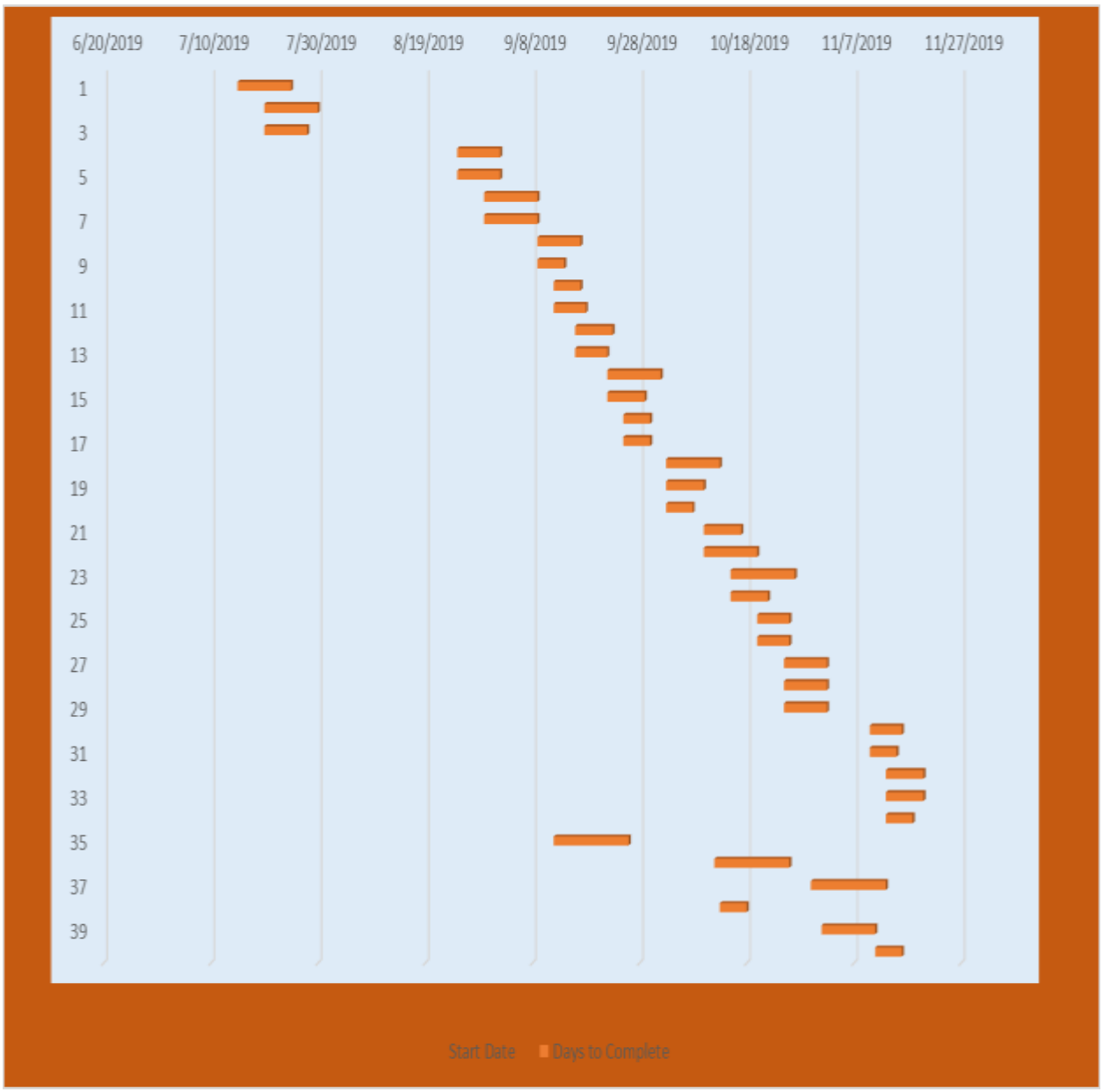
COMPONENT	ENGINEERING STANDARDS	MATERIAL
Coil	ASTM B280	Copper
Motor	ASTM E 45	Steel
Bolts	ASTM A 193	Alloy Steel
Nuts	ASTM F 593	Stainless Steel
Metal Gear Mini Servo	ASTM MG90S	Steel
OHM Resistor	ASTM F1844	Stainless Steel
Servo Motor	UL- 1004-6	Steel

Appendix C: CAD Drawing





Appendix E: Gantt chart



Designing and Fabrication of Solar Tracker	Start Date	Days to Complete	Student Name
Identifying Project	7/15/2019	10	Everyone
Determining Objectives	7/20/2019	10	Everyone
Formation of Deliverables List	7/20/2019	8	Nawwaf Alwhhas
Evaluating Project Needs	8/25/2019	8	Nasser Alotaibi
Defining Project Objectives	8/25/2019	8	Everyone
Outlining information Needs	8/30/2019	10	Fouad Alzahrani
Project Applications	8/30/2019	10	Saeed Alqahtani
Abstract, Acknowledgment, Table of Content	9/9/2019	8	Nawwaf Alwhhas
Introduction	9/9/2019	5	Nasser Alotaibi
Project Specification	9/12/2019	5	Saeed Alqahtani
Develop strategies	9/12/2019	6	Fouad Alzahrani
Literature Review	9/16/2019	7	Everyone
Review definition and Scope	9/16/2019	6	Nasser Alotaibi
Develop System Design	9/22/2019	10	Everyone
Design Project Procedures	9/22/2019	7	Saeed Alqahtani
Identify Design Constraints	9/25/2019	5	Nawwaf Alwhhas
Equipment and Material Selection	9/25/2019	5	Fouad Alzahrani
Design Calculations	10/3/2019	10	Nasser Alotaibi
Design Constraints Identification	10/3/2019	7	Nawwaf Alwhhas
Finalizing the Design	10/3/2019	5	Everyone
Solidworks Model	10/10/2019	7	Saeed Alqahtani
Solidworks Simulation	10/10/2019	10	Nawwaf Alwhhas
Stress Analysis	10/15/2019	12	Fouad Alzahrani
Results, Analysis and Discussion	10/15/2019	7	Nasser Alotaibi
Experimental Setup	10/20/2019	6	Saeed Alqahtani
Required Alterations	10/20/2019	6	Fouad Alzahrani
Data Acquisitions	10/25/2019	8	Everyone
Checking Required Sensors	10/25/2019	8	Nawwaf Alwhhas
Final Prototype Testing	10/25/2019	8	Nasser Alotaibi
Project Plan	11/10/2019	6	Nasser Alotaibi
Project Budget and Cost Analysis	11/10/2019	5	Nawwaf Alwhhas
Project Execution and Monitoring	11/13/2019	7	Saeed Alqahtani
Challenges and Decision Making	11/13/2019	7	Fouad Alzahrani
Contribution of Team Members	11/13/2019	5	Everyone
1st Monthly Progress Report	9/12/2019	14	Saeed Alqahtani
2nd Monthly Progress Report	10/12/2019	14	Nasser Alotaibi
3rd Monthly Progress	10/30/2019	14	Nawwaf Alwhhas
Preparing Midterm Presentation	10/13/2019	5	Fouad Alzahrani
Final Report Preparation	11/1/2019	10	Everyone
Preparing Final Presentation	11/11/2019	5	Everyone