Solar Tracking Device

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Abstract

The recent decades have seen the increase in demand for reliable and clean form of electricity derived from renewable energy sources. As we are on the verge of exhausting fossil fuels, we require some other promising energy source to fuel our daily needs. Solar energy is the one of best option for the primary source of energy in the future, as it is renewable, eco-friendly and safe to use.

An Intelligent Solar Tracker is a device (onto which solar panels are fitted) which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. The Intelligent Solar Tracker will attempt to navigate to the best angle of exposure of light from the sun. The challenge remains to maximize the capture of the rays from the sun for conversion into electricity. This paper presents the steps of implementing a single-axis solar tracking controller. This is done so that rays from the sun fall perpendicularly unto the solar panels to maximize the capture of the rays by pointing the solar panels towards the sun and following its path across the sky,hence increasing electricity and efficiency.

Acknowledgement

We would like to take this opportunity to express sincere gratitude to our Project Supervisor: Prof. DR.Kazi Khairul Islam (Professor, Department of EEE, IUT), whose invaluable insight into the construction and design of the Solar Tracker helped us completing our project.

We would also like to acknowledge the support of EEE Department's Laboratory and Workshop during the period of our project work.

We are grateful to all of our family and well-wishers, who provided their perpetual support towards accomplishing this task successfully.

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Chapter 1

Introduction:

1.1 Overview

Electrical energy from solar panels is derived by converting energy from the rays of the sun into electrical current in the solar cells. The main challenge is to maximize the capture of the rays of the sun upon the solar panels, which in turn maximizes the output of electricity. A practical way of achieving this is by positioning the panels such that the rays of the sun fall perpendicularly on the solar panels by tracking the movement of the sun. This can be achieved by means of using a solar panel mount which tracks the movement of the sun throughout the day. Energy conversion is most efficient when the rays fall perpendicularly onto the solar panels. Thus, the work is divided into three main parts namely the mounting system, the tracking controller system and the electrical power system.

In solar tracking systems, solar panels are mounted on a structure which moves to track the movement of the sun throughout the day. There are three methods of tracking: active, passive and chronological tracking. These methods can then be configured either as single-axis or dual-axis solar trackers. In active tracking, the position of the sun in the sky during the day is continuously determined by sensors. The sensors will trigger the motor or actuator to move the mounting system so that the solar panels will always face the sun throughout the day. This method of sun-tracking is reasonably accurate except on very cloudy days when it is hard for the sensor to determine the position of the sun in the sky thus making it hard to reorient the structure.

Passive Tracking unlike active tracking which determines the position of the sun in the sky, a passive tracker moves in response to an imbalance in pressure between two points at both ends of the tracker. The imbalance is caused by solar heat creating gas pressure on a ‘low boiling point compressed gas fluid that is driven to one side or the other’ which then moves the structure. However, this method of sun-tracking is not accurate. A chronological tracker is a timer-based tracking system whereby the structure is moved at a fixed rate throughout the day. The theory behind this is that the sun moves across the sky at a fixed rate. Thus the motor or actuator is programmed to continuously rotate at a ‘slow average rate of one revolution per day (15 degrees per hour)’. This method of sun-tracking is very accurate. However, the continuous rotation of the motor or actuator means more power consumption and tracking the sun on a very cloudy day is unnecessary.

A single-axis solar tracker follows the movement of the sun from east to west by rotating the structure along the vertical axis. The solar panels are usually tilted at a fixed angle corresponding to the latitude of the location. According to, the use of single-axis tracking can increase the electricity yield by as much as 27 to 32 percent. On the other hand, a dual-axis solar tracker follows the angular height position of the sun in the sky in addition to following the sun’s east-west movement reports that dual-axis tracking increases the electricity output as much as 35 to 40 percent.

1.2 Project Statement

Project

- ✓ To design and build a Solar Tracker system for course subject ENG 499 Capstone Project.

Supervisor

- ✓ Dr. Kazi Khairul Islam

Area of Project Development

- ✓ Project Management
- ✓ Hardware
- ✓ Motor
- ✓ Firmware

1.3 Project Objectives

- ✓ To ensure the position of a photo-voltaic panel to the best angle of exposure to sunlight for collection of solar energy.
- ✓ Increase solar panel output.
- ✓ Maximize power per unit area.
- ✓ To reduce the cost of the energy we want to capture.

1.4 Scopes of the Project

- ➢ Research and Design of Solar Tracker
  - ✓ Gathering Information
  - ✓ Discussion on Ideas and Concepts
  - ✓ Finalization of Ideas
  - ✓ Solar Tracker Design Implementation
- ➢ Implementation
- ➢ Testing
- ➢ Presentation

1.5 Discussion on the Project Proposal and Approval Process

- ✓ Project was first introduced by the supervisor
- ✓ Understand the project statement and define the project objectives
- ✓ Expectations and tasks from the supervisor
- ✓ Special facilities requirement for the project which includes the software/hardware

Chapter 2

Literature Review:

This chapter aims to provide the reader a brief knowledge of Solar Panel, Solar Tracker and the components which made up Solar Tracker.

2.1 Technology of Solar Panel

Solar panels are devices that convert light into electricity. They are called solar after the sun or "Sol" because the sun is the most powerful source of the light available for use. They are sometimes called photovoltaic which means "light-electricity". Solar cells or PV cells rely on the photovoltaic effect to absorb the energy of the sun and cause current to flow between two oppositely charge layers.

A solar panel is a collection of solar cells. Although each solar cell provides a relatively small amount of power, many solar cells spread over a large area can provide enough power to be useful. To get the most power, solar panels have to be pointed directly at the Sun.

The development of solar cell technology begins with 1839 research of French physicist Antoine-Cesar Becquerel. He observed the photovoltaic effect while experimenting with a solid electrode in an electrolyte solution. After that he saw a voltage developed when light fell upon the electrode.

According to Encyclopedia Britannica the first genuine solar panel was built around 1883 by Charles Fritts. He used junctions formed by coating selenium (a semiconductor) with an extremely thin layer of gold.

Crystalline silicon and gallium arsenide are typical choices of materials for solar panels. Gallium arsenide crystals are grown especially for photovoltaic use, but silicon crystals are available in less-expensive standard ingots, which are produced mainly for consumption in the microelectronics industry.

2.2 Evolution of Solar Tracker

Since the sun moves across the sky throughout the day, in order to receive the best angle of exposure to sunlight for collection energy. A tracking mechanism is often incorporated into the solar arrays to keep the array pointed towards the sun.
A solar tracker is a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. When compare to the price of the PV solar panels, the cost of a solar tracker is relatively low.
Most photovoltaic (PV) solar panels are fitted in a fixed location- for example on the sloping roof of a house, or on framework fixed to the ground. Since the sun moves across the sky though the day, this is far from an ideal solution.

Solar panels are usually set up to be in full direct sunshine at the middle of the day facing South in the Northern Hemisphere, or North in the Southern Hemisphere. Therefore morning and evening sunlight hits the panels at an acute angle reducing the total amount of electricity which can be generated each day.

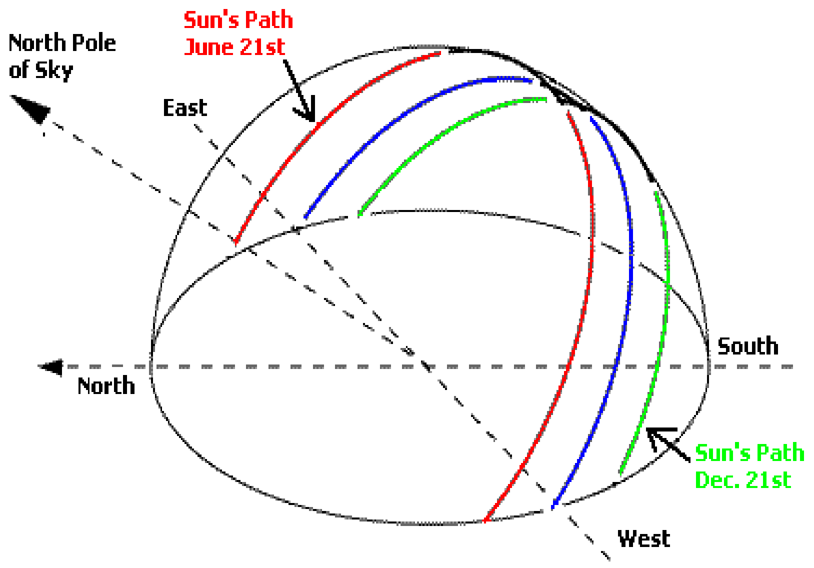


Figure 1: Sun's apparent motion

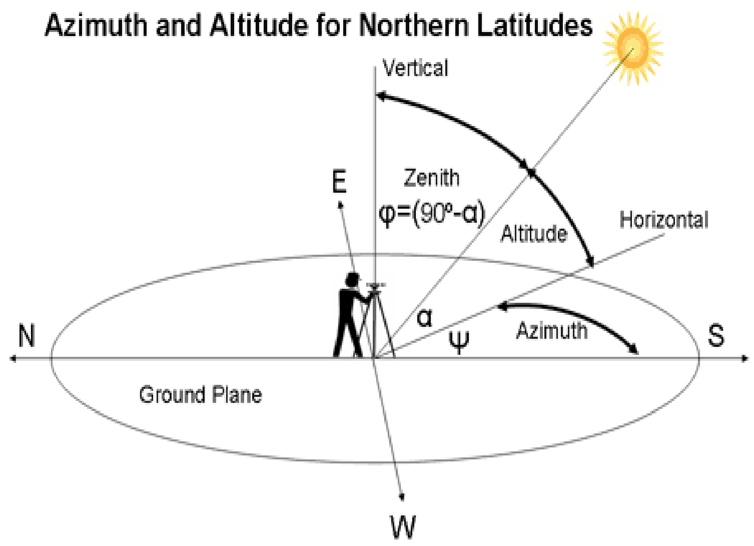


Figure 2

During the day the sun appears to move across the sky from left to right and up and down above the horizon from sunrise to noon to sunset. Figure 1 shows the schematic above of the Sun's apparent motion as seen from the Northern Hemisphere.

To keep up with other green energies, the solar cell market has to be as efficient as possible in order not to lose market shares on the global energy marketplace. There are two main ways to make the solar cells more efficient, one is to develop the solar cell material and make the panels even more efficient and another way is to optimize the output by installing the solar panels on a tracking base that follows the sun.

The end-user will prefer the tracking solution rather than a fixed ground system to increase their earnings because:

- ✓ The efficiency increases by 30-40%
- ✓ The space requirement for a solar park is reduced, and they keep the same output
- ✓ The return of the investment timeline is reduced
- ✓ The tracking system amortizes itself within 4 years (on average)

In terms of cost per Watt of the completed solar system, it is usually cheaper (for all but the smallest solar installations) to use a solar tracker and less solar panels where space and planning permit.

2.3 Solar Tracker

Solar Tracker is basically a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. After finding the sunlight, the tracker will try to navigate through the path ensuring the best sunlight is detected.

The design of the Solar Tracker requires many components. The design and construction of it could be divided into six main parts, each with their main function.

The six parts of solar tracker are:

- Methods of Tracker Mount
- Methods of Drives
- Sensor and Sensor Controller
- Motor and Motor Controller
- Data Acquisition
- Power Supply

The six main parts would need to work together harmoniously to achieve a smooth run for the Solar Tracker. We shall explore their functions individually in the next section.

2.3.1 Methods of Tracker Mount

Single axis solar trackers

Single axis solar trackers can either have a horizontal or a vertical axle. The horizontal type is used in tropical regions where the sun gets very high at noon, but the days are short. The vertical type is used in high latitudes where the sun does not get very high, but summer days can be very long. Figure 3 shows a Solar Tracker using horizontal axle. The single axis tracking system is the simplest solution and the most common one used.

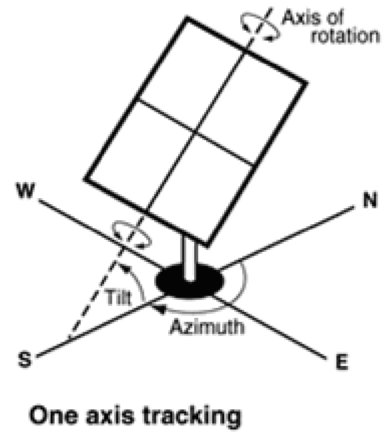


Figure 3

Double axis solar trackers

Double axis solar trackers have both a horizontal and a vertical axle and so can track the Sun's apparent motion exactly anywhere in the World. Figure 4 shows a Solar Tracker using horizontal and vertical axle. This type of system is used to control astronomical telescopes, and so there is plenty of software available to automatically predict and track the motion of the sun across the sky. By tracking the sun, the efficiency of the solar panels can be increased by 30-40%.The dual axis tracking system is also used for concentrating a solar reflector toward the concentrator on heliostat systems.

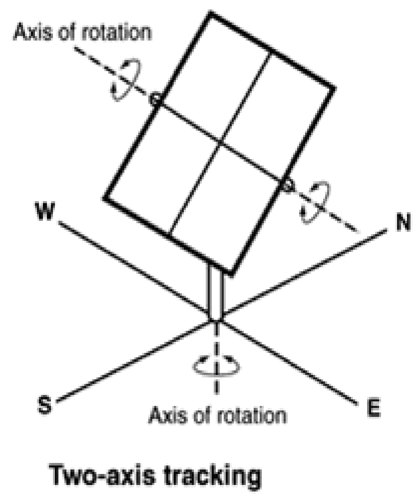


Figure 4

2.3.2 Methods of Drive

1. Active Trackers

Active Trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. Light-sensing trackers typically have two photo sensors, such as photodiodes, configured differentially so that they output a null when receiving the same light flux. Mechanically, they should be unidirectional (i.e. flat) and are aimed 90 degrees apart. This will cause the steepest part of their cosine transfer functions to balance at the steepest part, which translates into maximum sensitivity.

2. Passive Trackers

Passive Trackers use a low boiling point compressed gas fluid that is driven to one side or the other (by solar heat creating gas pressure) to cause the tracker to move in response to an imbalance.

3. Open Loop Tracker

It does not require any feedback element. With the help of solar tracker software all the sun positioning data is calculated and updated regularly in a day with help of microcontroller.

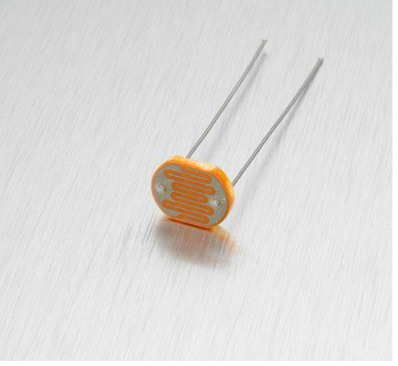
4. Closed Loop Tracker

There is feedback element in the system. When sensor senses maximum intensity of light then the output from photo sensor fed to microcontroller. The microcontroller controls the rotation of motor shaft.

2.3.3 Sensors

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument.

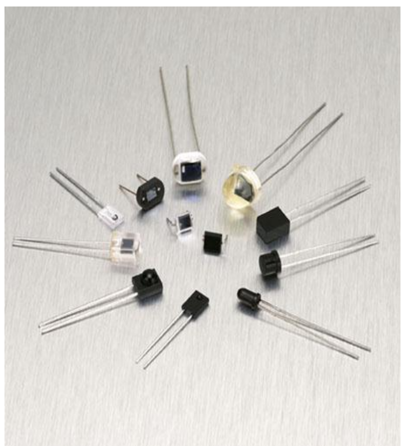
1. Light Dependent Resistor



Light Dependent Resistor (LDR) is made of a high-resistance semiconductor. It can also be referred to as a photoconductor. If light falling on the device is of the high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.

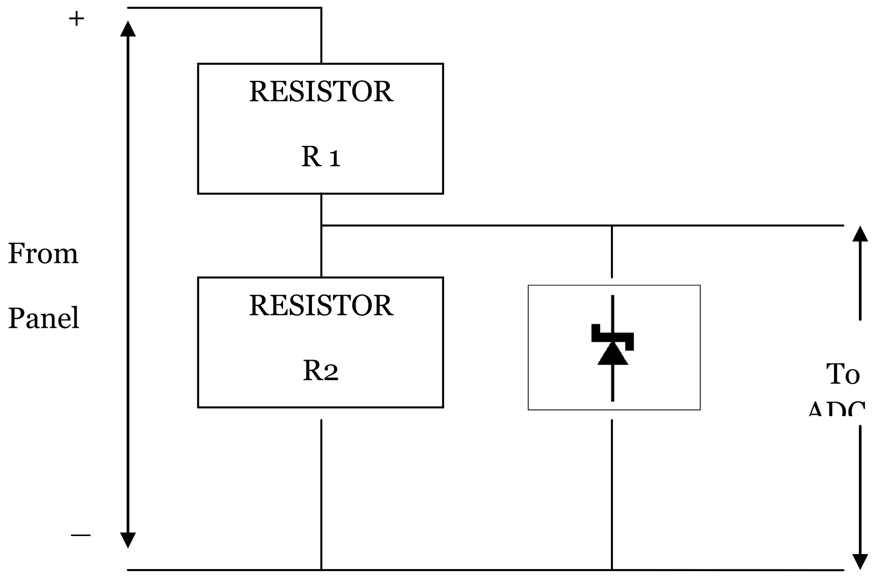
2. Photodiode

Photodiode (BPW34) is a light sensor which has a high speed and high sensitive silicon PIN photodiode in a miniature flat plastic package. A photodiode is designed to be responsive to optical input. In zero bias, light falling on the diode causes a voltage to develop across the device, leading to a current in the forward bias direction. This is called the photovoltaic effect, and is the basis for solar cells - in fact a solar cell is just a large number of big, cheap photodiodes.



3. Voltage Divider Circuit

Takes output directly from the solar panel and feeds it to the ADC for signal conversion before sending it to the microcontroller



2.3.4 Motors

Motors are use to drive the Solar Tracker to the best angle of exposure of light. For this section, we shall look at some of the motor types available on the market.

1. Stepper Motors

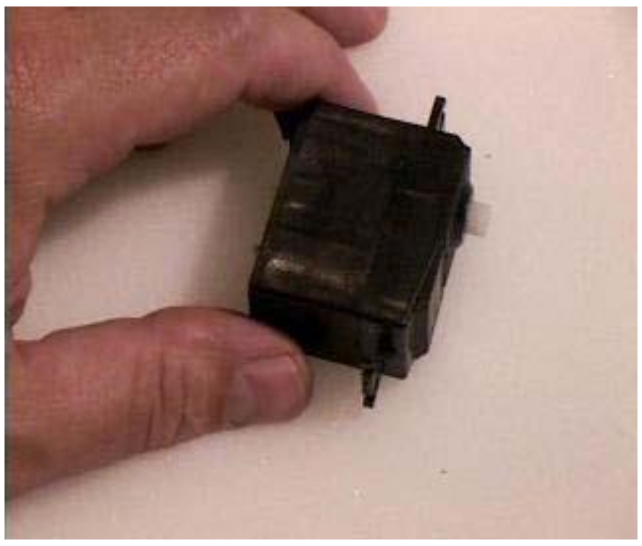
Stepper motor has relatively limited power which means that wheel spin will not be a problem. It is not fast but it will work. The driver chips are operated by two signals. One signal determines the direction of rotation, plus for forward and minus for backwards. The other moves the stepper by one step each time it goes from minus to plus.

Stepper motors move in steps, 200 or 400 steps per revolution to be precise. To move them, the stepper driver firmware had to have a smooth pulse. If the pulse timing is out, the motor would just stop and not move. They can also produce precise motor rotation if the correct motor driver firmware signals are obtained.

2. DC Motors

DC motors are cheaper to buy, and simple to drive but they need feed-back sensors to allow control of the speed. It is necessary to detect the rotation of the wheels, usually by means of sensors better controlled by pulling the motor supply that uses less battery power than the analogue/resistor methods. Low-inertia, efficient servo-motors bring advantages of fast response and efficiency, but add cost.
The advantages of the DC motor are the torque and their speed is easier to control. The drawbacks of DC motors are that they consumed huge amounts of power. They would consumed the battery power in no time and power saving techniques must be employed to ensure the mouse do not stop halfway while navigating. They are also prone to dust and harder to maintain.

3. Servo Motors



Servos contain a small DC motor, a gearbox and some control circuitry, and feed on 5 volts at about 100mA maximum, and about 10-20mA when idle. They have a three-wire connector, one common wire (0 volt, usually black), one +5v wire (usually red), and one signal wire. In normal use they are controlled by pulses of about 1 to 2 milli-seconds at a repetition rate of about 50 per second. A short pulse makes the servo drive to one end of the travel, a long pulse makes it drive to the other end, and a medium one puts it somewhere proportionally between. Some servos have gear components that allow them to rotate continuously. This method needs the servo to have a feedback potentiometer used by internal circuits to measure the position of the output shaft. If this is disconnected and the wires taken to an external pre-set potentiometer, the servo will drive continuously in one direction if fed with short pulses and vice-versa. If there are no pulses, the servo stops. It is uses to drive the Solar Tracker Eastward and Westward. In summary, servos are very small and precise motors.

2.3.5 Data Acquisition

We need to acquire data about the rate at which the battery is charging. We need voltage and current reading and note the position of the tracker. This data will help us in performing our analysis regarding the gain in energy output that can be obtained while using a solar tracker.

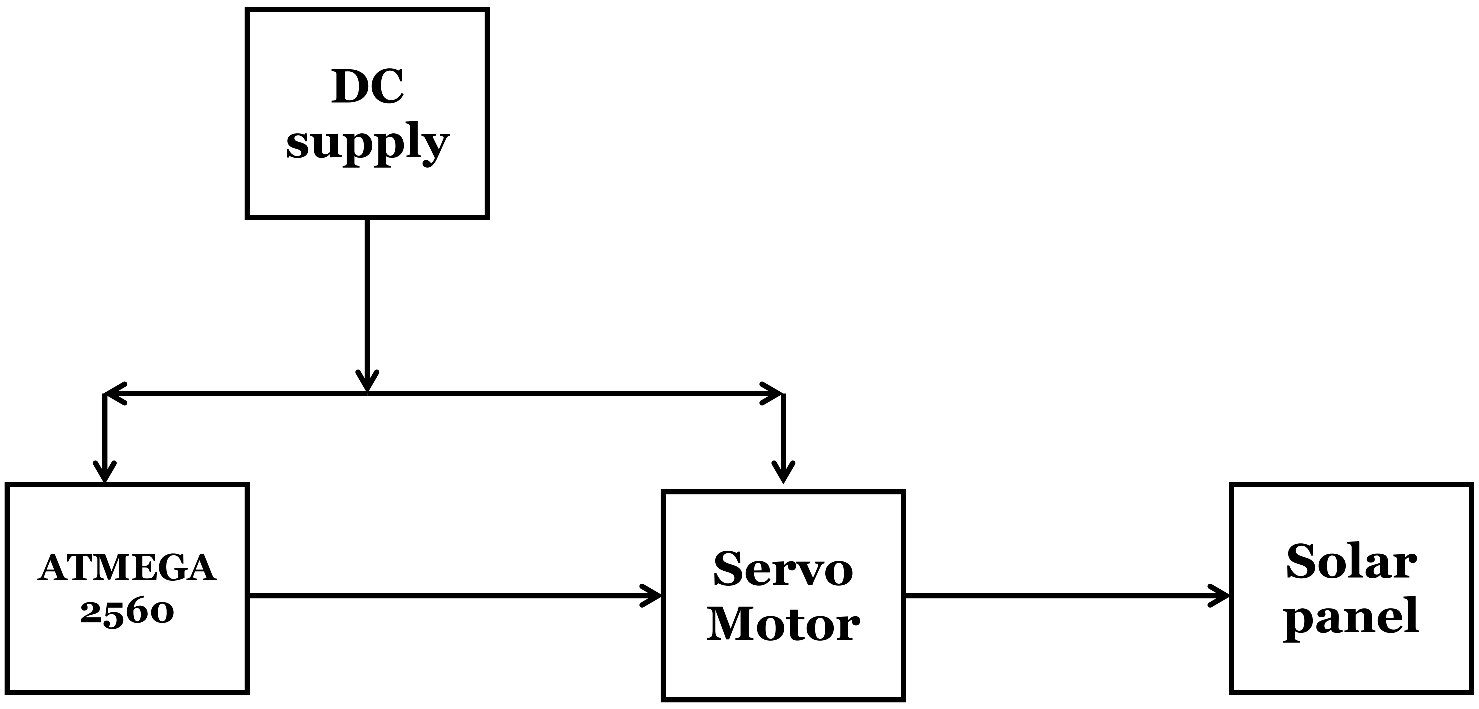
2.3.6 Power Supply

The power supply of the solar tracker is also a consideration when designing. They would have to supply power to the microcontroller, ADC, the motors and the sensors. Although there are other electric power sources available, batteries is the best source for the Solar Tracker. To ensure the proper operation of all circuitry and their components, power must be provided through a voltage regulation scheme.

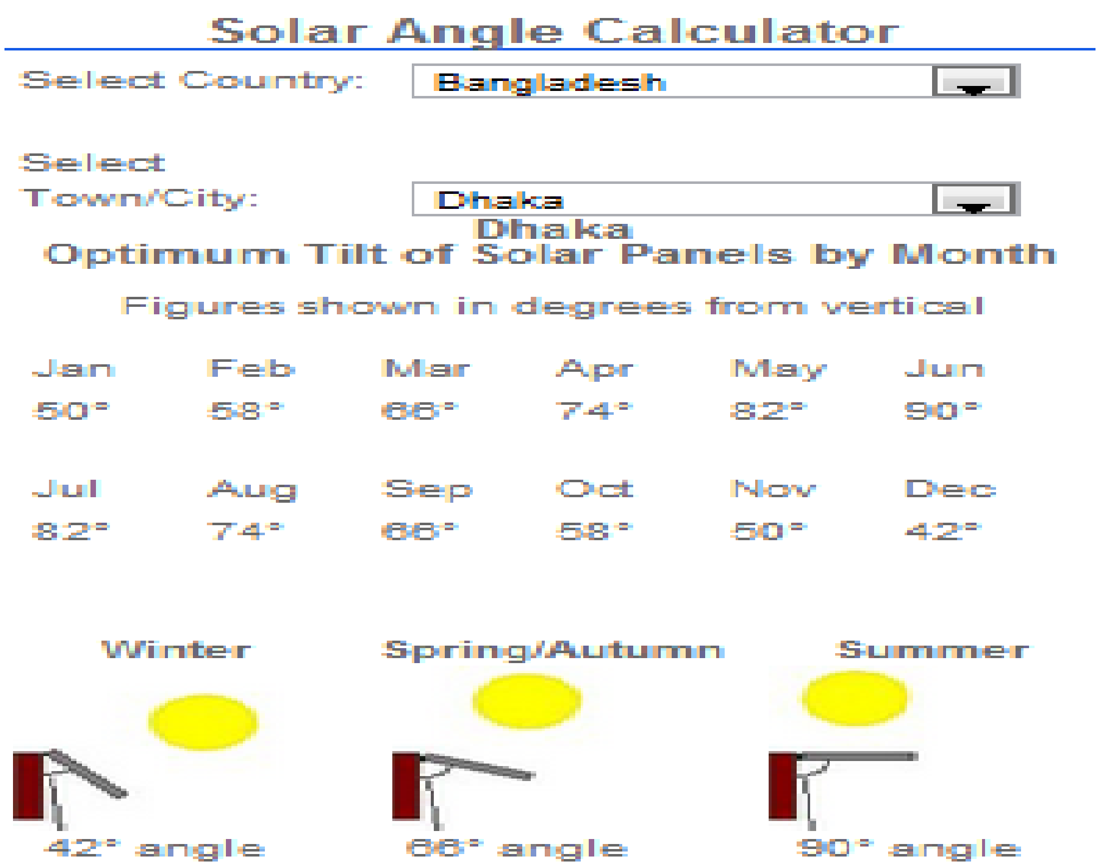
Chapter 3

Proposed Method

3.1 Overall Concept



3.2 Tracking Mechanism



Notes:
On the 21st December, the sun will rise 80° east of due south and set 80° west of due south.
On the 21st March/21st September, the sun will rise 91° east of due south and set 91° west of due south. On the 21st June, the sun will rise 102° east of due south and set 102° west of due south.

http://solarelectricityhandbook.com/solar-angle-calculator.html

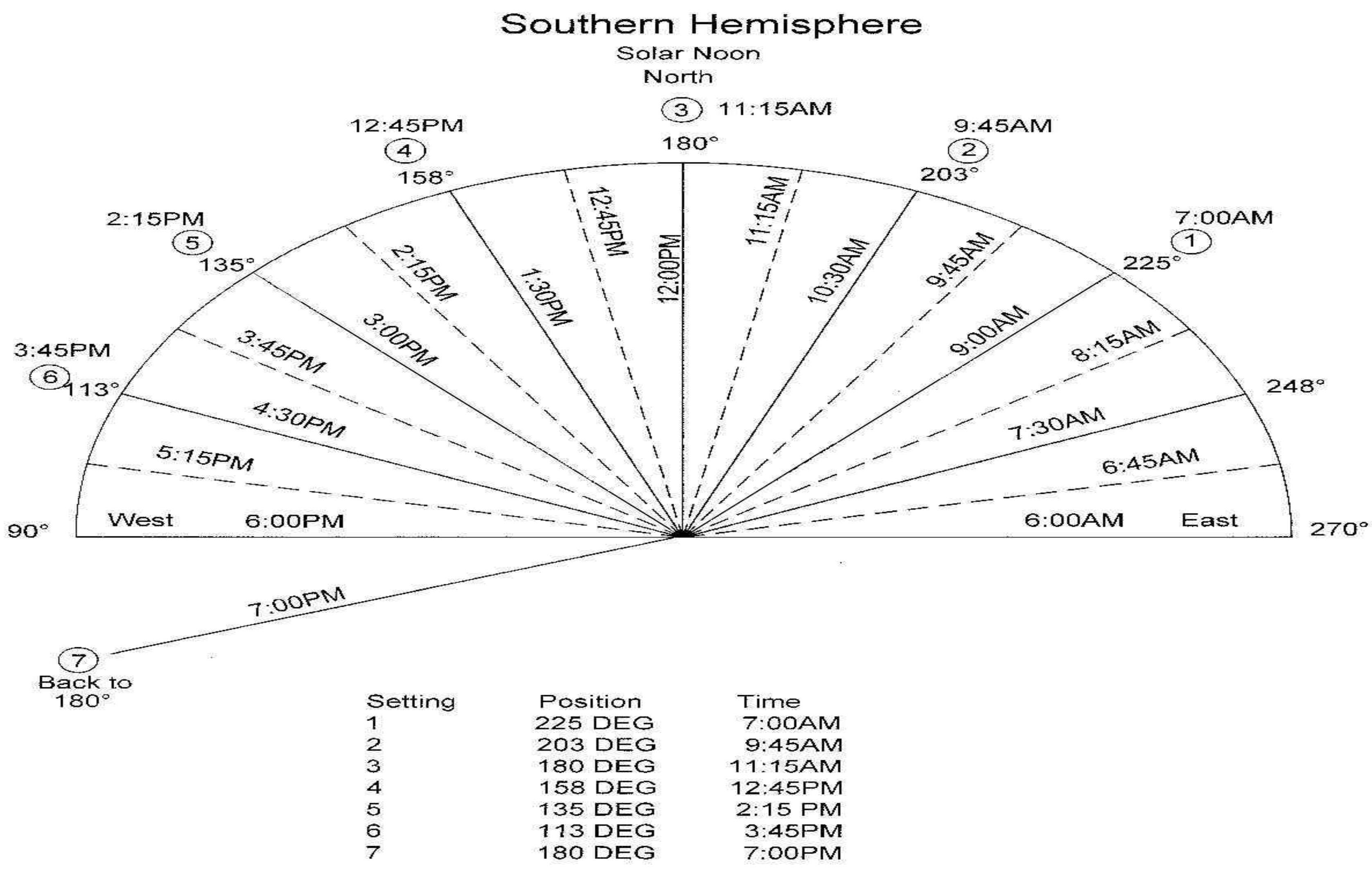
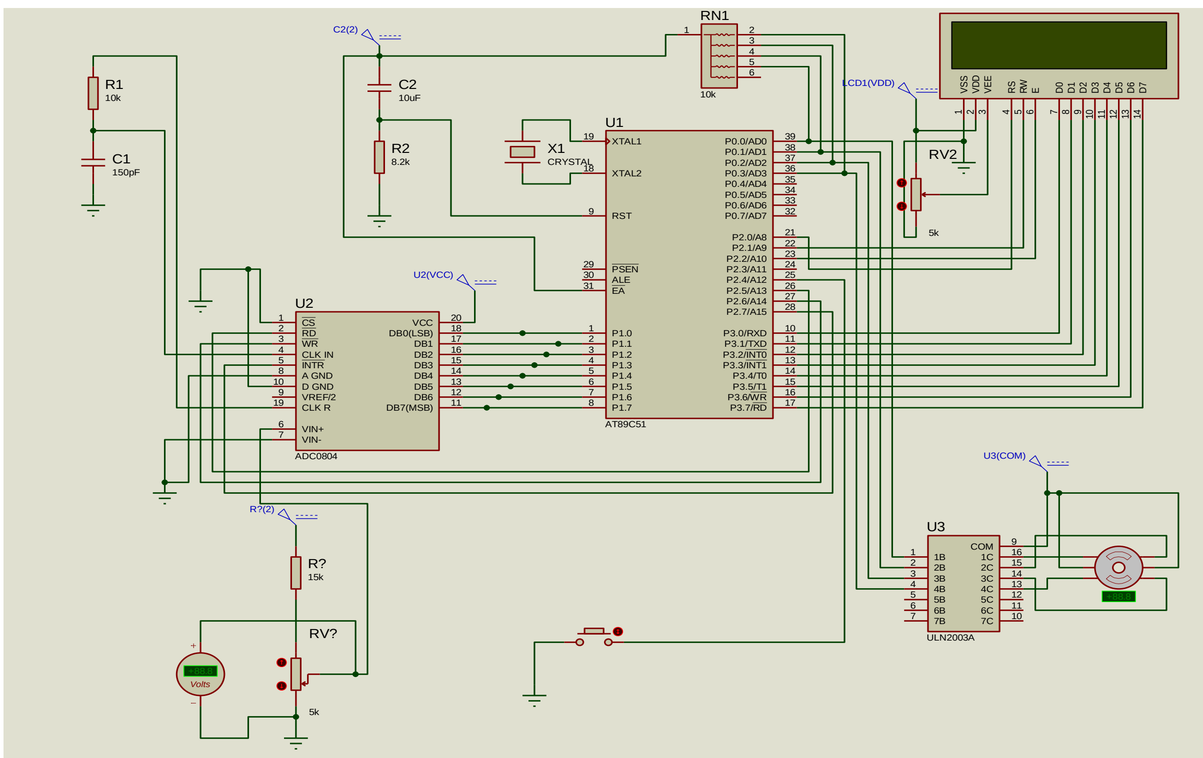


Figure: Elevation of sun for southern hemisphere

What the tracker does is that it just follows the sun. It sticks to the sun like glue all the day, whether it is clear sky or cloudy sky. The tracker takes command from the micro controller and follows the sun according to it's way of travel.

3.3 Complete Circuit



3.4 Program

```
////SOLAR TRACKER

#include <Servo.h>

Servo myservo;  // create servo object to control a servo  control


int pos = 0;    // variable to store the servo position

void setup()
{
  myservo.attach(9);  // attaches the servo on pin 9 to the servo object
}


void loop()
{
  for(pos = 0; pos < 180; pos += 23)  // goes from 0 degrees to 180 degrees
  {                                   // in steps of 23 degree
    myservo.write(pos);              // tell servo to go to position in variable 'pos'
    delay(3600000);                       // waits 3600000ms for the servo to reach the position
  }
  for(pos = 180; pos>=1; pos-=23)     // goes from 180 degrees to 0 degrees
  {
    myservo.write(pos);              // tell servo to go to position in variable 'pos'
    delay(15);                       // waits 15ms for the servo to reach the position
  }
}
```

3.5 Analysis and Perception

The six main functions of a Solar Tracker are the methods of tracker mount, drives, sensors, motors, data acquisition and the Solar Tracker solving algorithm. There are a few methods of tracker mount and drive that is available for use. Each of the methods had their advantages and disadvantages. Of particular interest would be the single-axis and ch ronological tracker method as it has symmetric placements and turnings of the motor.

Different motors are available on the market to drive the mouse as reviewed. The servo motors are highly recommended as they have precise motor movements and consume power only when moving. One thing that would turn against them would be the cost they bring to the project. As for the DC motors, although they are easy to control and cheaper to buy, they consume lots of power and are harder to maintain.

Chapter 4

Overview of hardware and software

We have used Matlab R2009 as the main platform of our work and used several function references under Bioinformatics Toolbox.

4.1 Hardware

4.1.1 Panel supporting structure construction:

- ✓ Galvanized pipes for the panel & tracker support
- ✓ Angular base alignment for the rotor, bearing & panel shaft connected to the rotating motor
- ✓ Brackets to hold the panel

Description:

We decided to make the installation removable so that the tracker and solar panel could be taken down when needed. We placed 2 inch pipe flanges in two iron bases so that we could use threaded 2 inch galvanized pipes for the tracker vertical support.

We placed the 2 inch pipes into the flanges. Two more flanges were placed on top of the pipes and a 4 inch caster with the wheel removed was bolted to the flanges to provide support for the main diagonal pipe support.

The length of the 2 inch vertical pipe supports was determined to allow for an angle of latitude minus 15 degrees which is the best angle for the summer. This places the solar panel at an angle of 90 degrees to the sun at solar noon. The angle is measured from a line that is parallel to the ground. Two ½ inch holes were drilled in the pipe 2 inches from each end. With the wheel removed the caster makes a great support for the diagonal pipe. We used the ½ inch bolt that came with the caster that went through the wheel to secure the pipe. The rotator was mounted onto the diagonal support pipe using the customized U-bolts which we made. The bottom of the rotator was placed 5 inches from the bottom of the diagonal support pipe. A second piece of 1-1/4 inch by 68 inch EMT was placed into the rotator and was secured by the U-bolts. The opposite end of the top support pipe was mounted through a bearing. It was then attached to the bottom support pipe by the bolts and clamp supplied with the bearing. The bearing was placed 3 inches from the end of the top support pipe.

Brackets were used to secure the solar panel to the top support pipe. We had to bend the bracket to square it up. We drilled holes through the bracket into the center of a 1-1/2 inch by 1-1/2 inch aluminum angle that was attached to the solar panel. We had to cut out a small circular piece of the angle to make room for the top pipe. The location of the bracket along the top pipe will also depend upon where the holes on the panel are.

Panel Frame

Standing Structure

Top Bearing

Motor support and bottom bearing

4.1.2 Microcontroller & Arduino

4.1.2.1 Microcontroller

In this system we used ATMEGA 2560 (Manufactured by Atmel) Microcontroller. We programmed the MCU using C. We used Arduino to load the program into the MCU.

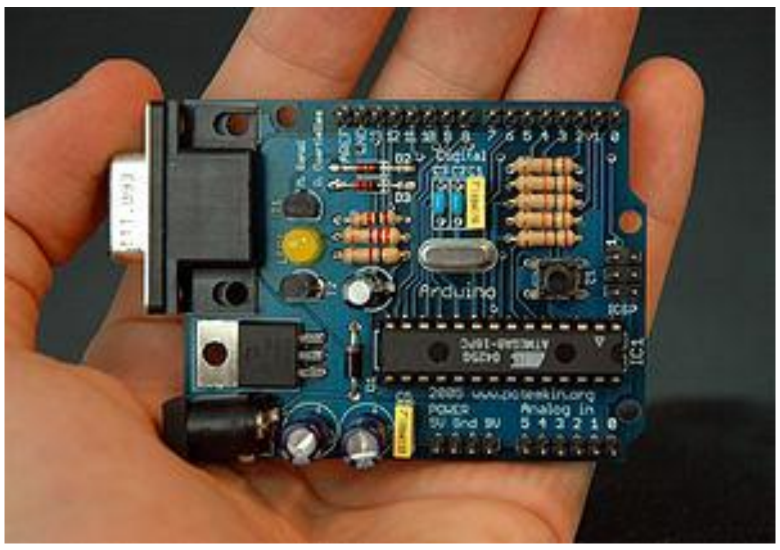


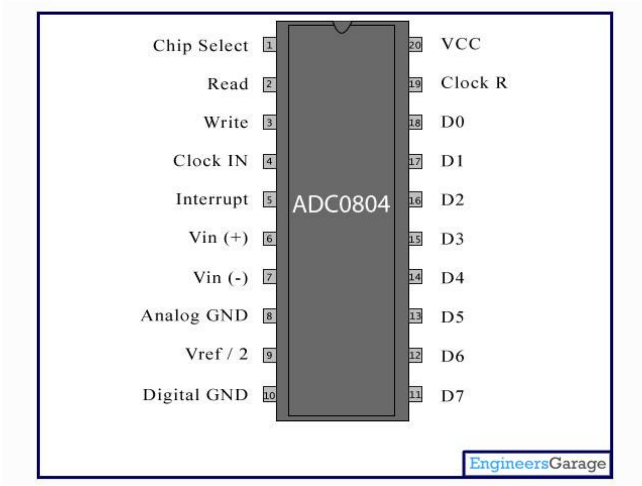
Figure: Arduino

Figure: ATMEGA 2560

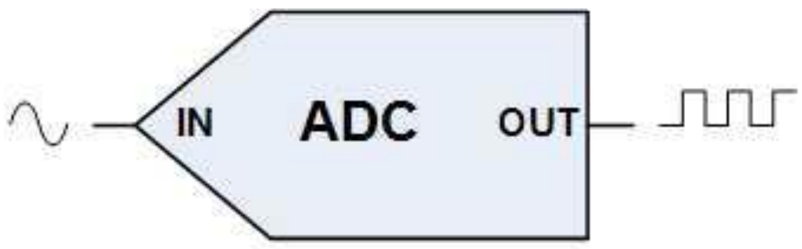
4.1.2.2 Arduino

Arduino is an open-source single-board microcontroller, descendant of the open-source Wiring platform designed to make the process of using electronics in multidisciplinary projects more accessible. The hardware consists of a simple open hardware design for the Arduino board with an Atmel AVR processor and on-board input/output support. The software consists of a standard programming language compiler and the boot loader that runs on the board.

4.1.3 ADC (Analog-to-Digital Converter)



An analog-to-digital converter (abbreviated ADC, A/D or A to D) is a device that converts a continuous quantity to a discrete time digital representation.



ELECTRICAL SYMBOL FOR ANALOG TO DIGITAL CONVERTER (ADC)

Typically, an ADC is an electronic device that converts an input analog voltage or current to a digital number proportional to the magnitude of the voltage or current.

For details of the ADC 0804 that we have used, please look into the appendix.

4.1.4 Motor Driver IC

MC 330 30P IC was used for servo motor control in our system because the MCU couldn't supply sufficient current to drive the servo motor. MC 330 30P supports TTL, DTL, MOS or CMOS compatible inputs.

For details of the Motor IC that we have used, please look into the appendix.

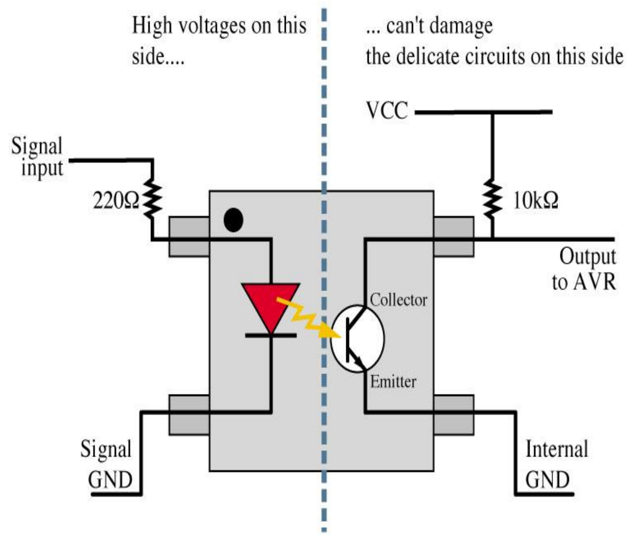
4.1.5 Motor

The servo motor is paired with some type of encoder to provide position/speed feedback. This feedback loop is used to provide precise control of the mechanical degree of freedom driven by the motor. A servomechanism may or may not use a servomotor. For example, a household furnace controlled by a thermostat is a servomechanism, because of the feedback and resulting error signal, yet there is no motor being controlled directly by the servomechanism. Servo motors have a range of 0°-180°.

Servo motors are not the only means of providing precise control of motor output. A common alternative is a stepper motor. In a stepper motor, the input command specifies the desired angle of rotation, and the controller provides the corresponding sequence of commutations without the use of any feedback about the position of the system being driven.

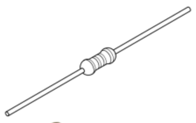
4.1.6 Optocoupler

In electronics, an **opto-isolator**, also called an **optocoupler**, **photocoupler**, or **optical isolator**, is "an electronic device designed to transfer electrical signals by utilizing light waves to provide coupling with electrical isolation between its input and output". The main purpose of an opto-isolator is "to prevent high voltages or rapidly changing voltages on one side of the circuit from damaging components or distorting transmissions on the other side." Commercially available opto-isolators withstand input-to-output voltages up to 10 kV and voltage transients with speeds up to 10 kV/μs



4.1.7 Other Components

Resistors



Capacitors

Zener diode

Network resistor

LCD

4.2 Software

In this system we used ATMEGA 2560 (Manufactured by Atmel) Microcontroller. We programmed the MCU using **C**. We used Arduino to load the program into the MCU.

Chapter 5

Critical Review and Reflections

When we took the project of building a solar tracker which attempted to navigate to the best angle of exposure of light from the sun, we were apprehensive because we had no prior experience in this area.

For the initial report, we focused in onto the various solar trackers that had been created through journals and online reading. We also researched the various methodologies and technologies available for the solar tracker project.

We arranged few meetings with our project instructor to discuss on the concept of solar tracker.

5.1 Problems Encountered

The problem we faced was in the selection for the appropriate stepper motor. In the prototype we used a motor of low torque. But for the real case we needed a motor of high capacity and high torque. This type of motor is rare in the market.

5.2 Prospect of Solar Power in Bangladesh

At present the official generation capacity of Bangladesh Power Development Board is around 5500MW, while it can practically generate less than 4500MW. The government has taken up various power projects which will add around 5000MW by 2014 and further 5500MW by 2017. The Government is giving its best effort to reach the goal of providing electricity to the entire population by the year 2020.

Salient features of the government’s policy on solar energy:

- Policy sets target to meet 5% of the total power demand by 2015 and 10% by 2020.
- Create enabling environment and legal support to encourage the use of solar energy.
- Promote development of local technology in the field of solar energy.
- Provide fund for the development of standardized solar energy configurations to meet common energy and power applications.
- Released VAT in solar panel import, local production and distribution.
- Reduced the tax on the solar panel from 3% to 0%.
- Reduced the tax and VAT on import of energy saving lights from 7% to 0%.
- Bangladesh Bank has sanctioned a revolving fund of 150Crore Tk. for solar energy projects.
- Renewable energy project investors both in public and private sectors shall be exempted from corporate income tax for a period of 5 years.
- Provide fund for the development of standardized solar energy configurations to meet common energy and power applications.
- Released VAT in solar panel import, local production and distribution.
- Reduced the tax on the solar panel from 3% to 0%.
- Reduced the tax and VAT on import of energy saving lights from 7% to 0%.

5.3 Present Application

5.3.1 Rotating Buildings

This cylindrical house in Austria (latitude above 45 degrees north) rotates in its entirety to track the sun, with vertical panels mounted on one side of the building. This *Gemini House* is a unique example of a vertical axis tracker

Gemini House rotates in its entirety and the solar panels rotate independently, allowing control of the natural heating from the sun

5.3.2 Floating House

ReVolt House is a rotating floating house designed by TU Delft students. The house would be realized in September 2012. A closed façade turns itself towards the sun in summer to prevent the interior space from direct heat gains. In winter, the glass façade faces the sun to get direct sunlight in the house.

ReVolt House, TU Delft's entry to Solar Decathlon Europe 2012.

5.4 Future Developments

The future of primary energy sources are renewable energies like solar and the future of solar energy is **CSP**. CSP is **C**oncentrated **S**olar **P**ower. It is a technique of concentrating the sunlight to a fixed focal point using the help of **S**olar **T**rackers. CSP is still in the R&D process. Presently USA, SPAIN and CHINA are operating some of this type of power stations.

Solar house is also in R&D level which would be not only eco-friendly but also cost-effective.

5.4.1 Concentrated Solar Power

Concentrated solar power (also called **concentrating solar power**, **concentrated solar thermal**, and **CSP**) systems use mirrors or lenses to concentrate a large area of sunlight, or solar thermal energy, onto a small area. Electrical power is produced when the concentrated light is converted to heat, which drives a heat engine (usually a steam turbine) connected to an electrical power generator.

CSP is being widely commercialized and the CSP market has seen about 740 MW of generating capacity added between 2007 and the end of 2010. More than half of this (about 478 MW) was installed during 2010, bringing the global total to 1095 MW. Spain added 400 MW in 2010, taking the global lead with a total of 632 MW, while the US ended the year with 509 MW after adding 78 MW, including two fossil–CSP hybrid plants.

CSP growth is expected to continue at a fast pace. As of April 2011, another 946 MW of capacity was under construction in Spain with total new capacity of 1,789 MW expected to be in operation by the end of 2013. A further 1.5 GW of parabolic-trough and power-tower plants were under construction in the US, and contracts signed for at least another 6.2 GW. Interest is also notable in North Africa and the Middle East, as well as India and China. The global market has been dominated by parabolic-trough plants, which account for 90 percent of CSP plants.

CSP is not to be confused with concentrated photovoltaics (CPV). In CSP, the concentrated sunlight is converted to heat, and then the heat is converted to electricity. In CPV, the concentrated sunlight is converted directly to electricity via the photovoltaic effect.

5.4.2 Solar Tree

A **solar tree** is a decorative means of producing solar energy. It uses multiple solar panels which form the shape of a tree by assistance of poles. Solar trees can double as street lights. The solar tree can produce 50% more power than a flat solar power layout during winter, and 20% more power during other seasons.

5.4.3 Solar Home

A solar home uses free energy from the sun for heat and light and power.

Passive solar homes are designed to make use of the sun's free heat and light, allowing, for example, the sun to shine deeply into the house during cold months to be absorbed by the mass of floor or walls and then radiated out slowly at night.

Solar electric homes *actively* use photovoltaic technology to convert sunlight to electrical power. Solar home power gives freedom from dependence on rising utility prices. It can power a house far away from utility power or can be tied into the utility in a give and take relationship.

But a solar powered home is much more than this. Before mounting solar panels onto a home, the owner must consider a very important concept: the house's energy efficiency. The very first step towards creating a solar home is to convert an energy wasteful home into a lean, clean energy efficient home. More on how to make your home energy efficient.

5.5 Conclusion

This project had been a great learning experience. Apart from engineering skills, we also learnt time management skills, project management skills and experience in starting a project which we had no idea about. We also learnt a great deal about working as a team.

The main reason for pursuing this project was to establish the idea that a solar tracker can reduce the cost of the energy we want to capture.

After some discussion with team partner and the supervisor, we agreed to implement chronological tracker rather than tracker with sensor.

There is still room for improvement in this system. And it is hoped that further study can be carried out to further develop the system. Improvements can be done to the design of structure e.g by adding covers for the motors. Double axis tracker would increase the efficiency of the system. Also a detailed study should be carried outto ascertain the percentage increase of electricity yield by using this system to establish whether or not the system is viable. Moreover the cost-effectiveness and the payback period are also to be considered.

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