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DHAKA, BANGLADHESH

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DESIGNING AND CONSTRUCTION OF SOLAR TRACKER

A thesis submitted to the Department of Mechanical and Chemical Engineering (MCE), Islamic University of Technology (IUT), in the partial fulfillment of the requirement for degree of Bachelor of Science in Mechanical Egineering.

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CERTIFICATE OF RESEARCH

The thesis title **“DESIGNING AND CONSTRUCTION OF SOLAR TRACKER”** submitted by Abdullah **(Student no: 131441)** and**Jebreel Muhammad (Student no: 131401)** has been accepted as satisfactory in partial fulfillment of the requirement for the Degree of BSc in Mechanical and Chemical Engineering on November, 2017.

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DECLARATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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I wish to take this opportunity to express my sincerest gratitude and heartiest thanks to my dear parents and family members for being such delightful people and the inspiration for our effort. Without their prayers, continued encouragement, moral and financial support, it would not have been easy for us to accomplish this work, indeed their reward is with the Almighty Allah.

I also thank to all my friends, colleagues and whoever helped us in the course of our work and or write-up.

We seek excuse for any errors that might occur in this report despite of our best efforts.

ABSTRACT:

The crucial purpose of our systematic experimental technique is to concentrate the solar radiation on the solar panel i.e. to construct a solar tracker system which will be capable of converting maximum sun light to electrical energy in accordance with the direction of the sun. Finally our Create a non-soldering, inexpensive, "smart" computer controlled, dual axis tracker for school and home use.

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CHAPTER 1:Introduction

1.1: Background information:

Solar energy has emerged as a viable source of renewable energy for the past two or three decades and now is widely used for industrial and domestic applications. Our systematic study deals with the eradication of the world's vital issue which is the Energy Crisis. As world population is increasing day by day which leads to the maximum demand of energy sources. We are well aware that most of the rural areas in developing countries like Bangladesh, Pakistan Afghanistan etc. not able to access electricity. Our experimental approach will play significant role to get rid of this problem. After studying several researchers work we are able enough to conduct experimental study.

In any kind of use of solar energy there are mainly two basics steps to follow, the first step is to receive the energy from solar as a radiation and the second step is to store the energy in battery or in a solid metal.

The first step is that to receive the energy is done by using solar panel made of silicon; this is the very important point of using energy. Because the efficiency of whole solar system depends on how the efficiency panel is receiving. It is always desired to get the beam radiation and to reduce the amount of diffused radiation.

1.2: PRINCIPLE:

Our tracker is an **active tracker** which is controlled by computer program (via an Arduino). This means that we use sensors to find the brightest source of light at all times. If you were to take a flashlight and shine it at the sensors the tracker would follow it around. While this is the most interactive and exciting kind of tracking we can build, it's also overkill for larger setups.

The sun is highly predictable. If you can easily look up the time of every sunrise and sunset for the next 100 years as well as use some simple math to figure out the angle of the sun relative to your location at any time of the year. With this in mind many people end up using a scheduled tracker. This system uses a computer program that changes the angle of the panel based on the date, time, and physical location. While not as fancy or exciting as an active tracker, it is in fact far more efficient provided everything is set up properly. We can be sure that our panel is at the mathematically most efficient spot possible even under heavy cloud coverage.

Since our program is rather simple we've opted to use an Arduino Uno. The Arduino is extremely common for DIY projects as well as quite inexpensive to buy. The Arduino platform is also very easy to for anyone to learn or just modify code using a home computer, something we'll get into later on.

We're using two "micro" servos in the 9g size. We're opting to use ones with metal gears (our kits also include these) since we want our project to last a very long time. The metal gear versions also provide a bit more torque than the plastic geared versions. If you want to use larger servos you can easily modify our laser cut files.

For sensors we're using four light sensitive (detecting) resistors, also known as LDRs. Again, these are super common and you can often find them in outdoor garden lights or indoor night lights. They work by changing their resistance level based on how much light is hitting them. The more light, the less resistance they have.

Move within a certain predefined area (as to not damage the rest of the project) and at a set speed. These two aspects can also be changed very easily in the code. We'll show you how to do this later on.

To also help things along and remove a bunch of wiring we're using an Arduino Sensor Shield. This is mainly to plug the two Servos into. If you're building this from scratch you could go without, but Sensor Shields are inexpensive and makes life a lot easier.

1.3: Scope of project:

This project will help in getting high efficiency and the use of solar energy. Today's time solar cells are becoming extremely popular for utilizing solar energy to use in different ways such as producing electricity, transportation etc. so many solar panels have been installed all over the world and most of them are stable. They are installed in the direction of maximum radiation of sunlight. Now the problem arises is that the sun is moving. So we cannot use maximum radiation of sun all the time. The position of maximum radiation receiving only comes in 24 hours. The crucial and innovative objective of this project will be to develop a model that could yield maximum chances of improvising already made solar panels and ensure the capability of receiving maximum radiation from moving sun.

1.4:Limitation of this project:

In this project we will track the sunlight by using sensors like LDR (Light Dependent Resistor)

- For these types of sensors there must be the direct rays to fall in the sensor to track the sun properly. But in rainy days the tracking system may not work properly.

- Solar panels can be costly to install resulting in a time lag of many years for savings on energy bills to match initial investments.

- Generation of electricity from solar is dependent on the country's exposure to sunlight. This means some countries are slightly disadvantaged.

- Solar power stations do not match the power output of conventional power stations of similar size. Furthermore, they may be expensive to build.

- Solar power is used for charging large batteries so that solar powered devices can be used in the night. The batteries used can be large and heavy, taking up plenty of space and needing frequent replacement.

CHAPTER 2: Literature review:

A solar tracker is a device used for orienting a photovoltaic array solar panel or for concentrating. Solar reflector or lens toward the sun. The position of the sun in the sky is varied both with

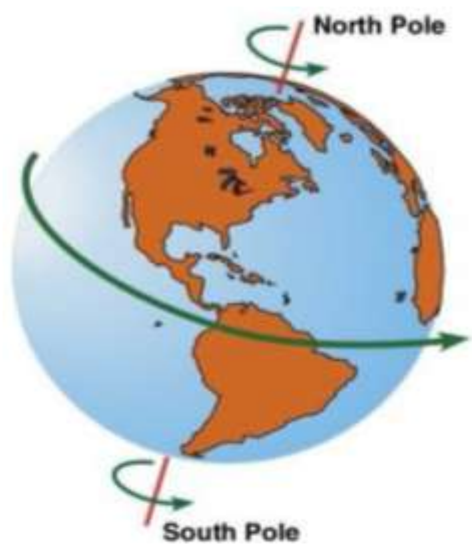
Seasons and time of day as the sun moves across the sky. Solar powered equipment work best when they are pointed at the sun. Therefore, a solar tracker increases how efficient such equipment is over any fixed position at the cost of additional complexity to the system. There are different types of trackers.

Extraction of usable electricity from the sun became possible with the discovery of the photoelectric mechanism and subsequent development of the solar cell. The solar cell is a Semiconductor material which converts visible light into direct current. Through the use of solar arrays, a series of solar cells electrically connected, there is generation of a DC voltage that can be used on a load. There is an increased use of solar arrays as their efficiencies become higher.

They are especially popular in remote areas where there is no connection to the grid.Photovoltaic energy is that which is obtained from the sun. A photovoltaic cell, commonlyknown as a solar cell, is the technology used for conversion of solar directly into electrical power. The photovoltaic cell is a non-mechanical device made of silicon alloy.The photovoltaic cell is the basic building block of a photovoltaic system. The individual cellsCan vary from 0.5 inches to 4 inches across. One cell can however produce only 1 or 2 watts that is not enough for most appliances. Performance of a photovoltaic array depends on sunlight. Climatic conditions like clouds and fog significantly affect the amount of solar energy that is received by the array and therefore its performance. Most of the PV modules are between 10 and 20 percent efficient.

2.2 The Earth: Rotation and Revolution

The earth is a planet of the sun and revolves around it. Besides that, it also rotates around its ownaxis. There are thus two motions of the earth, rotation and revolution. The earth rotates on its axis from west to east. The axis of the earth is an imaginary line that passes through the northern and southern poles of the earth. The earth completes its rotation in 24 hours. This motion is responsible for occurrence of day and night. The solar day is a time period of 24 hours and the duration of a sidereal are 23 hours and 56 minutes. The difference of 4 minutes is because of the fact that the earth's position keeps changing with reference to the sun.



The movement of the earth round the sun is known as revolution. It also happens from west to East and takes a period of 365 days. The orbit of the earth is elliptical. Because of this the distance between the earth and the sun keeps changing. The apparent annual track of the sun via the fixed stars in the celestial sphere is known as the ecliptic. The earth's axis makes an angle of 66.5 degrees to the ecliptic plane. Because of this, the earth attains four critical positions with reference to the sun.

2.3 Solar Irradiation: Sunlight and the Solar Constant

The sun delivers energy by means of electromagnetic radiation. There is solar fusion that results From the intense temperature and pressure at the core of the sun. Protons get converted into helium atoms at 600 million tons per second. Because the output of the process has lower energy than the protons which began, fusion gives rise to lots of energy in form of gamma rays that are absorbed by particles in the sun and re-emitted.

The total power of the sun can be estimated by the law of Stefan and Boltzmann.
$P=4\pi r2\ \sigma\epsilon T4$ W .

T is the temperature that is about 5800K, r is the radius of the sun which is 695800 km and **σ** is The Boltzmann constant which is 1.3806488 × 10-23 m2 kg s-2 K-1. The emissivity of the surface is denoted by **ϵ.** Because of Einstein's famous law E=mc2 about millions of tons of matter are converted to energy each second. The solar energy that is irradiated to the earth is 5.1024 Joules per year. This is 10000 times the present worldwide energy consumption per year.
Solar radiation from the sun is received in three ways: direct, diffuse and reflected.
Direct radiation: is also referred to as beam radiation and is the solar radiation which travels on astraight line from the sun to the surface of the earth.
Diffuse radiation: is the description of the sunlight which has been scattered by particles and molecules in the atmosphere but still manage to reach the earth's surface. Diffuse radiation has no definite direction, unlike direct versions.
Reflected radiation:describes sunlight which has been reflected off from non-atmospheric surfaces like the ground.

2.4 Sunlight

Photometry enables us to determine the amount of light given off by the Sun in terms of brightness perceived by the human eye. In photometry, a luminosity function is used for the radiant power at each wavelength to give a different weight to a particular wavelength that models human brightness sensitivity. Photometric measurements began as early as the end of the 18th century resulting in many different units of measurement, some of which cannot even be converted owing to the relative meaning of brightness. However, the luminous flux (or lux) is commonly used and is the measure of the perceived power of light. Its unit, the lumen, is concisely defined as the luminous flux of light produced by a light source that emits one candela of luminous intensity over a solid angle of one steradian. The candela is the SI unit of luminous intensity and it is the power emitted by a light source in a particular direction, weighted by a luminosity function whereas a steradian is the SI unit for a solid angle; the two-dimensional angle in three-dimensional space that an object subtends at a point.

2.4.1 Elevation angle

The elevation angle is used interchangeably with altitude angle and is the angular height of the sun in the sky measured from the horizontal. Both altitude and elevation are used for descriptionof the height in meters above the sea level. The elevation is 0 degrees at sunrise and 90 degrees when the sun is directly overhead. The angle of elevation varies throughout the day and also depends on latitude of the particular location and the day of the year.

2.4.2 Zenith angle

This is the angle between the sun and the vertical. It is similar to the angle of elevation but is measured from the vertical rather than from the horizontal. Therefore, the zenith angle = 90 degrees – elevation angle.

2.5 Types of solar trackers and tracking technologies

There are various categories of modern solar tracking technologies;

2.5.1 Active tracker

Active trackers make use of motors and gear trains for direction of the tracker as commanded bythe controller responding to the solar direction. The position of the sun is monitored throughout the day. When the tracker is subjected to darkness, it either sleeps or stops depending on the design. This is done using sensors that are sensitive to light such as LDRs.

Their voltage output is put into a microcontroller that then drives actuators to adjust the position of the solar panel.

2.5.2 Passive solar tracking

Passive trackers use a low boiling point compressed gas fluid driven to one side or the other to cause the tracker to move in response to an imbalance. Because it is a non-precision orientation it is not suitable for some types of concentrating photovoltaic collectors but works just fine for common PV panel types. These have viscous dampers that prevent excessive motion in response to gusts of wind.

2.5.3 Single axis trackers

Single axis trackers have one degree of freedom that act as the axis of rotation. The axis of rotation of single axis trackers is aligned along the meridian of the true North. With advanced tracking algorithms, it is possible to align them in any cardinal direction. Common implementations of single axis trackers include horizontal single axis trackers (HSAT), horizontal single axis tracker with tilted modules (HTSAT), vertical single axis trackers (VSAT), tilted single axis trackers (TSAT) and polar aligned single axis trackers (PSAT).

2.5.4 Dual axis trackers

Dual axis trackers have two degrees of freedom that act as axes of rotation. These axes aretypically normal to each other. The primary axis is the one that is fixed with respect to the ground. The secondary axis is the one referenced to the primary axis. There are various common implementations of dual trackers. Their classification is based on orientation of their primary axes with respect to the ground.

2.5 Effect of light intensity

Change of the light intensity incident on a solar cell changes all the parameters, including theopen circuit voltage, short circuit current, the fill factor, efficiency and impact of series and shunt resistances. Therefore, the increase or decrease has a proportional effect on the amount of power output from the panel.

2.6 Efficiency of solar panels

The efficiency is the parameter most commonly used to compare performance of one solar cells to another. It is the ratio of energy output from the solar panel to input energy from the sun. in addition to reflecting on the performance of solar cells, it will depend on the spectrum and intensity of the incident sunlight and the temperature of the solar cell. As a result, conditions under which efficiency is to be measured must be controlled carefully to compare performance Of the various devices.

In ref [1, 6, and 7] experimental study was conducted to convert maximum solar energy in electricity by constructing a multidirectional solar tracker system. They reported that their solar tracking device is able enough to move along X, Y and Z direction, hence enhancing the efficiency by absorbing maximum solar rays. Ref [2, 4] deduced the same result by constructing a solar tracker by incorporating Arduino and DC motor. It was noticed that 30% energy enhancement appeared by using Arduino instead of installing fixed PV panels. In ref [3,5] Okpeki U k constructed Bi-directional solar tracker system to obtain the same objective I.e. availability of maximum electrical energy from sun rays through solar tracker system. They were able enough to construct Bi directional tracer system at cheapest rate and with high efficiency.

CHAPTER 3: DESIGN AND IMPLEMENTATION

3.1 Light Sensor Theory and Circuit of Sensor Used

Light detecting sensor that maybe used to build solar tracker include; phototransistors, photodiodes, LDR and LLS05. A suitable, inexpensive, simple and easy to interface photo sensor is analog LDR which is the most common in electronics. It is usually in form of a photo resistor made of cadmium sulfide (CdS) or gallium arsenide (GaAs).

3.2 Light Dependent Resistor Theory

The simplest optical sensor is a photon resistor or photocell which is a light sensitive resistor these are made of two types, cadmium sulfide (CdS) and gallium arsenide (GaAs). The sun tracker system designed here uses two cadmium sulfide (CdS) photocells for sensing the light. The photocell is a passive component whose resistance is inversely proportional to the amount of light intensity directed towards it. It is connected in series with capacitor.

The photocell to be used for the tracker is based on its dark resistance and light saturation resistance. The term light saturation means that further increasing the light intensity to the CdS cells will not decrease its resistance any further. Light intensity is measured in Lux, the illumination of sunlight is approximately 30,000 lux.

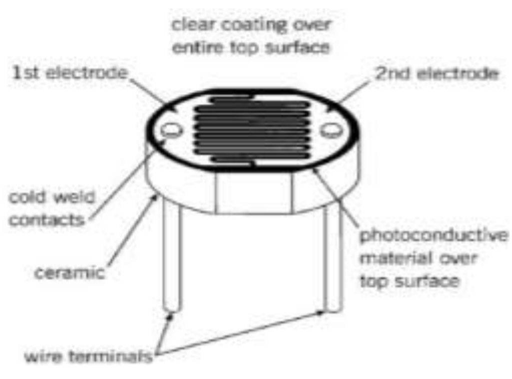


Figure 1: LDR construction

Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when They are illuminated with light resistance drops dramatically. When the light level is low the resistance of the LDR is high. This prevents current from flowing to the base of the transistors. Consequently the LED does not light. However, when light shines onto the LDR its resistance falls.

3.3: Servo motors

It is an electrical device which is mostly used for pushing or rotating an object in specified angular position with effective precision. A simple motor with servo mechanism is called servo motors which is impeccably used in Automation Technology. If it runs by AC power source then it is called AC servo motor or if its runs by DC power source then it is called DC servo motor shown in fig3. It is used for several applications in every sector of field. It is mostly used in Robotics, RC helicopters and planes, or in machines where precise movement is required. These are specifically rated in Kg/cm. For example, 4Kg/cm rated servo motor is capable of lifting 4Kg load while load suspension is 1cm away from the shaft. The main purpose of elucidating Servo motors in this report is to get ourselves familiar with its objective, working principle, application, advantages and disadvantages. However, mainly we are studying as it is widely used in Automobiles for controlling the speed of the Vehicle. Servo motor is mainly classified into several categories and types. However, each classification has its own application in every field.

I AC servo motor

II DC servo motor

III brushless DC servo motor

IV positional rotation

V continuous rotation

VI linear servo motor

Furthermore, Servo Mechanism has following three crucial parts,

1. Controlled device 2. Output sensor 3. Feedback system

3.3.1 How the servo is controlled

Servos are sent through sending electrical pulses of variable width, or pulse width modulation (PWM), through the control wire. There is a minimum pulse, maximum pulse and a repetition rate. Servos can usually turn only 90 degrees in either direction for a total of 180 degrees movement. The neutral position of the motor is defined as that where the servo has the same amount of potential rotation in both the clockwise and counter-clockwise direction. The PWM sent to the motor determines the position of the shaft, and based on the duration of the pulse sent Through the control wire the rotor will turn to the position that is desired [7].

The servo motor expects to see a pulse after every 20 milliseconds and the length of the pulse will determine how far the motor will turn. For instance, a 1.5ms pulse makes the motor to turn in the 90 degrees position. If the pulse was shorter than 1.5ms, it will move to 0 degrees and a longer pulse moves it to 180 degrees. This is shown below.

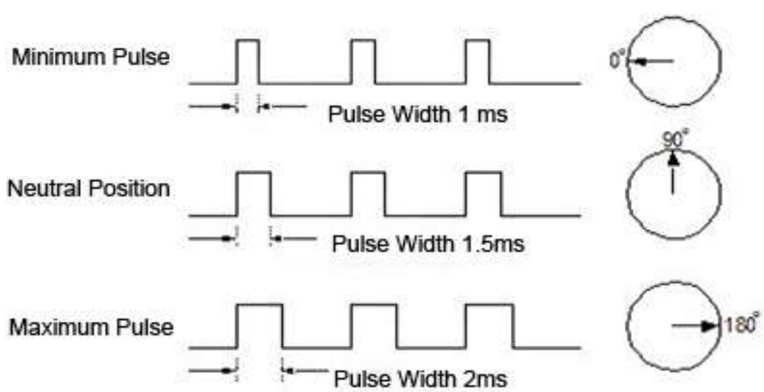


Figure 2: variable pulse width control servo position

For applications where there is requirement of high torque, servos are preferable. They will also maintain the torque at high speeds, up to 90% of the rated torque is available from servos at high Speeds. Their efficiencies are between 80 to 90%. A servo is able to supply approximately twice their rated torque for short periods of time, offering enough capacity to draw from when needed. In addition, they are quiet, are available in AC and DC, and do not suffer from vibrations.

3.3.2 Advantages and disadvantages of servo motors

For applications where high speed and high torque are required, servo motors are the better option. While stepper motors peak at around 2000 RPM, servos are available at much faster speeds. Servo motors also maintain torque at high speed, up to 90% of the rated torque is available from servos at high speeds. They have an efficiency of about 80-90% and supply roughly twice their rated torque for short periods. Furthermore, they do not vibrate or suffer fromresonance issues.

Servo motors are more expensive than other types of motors. Servos require gear boxes, especially for lower operation speeds. The requirement for a gear box and position encoder makes the designs more mechanically complex. Maintenance requirements will also increase.

3.3.3 Microcontroller

Microcontroller is a single chip microcomputer made through VLSI fabrication. A microcontroller also called an embedded controller because the microcontroller and its support circuits are often built into, or embedded in, the devices they control. A microcontroller is available in different word lengths like microprocessors (4bit, 8bit, 16bit, 32bit, 64bit and 128 bit microcontrollers are available today).

A microcontroller contains one or more of the following components:

- Central processing unit (CPU)
- Random Access Memory (RAM)
- Read Only Memory (ROM)
- Input/output ports

- Timers and Counters
- Interrupt controls
- Analog to digital converters
- Digital analog converters
- Serial interfacing ports
- Oscillatory circuits

3.3.4: Block Diagram:

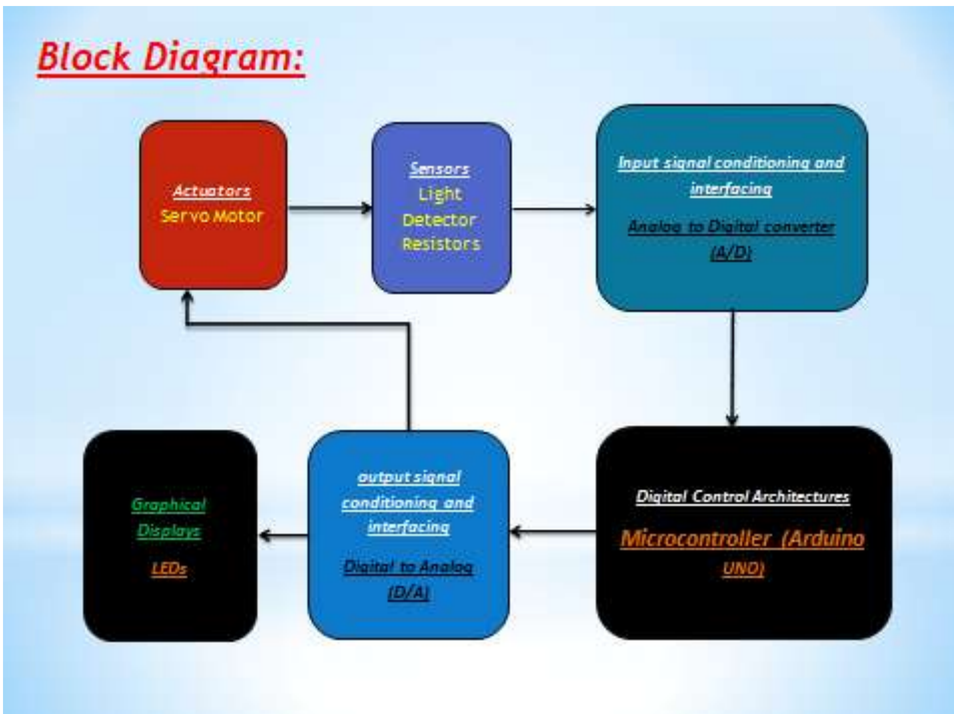


Figure 3: Block Diagram

3: Construction sequence of the Project:

4.1: ***Attach the Servo Arms to Their Mounts:***

We started with constructing the base of the project by using PVC sheet. By using anti-cutter we divided our base into the desired parts also drilled holes. We drilled four holes surrounding a larger center hole. We'll be attaching the **Servo Arm** to two of these holes.

Start by laying the round PVC sheet piece on the table with the etched arrow facing down. The arrow side is our "top" side, and we want the **Servo Arm** to be screwed into the "bottom" side.. Be sure that the crown of the Servo Arm is facing up, and not buried in the hole and line up the little holes of the **Servo Arm** with two of the holes in the wood. In our case this resulted in us using the second hole on one side and the third hole on the other.

We attached the desired parts by using glue instead of screws. We prefer to get both our screws set a bit into the plastic before we start to screw them into the wood. We made sure they're both secure in the PVC sheet.

We'll have done the same thing to one of our two triangle shaped braces. They're both identical so it doesn't matter which one you choose.By following the same procedure using another **Servo Arm** and two more **Size 2**.

4.2:Building the Base:

By grabbing the very base plate, the four legs, and the large round piece that now has a **Servo** attached to it. First attach the four legs to the round servo holder. The **Servo** needs to be inside all the legs, between the base plate and the round servo holder. Then we fit the four legs into the base plate. By doing so we made sure the position of the wire so that it's coming out towards the back where all our electronics will be. Lastly, we put the four rubber feet on the bottom of the base plate.At this time we also put together the LED display holder. The LED display just fits between the two wooden holders and is secured by glue.

4.3:Building the Top:

Grab the large solar array face. It's the one that says "Solar Cell Here" on it. We'll also need the two triangle wings, the small rounded corner square piece, and the two small sensor divider pieces. Put the face plate on the table in front of you so that you can read the words. Attach the triangle wing piece with the servo arm on the right side, and the other triangle wing piece onto the left side. We want the plastic servo arm to be facing the inside.

4.4:*Build the Center:*

Take the two long pieces, the second servo mount, and the two other pieces that look like your **Servo** mount. Pop them together, and then put them into place on the round board. The **Servo** should be on the "inside", and the arrow side of the round piece should be facing up. At this point you had three PVC structures assembled independently of each other, one very large and long screw, and the two little servo machine screws remaining.

4.5:Home the Base Servo:

Servos move in 180 degrees. The **Servo** knows where "zero" degree is and where "180" degree is. Since we don't want or need full 180 degree range on our servos (we'd be hitting wood or the electronics) we want to set our "zero" degree to some very specific locations.

Start with the **Base** plate **Servo**. Without using the little screws (not yet!) push the **Servo Arm** that's attached to the Center into the servo. This may take a little effort, so you may wish to brace the servo with your other hand. Once together, slowly rotate the **Center** counter clockwise until there servo stops. This is "zero" degrees on the **Servo**.

(If you're doing this from scratch with plastic gear servos, be super careful as you can break the internal gears.) Now take **Center** off your **Servo**. Align **Center** in a similar configuration to the above picture. As you can see, the second **Servo** is near where our **Arduino** will go, and the **Center** is at a 45 degree angle compared to the **Base**. We used one of the two small **Servo Machine Screws** to secure the **Center** and **Base** together.

4.6:Attach the Arduino:

Glued the **Arduino** into place using at least 2 of the M3 Screws and Nuts. You can use all 4 if you'd like, but one in front and one in back should do it. We can also attach the **Sensor Shield** at this time.

4.7:Hook Up the Terminal Block:

Take all four red wires coming from your sensors, twist them together, and put them into the first spot on your Terminal Block. This is the common **Positive**. Now be careful on this wiring. Take the black wire coming from your **Top Left** sensor (it's labeled TL) and put it into the second Terminal block hole. Take **Bottom Left** and go into the third hole. **Top Right** goes into the fourth hole. **Top Left** goes into the fifth hole. Make sure they're all screwed down tight. Grab your **4 Port Terminal Block** and your four **10,000ohm Resistors**. Twist all four **Resistors** together and put them into one of the holes on the **4 Port Block**. In the opposite hole screw in a **Jumper**. That jumper is our common **Negative**. Now grab four **Jumpers**. Each of these **Jumpers** will share a hole with a **Resistor** on our **5 Port Block**. Stick a **Resistor** end and a Jumper into opposite hole of each of the four Black Wire holes. You'll also want to use your last remaining **Jumper** in the opposite hole to your **Common Positive** (with all the red wires) in your **5 Port Terminal Block.**

5.1: SKETCHES:

The following sketch showing our complete geometric setup. In this topic we are going to elaborate every part.

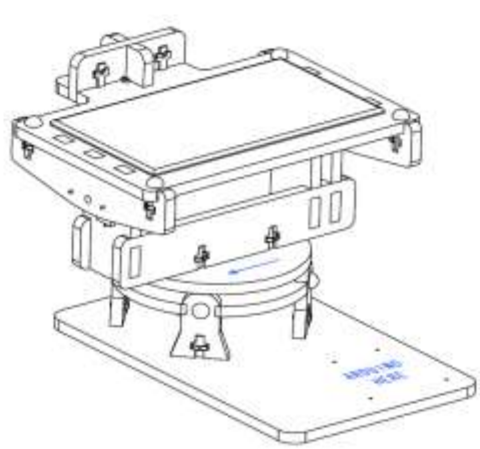


Figure 4:complete geometric setup

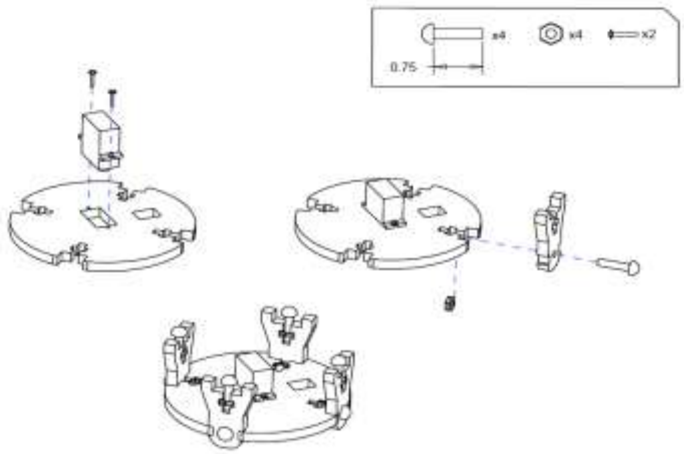


Figure 5:Mounts

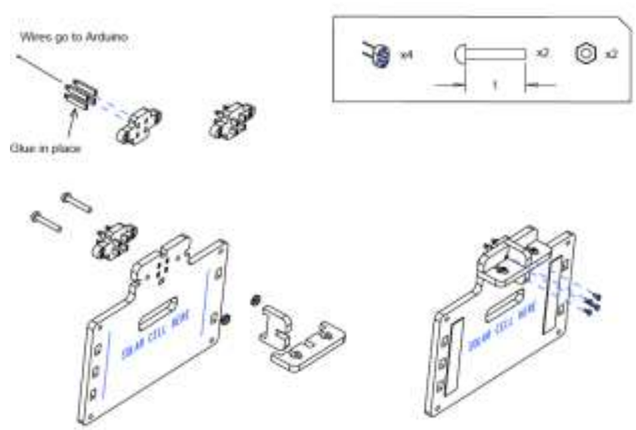


Figure 6:Base

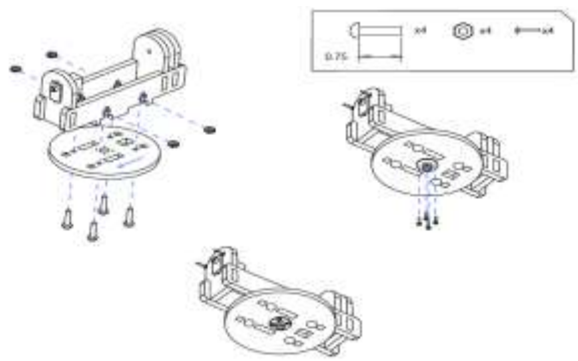


Figure 7:locating base servo

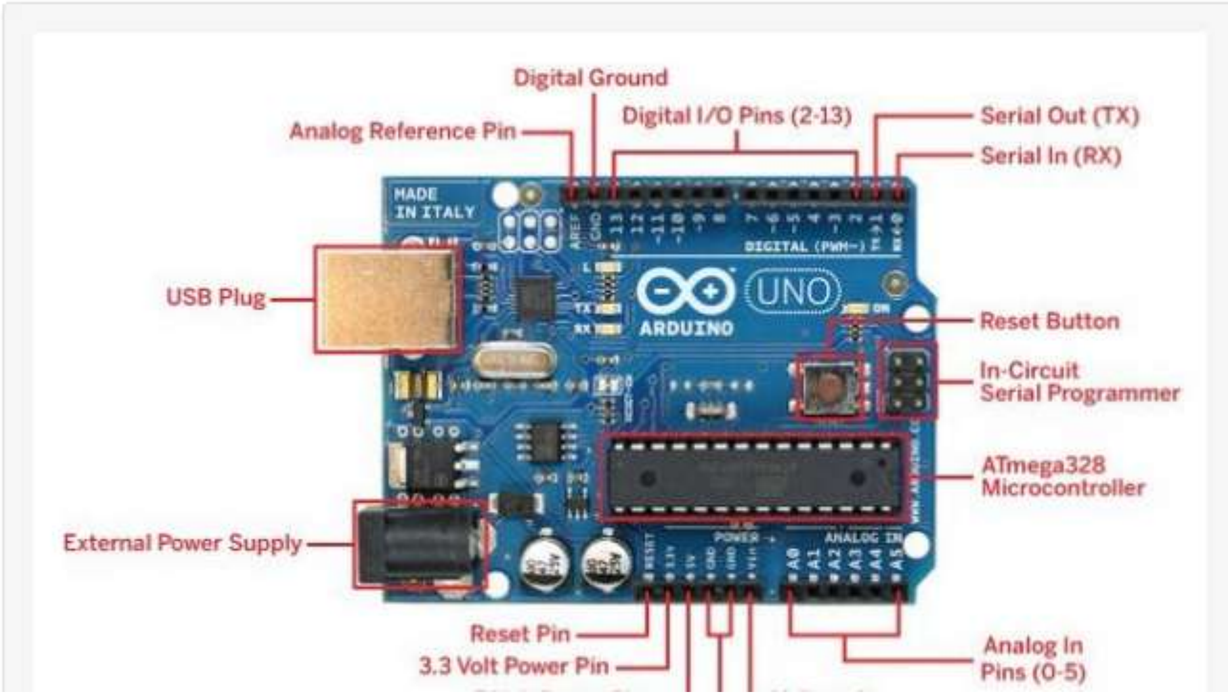


Figure 8: Arduino

5.4: Arduino UNO Shield:

The Arduino Motor Shield allows you to easily control motor direction and speed using an Arduino. By allowing you to simply address Arduino pins, it makes it very simple to incorporate a motor into your project. It also allows you to be able to power a motor with a separate power supply of up to 12v. Best of all, the shield is very easy to find. Aside from being sold a number of places online, they are now stocked by most RadioShack stores. For all of these reasons, the Arduino Motor Shield if a cool little to have in your arsenal for rapid prototyping, and general experimenting.

Step 1: Install

The pins of the official Arduino motor shield will only align with Arduino Uno Rev. 3. In order to make it work with older versions of the Arduino, you will need to trim a few pins off that solar tracker. The motor shield has 2 channels, which allows for the control of two DC motors, or 1 stepper motor.It also has 6 headers for the attachment of Tinkerkit inputs, outputs, and communication lines. The use of these pins is somewhat limited, and therefore not covered in this tutorial.With an external power supply, the motor shield can safely supply up to 12Vand 2A per motor channel (or 4A to a singlechannel).There are pins on the Arduino that are always in use by the shield. By addressing these pins you can select a motor channel to initiate, specify the motor direction (polarity), set motor speed (PWM), stop and start the motor, and monitor the current absorption of each channel.

Step 2: Shield Features

The motor shield has 2 channels, which allows for the control of two DC motors, or 1 stepper motor.

It also has 6 headers for the attachment of Tinkerkit inputs, outputs, and communication lines. The use of these pins is somewhat limited, and therefore not covered in this tutorial. With an external power supply, the motor shield can safely supply up to 12V and 2A per motor channel(or4Atoasinglechannel).There are pins on the Arduino that are always in use by the shield. By addressing these pins you can select a motor channel to initiate, specify the motor direction (polarity), set motor speed (PWM), stop and start the motor, and monitor the current absorption of each channel.

Step 3: Program:

Plug the Arduino into your computer's USB port and open the Arduino development environment.

In order to get the board to do anything, you need to initialize the motor channel by toggling three parameters:

1. First you need to set the motor direction (polarity of the power supply) by setting it either HIGH or LOW.
2. Then you need to disengage the brake pin for the motor channel by setting it to LOW.
3. Finally, to get the motor to start moving, you need to set the speed by sending a PWM command (analog Write) to the appropriate pin.

Step 4: One Motor:

To control a motor using the Arduino Motor Shield, first plug the motor's positive (red) wire into Channel A's + terminal on the motor shield, and the motor's ground (black) wire into channelA's-terminalon the shield.An external power supply is not always necessary, but it drastically improves the motor's performance. It is recommended that you always useone.To connect your external power supply, connect the positive (red) wire from the power supply to the "Vin" terminal, and the ground (black) wire to the "GND" terminal:

Step 5: Two Motors:

Interfacing with two motors is pretty much the same as interfacing with one motor. Simply plug the motor into Channel B.

The only difference code-wise is that you need to engage a second channel to control the second motor.

Here is code for controlling two motors

5.3:Working principle of the tracker:

Motor1:

Case1:

Motor 1 (W-E) is in initial position; if R3 is higher than R1 that means light intensity effecting R1 is higher than effecting R3 and this is the first motivation of the day. In the morning motor 1 (W-E) start to rotate clockwise, until the two sensors are having the same value (R1=R3).

Case 2:

After case one the sensor measured same value. The motor will not rotate, that means the solar cell is now in the correct position facing the sun.

Case 3:

After the case 2 the motor 1 will stop rotating and the sun continues towards West the Eastern sensor (R1) begins to have higher value than Western sensor (R3). So the motor will rotate anticlockwise until sensors read the same value.

Motor2:

Case one:

The Northern sensor (R5) is higher than the Southern sensor (R7). Hence motor 2 starts to clockwise, so the value of R7 increases until the two sensors are having the same value (R5=R7).

Case two:

The southern sensor R7 is higher than the Northern sensor R5. Here motor 2 starts to rotate anticlockwise, hence the value of R5 increases until the two sensors possesses the same value (R5=R7).

Case three:

This case happens when the two sensors read the same value (R5=R7). The motor will not rotate, that means the solar cell is now is in the correct position facing the sun.

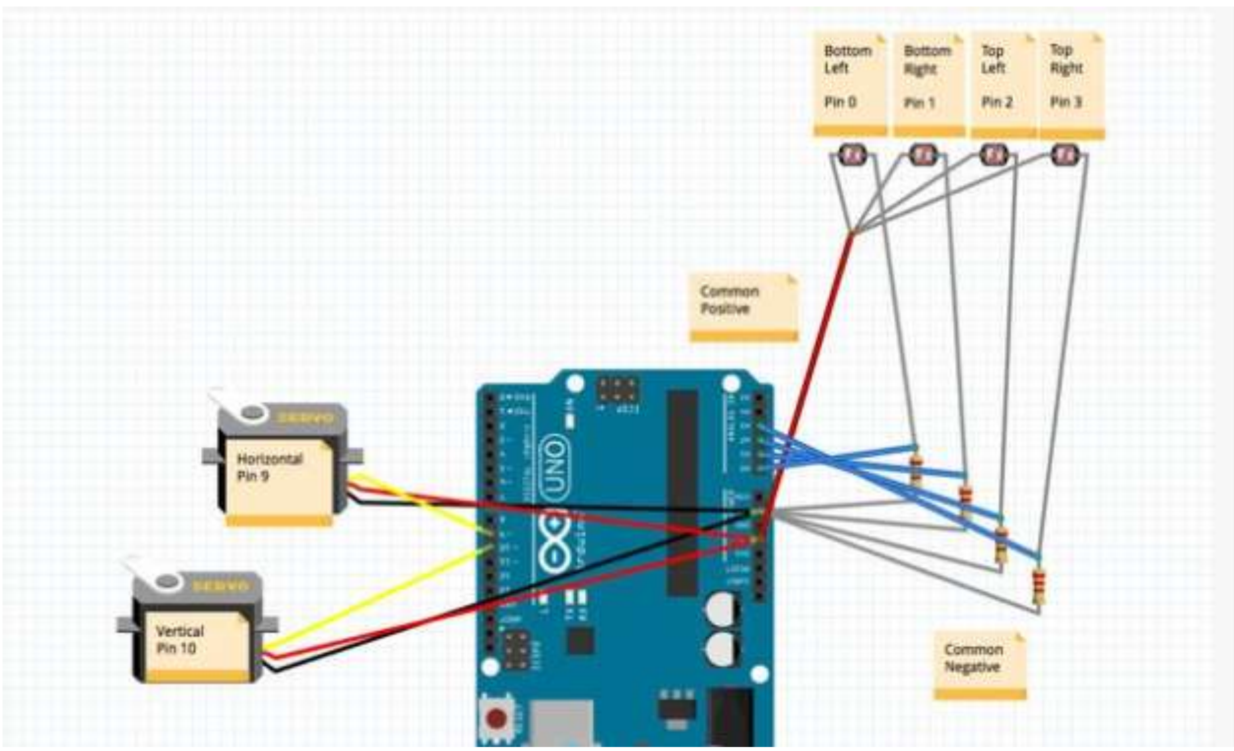


Fig: Embedding sensors with Arduino

Chapter4: Discussion:

5.1 Discussion

The objective of the project was to design a system that tracks the sun for a solar panel. This was achieved through using light sensors that are able to detect the amount of sunlight that reaches the solar panel. The values obtained by the LDRs are compared and if there is a significant difference, there is actuation of the panel using a servo motor to the point where it is almost perpendicular to the rays of the sun.

This was achieved using a system with three stages or subsystems. Each stage has its own role. The stages were;

- An input stage that was responsible for converting sunlight to a voltage.
- A control stage that was responsible for controlling actuation and decision making.
- A driver stage with the servo motor. It was responsible for actual movement of the panel.

The input stage is designed with a voltage divider circuit so that it gives desired range of illumination for bright illumination conditions or when there is dim lighting. This made it possible to get readings when there was cloudy weather. The potentiometer was adjusted to cater for such changes. The LDRs were found to be most suitable for this project because their resistance varies with light. They are readily available and are cost effective. Temperature sensors for instance would be costly.

The control stage has a microcontroller that receives voltages from the LDRs and determines the action to be performed. The microcontroller is programmed to ensure it sends a signal to the servo motor that moves in accordance with the generated error.

The final stage was the driving circuitry that consisted mainly of the servo motor. The servo motor had enough torque to drive the panel. Servo motors are noise free and are affordable,making them the best choice for the project.

6.1:Conclusions:

This project has presented a means of controlling sun tracking array with an embedded microcontroller system. Specifically it demonstrates a working software solution for maximizing solar cell output by positioning a solar array at the point of maximum light intensity. This project presents a searching and tracking of the sun.

A solar panel that tracks the sun was designed and implemented. The required program was written that specified the various actions required for the project to work. As a result, tracking was achieved. The system designed was a single axis tracker. While dual axis trackers are more efficient in tracking the sun, the additional circuitry and complexity was not required in this case. This is because Kenya lies along the equator and therefore there are no significant changes in the apparent position of the sun during the various seasons. Dual trackers are most suitable in regions where there is a change in the position of the sun. This project was implemented with minimum resources. The circuitry was kept simple, while ensuring efficiency is not affected.

6.1: Recommendations for further work

This project needs further work before practical usage.

In the mechanical system we must ensure the movement of the motor guarantee that the solar panel facing the sun.Increase the sensitivity and accuracy of tracking by using a phototransistor with an amplification circuit, this would provide improved resolution and the better tracking accuracy.

CHAPTER 5: SOFTWARE PROGRAMING

```
#include<Servo.h>

Servo base;
Servo hand;

int pos_base, pos_hand;
int8_t LL, UL, UR, LR;

// run once in lifetime.
void setup() {
  Serial.begin(9600);



  base.attach(11);
  hand.attach(10);
}

// run forever in lifetime.
void loop() {

  LDR();
  rotateServos();

  delay(500);
}
```

```
int val[4];
void LDR()
{
  for (int i = 0; i < 4; i++)
  {
    val[i] = analogRead(i); // range of values 0-1023
    val[i] = map(val[i], 0, 1023, 0, 100);
    Serial.print(val[i]);
    Serial.print('\t');
  }
  Serial.println();
  UL = val[0];
  LL = val[1];
  UR = val[2];
  LR = val[3];
}
void rotateServos()
{
  int8_t thresh = 2;
  if ( (LL -  UL) > thresh ) down();
  else if ((UL -  LL) > thresh) up();

  if ( (LR -  UR) > thresh) down();
  else if ((UR -  LR) > thresh) up();



  if ( (LL -  LR) > thresh ) left();
  else if ((LR -  LL) > thresh) right();
```

```
  if ( (UL -  UR) > thresh ) left();
  else if ((UR -  UL) > thresh) right();
}


void left()
{
  pos_base = base.read();
  if (pos_base == 20 || pos_base == 160)return;
  pos_base--;
  base.write(pos_base);
}


void right()
{
  pos_base = base.read();
  if (pos_base == 20 || pos_base == 160)return;
  pos_base++;
  base.write(pos_base);
}

void up()
{
  pos_hand = hand.read();
  if (pos_hand == 20 || pos_hand == 160)return;
```

```
  pos_hand++;
  hand.write(pos_hand);

}
void down()
{
  pos_hand = hand.read();
  if (pos_hand == 20 || pos_hand == 160)return;
  pos_hand--;
  hand.write(pos_hand);
}
```

8.REFERENCES:

1: Designing a Dual-Axis Solar Tracking System for increasing efficiency of a Solar Panel. Suman Ghosh. Electronics and Instrumentation Engineering (An ISO 3297: 2007 Certified Organization) Vol. 5, Issue 12, December 2016

2: Dual Axis Solar Tracker Using Arduino Uno. Dhanalakshmi.V. International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169 Volume: 4 Issue: 6

3: Design and Construction of a Bi–Directional Solar Tracking System. Okpeki U.K. 2otuagoma.S.O. *Research Inventy: International Journal Of Engineering And Science Issn: 2278-4721, Vol. 2, Issue 5 (February 2013), Pp 32-38*

4: Concept of Mechanical Solar Tracking System. Rohit Agarwal. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334XPP 24-27.*

*5:*Design and construction of a solar tracking system. F. M. AL-NAIMA. *Solar & Wind Technology* Vol. 7, No. 5, pp. 611-617, 1990 0741-983X/90 $3.00+.00
Printed in Great Britain.

6: Design and construction of a one-axis sun-tracking system. Soteris a. kalogirou. *Solar Energy* Vol. 57, No. 6, pp. 465-469, 1996.

7: Design and construction of a system for sun-tracking. P. Roth. Renewable Energy 29 (2004) 393–402.

8: Hand book of Solar Energy Fundamentals, Technology, and Systems.

[9] A.K. Saxena and V. Dutta, “A versatile microprocessor based controller for solar tracking,” in Proc. IEEE, 1990, pp. 1105 – 1109.

[10] T.A. Papalias and M. Wong, “Making sense of light sensors,” http://www.embedded.com, 2006.

[11] R. Condit and D. W. Jones, “Simple DC motor fundamentals,” Texas Instruments. Publication AN907, pp. 1 – 22, 2004.

[12] S. J. Hamilton, “Sun-tracking solar cell array system,” University of Queensland Department of Computer Science and Electrical Engineering, Bachelors Thesis, 1999.

[13] M. F. Khan and R. L. Ali, “Automatic sun tracking system,” presented at the All Pakistan Engineering Conference, Islamabad, Pakistan, 2005.

[14] “Fabrication of Dual-Axis Solar Tracking Controller Project”, Nader Barsoum, Curtin University, Sarawak, Malaysia, Intelligent Control and Automation, 2011, 2, 57-68.

[15]Antonio L. Luque; Viacheslav M. Andreev (2007). Concentrator Photovoltaics. Springer Verlag.

[16]David Cooke, "Single vs. Dual Axis Solar Tracking", Alternate Energy eMagazine, April 2011.

[17]:International Energy Agency, “Technology Roadmap - Solar Photovoltaic Energy - 2014 Edition,” IEA Publications, 2014.

[18]:Nipun, "Difference Between p-type and n-type Semiconductor," 19 October 2015. [Online]. URL: http://pediaa.com/difference-between-p-type-and-n-type-semiconductor/. Accessed 2 May 2016.

[19]: Wikimedia Foundation, Inc., "Depletion region," Wikimedia Foundation, Inc., 5 May 2016. [Online]. URL: https://en.wikipedia.org/wiki/Depletion_region. Accessed 27 May 2016.

[20]: Apec Virtual Center, Japan, "Principle of Electricity Generation by Photovoltaic Cells," 2007. [Online]. URL: http://www.apec-vc.or.jp/e/modules/tinyd00/index.php?id=74. Accessed

[21]:R. Nave, "Semiconductor Band Gaps," [Online]. URL: http://hyperphysics.phy-astr.gsu.edu/hbase/tables/semgap.html. Accessed 20 April 2016.imaginarysite.com

[22]:Michigan State University | Department of Chemistry, "Frequency - Wavelength - Energy Converter,"[Online].URL: https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/cnvcalc.htm.Accessed 14 May 2016.

[23] T. Markvart, Ed., Solar Electricity, 2nd ed., Chichester, West Sussex: Wiley, 2000.

[24]R. Messenger and A. Abtahi, Photovoltaic Systems Engineering, 3rd ed., CRC Press, 2010.