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Advanced GPS Based Solar Tracking

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ABSTRACT: *The present rapid growth of industries needs large energy. In doing so global warming is a major problem and it has reached to such extent that it is almost impossible to eliminate it, but there is a way called Renewable energy and it is a best alternative to Non renewable type. In doing so when we look at these renewable energies the first answer is solar energy (Sun energy) which is available abundantly.But there are some problems in collecting maximum solar energy. In that solar tracking is one of the best solutions to overcome problems of solar energy collecting. There are plenty of ways to track the sun. They may be of single Axis or dual Axis using Light Sensor, but they are not working that exact due to their limitations like Shadow factor, Rain factor, Heavy winds, Leaves, Birds excreta, Ice hales etc. And these may need extra maintenance which makes maintenance costs to be higher or sometimes may cause damage to sensors during maintenance operations.The alternate solution proposed here is Global Positioning System (GPS) based Solar Tracking System. It locates exact location of the sun in the sky and rotates the solar panels accordingly. And this tracking does not depend on sun light which can work on even Rainy, Cloudy and non sunny days and utilizes the diffused radiation of the sun so as to improve the efficiency in electricity generation.The proposed system works by the use of the Latitude, Longitudinal, Year, Date, Time values it alters the tracker position to change its direction and rotate the panels accordingly to it. And this process can be done by a coding of Fuzzy Logics which is programmed in a Micro controller with a GPS receiver including a set of Stepper and servo motors with proper design mechanism.*

Keywords: *Fuzzy controller, Arduino, Global Position system, Zenith, Azimuthal angle*

I.INTRODUCTION

As far as we know solar technologies are emerging very rapidly all over the world because of their eco friendly current generation and various applications they have. Thus in this regard only many researches are going on continuously to attain higher efficiency rates of current generation by different mechanisms. In this sense only solar tracking mechanism is araised where solar tracker is used to attain high concentration of Sun light on to the panels in different ways. But there are some problems are there in the solar tracking systems like Shadow factor, Rain factor, Heavy winds, Leaves, Birds excreta etc. To deal with this we come up with a model Advanced GPS based solar tracking system using Fuzzy logics which is more reliable and easy to apply even at house hold solar tracking systems for better efficiencies. In order to perform this project, literature review has been made from sources like journals, books articles and others. This chapter includes all important studies which have been done previously by other research work.

Md. Tanvir Arafat Khan, Alam et al[4] has discussed the idea of Design and “Construction of an Automatic Solar Tracking System.”

Using a microcontroller based design methodology of an automatic solar tracker; Light dependent resistors are used as the sensors for the solar tracking. The designed tracker has precise control mechanism which will provide three ways of controlling system. A small prototype of solar tracking system is also constructed to implement the design methodology presented here. In this paper the design methodology of a microcontroller based simple and easily programmed automatic solar tracker is presented. A prototype of automatic solar tracker ensures feasibility of this design methodology. Nader Barsoum[5] had made a idea about” Implementation of a proto type for a traditional Solar tracking system “in 2009 Third at UKSim European Symposium on Computer Modeling and Simulation. The proto type describes in detail the design and construction of a solar tracking system with two degrees of freedom, which detects the sunlight using photocells. The control circuit for the solar tracker is based ona PIC16F84A microcontroller (MCU). This is programmed to detect the sunlight through the photocells and then actuate the motor to position the solar panel where it can receive maximum sunlight. This paper is about moving a solar panel along with the direction of sunlight; it uses a gear motor to control the position of the solar panel, which obtains its data from a PIC16F84A microcontroller. The objective is to design and implement an automated, double-axis solar tracking mechanism using embedded system design in order to optimize the efficiency of overall solar energy output.Aleksandar Stjepanovic et al [6] had paper reports about " Microcontroller Based Solar Tracking System"

The system describes the design and construction of a microcontroller based solar panel tracking system. Solar tracking allows more energy to be produce because the solar array is able to remain aligned to the sun. The paper begins with presenting background theory in light sensors and stepper motors as they apply to the project. In the conclusions are given discussions of design results. The paper begins with presenting background theory, light Sensors and stepper motors as they apply to the project. The paper continues with specific design methodologies pertaining to photocells, stepper motors and drivers, microcontroller selection, voltage regulation, physical construction, and a software/system operation explanation. The paper concludes with a discussion of design results and future work. LwinLwin Oo and Nang Kaythi Hlaing[7] had made a report on " Microcontroller-Based Two-Axis Solar Tracking System" In this system they tend to develop and implement a prototype of two axis solar tracking system based on a PIC microcontroller. The parabolic reflector or parabolic dish is constructed around two feed diameter to capture the sun's energy. The focus of the parabolic reflector is theoretically calculated down to an infinitesimally small

Point to get extremely high temperature. This two axis auto-tracking system has also been constructed using PIC 16F84A microcontroller. The assembly programming language is used to interface the PIC with two-axis solar tracking system. The temperature at the focus of the parabolic reflector is measured with temperature probes. This auto-tracking system is controlled with two 12V, 6W DC gear box motors. The five light sensors (LDR) are used to track the sun and to start the operation (Day/Night operation). Time Delays are used for stepping the motor and reaching the original position of the reflector. The two-axis solar tracking system is constructed with both hardware and software implementations. The designs of the gear and the parabolic reflector are carefully considered and precisely calculated.

II.PROBLEMS WITH THE TRADITIONAL SOLAR TRACKING SYSTEMS

There are plenty of ways to track the sun. They may be of single Axis or dual Axis using Light Sensor, but they are not working that exact due to their limitations like Shadow factor, Rain factor, Heavy winds, Leaves, Birds excreta etc. And these may need extra maintenance which makes maintenance costs to be higher or sometimes may cause damage to sensors during maintenance operations. In addition to the mentioned above problems the following below are some of the major problems to be considered

- Speed of servomotor is high when compared to stepper motor when it is utilized at zenith tilting operation and this causes misalignment in angles of tracking which in turn have great impact on the efficiency.
- Chance of failure of Sensors like LDR due to Dust, Smoke, Bird Excreta, ice hales, Leaves etc and makes their function improper which are to be considered more important in tracking concept.
- Inefficient working of sensors which has a great impact on total efficiency makes it poor.
- High installation Charges are needed.
- Continuous service is needed because of this the operating and running costs become too high to handle.

Objective

In the proposed system the main objective is to eliminate the light sensor failures due to the various factors like Shadow factor, Rain factor, Heavy winds, Leaves, Birds excreta, Ice Hales etc by the design and implementation of a fuzzy logic computer controlled sun tracking system to enhance the power output of photo voltaic solar panels. The tracking system was driven by two permanent magnet DC motors to provide motion of the PV panels in Two Axis. The project describes the use of a microcontroller based design methodology of an automatic solar tracker. It involves Light dependent resistors and GPS that are used as sensors for tracking the sunlight based on the sunlight. In case if it fails to track the sun by LDR it automatically start communicates with satellite through GPS and start fetching the Latitude, Longitude values of the particular location where plant is installed so as to get time values of that particular location. These time values are fed back to the Fuzzy based Arudino microcontroller from there fuzzy microcontroller makes the two motors to rotate in two axis and make the misbehaved solar tracker to remain in its original position according to the time and month.

Implementation

The aim of the project is to keep the solar photovoltaic panel perpendicular to the sun throughout the year in order to make it more efficient. The dual axis solar photovoltaic panel takes astronomical data as reference and the tracking system has the capability to always point the solar array toward the sun and can be installed in various regions with minor modifications. The vertical and horizontal motion of the panel is obtained by taking altitude angle and azimuth angle as reference. The fuzzy controller has been used to control the position of DC motors.

The proposed system works by the use of the Latitude, Longitudinal, Year, Date, Time values it alters the tracker position to change its direction and rotate the panels accordingly to it. And this process can be done by a coding of Fuzzy Logics which is programmed in a Micro controller with a GPS receiver including a set of Stepper and servo motors with proper design mechanism.

Working of Proposed System

Thetracking systemmaximizessolarcelloutputbypositioningasolarpanelat thepointofmaximum lightintensity as well as by GPS **.**The second mode namely called GPS enables only when the first one that is Light sensors fails to detect the sun light.That means misalignment of solar panel due to sensor failure and so therefore the GPS communicates with the satellite and result in the attaining of Latitude, Longitudinal Values which are necessary to acquire the location of the plant and the time at that place.

By these values there is no need of Light sensors to work properly. Even the apparatus works at any location based on the time, position of that place. It is very clear that the apparatus is not only helpful for commercial industrial purposes but also domestic household purposes because of its simpler design which reduces the installation charges for solar panel tracking again and again when shifted from one place to another place.

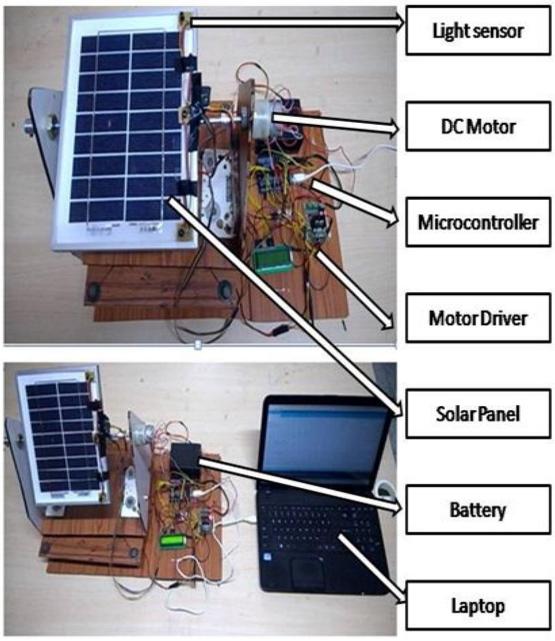

Fig. 1 GPS Solar tracking system along with computer

In thisDCmotors such as specialmotorslikesteppermotors,servomotors,and realtimeactuators are used tooperate movingpartsofthesolartracker.Thesystemisdesigned in such a way thatthenormal lineof solarcellalwaysmoveparalleltotherays ofthesun with a two-axissolartrackingsystembasedona microcontroller called Aurdino.This auto-tracking systemiscontrolledwithtwo12V,6WDCgearboxmotors one is Servo motor and the other one is stepper motor.The Threelightsensors (LDR)areusedtotrackthesunandtostarttheoperation (Day/Nightoperation).

Fuzzy Logic

2.1Fuzzy

One of the reasons for the popularity of Fuzzy Logic Controllers is its logical resemblance to a human operator. It operates on the foundations of a knowledge base which in turn rely upon the various if then rules, similar to a human operator. Unlike other control strategies, this is simpler as there is no complex mathematical knowledge required. The Fuzzy Logic Controller requires only a qualitative knowledge of the system thereby making the controller not only easy to use, but also easy to design.

The first step towards designing a Fuzzy Logic Controller is choosing appropriate inputs which will be fed to the same. These input variables should be such that, they represent the dynamical system completely. Then the function of the Fuzzifier comes into picture. As discussed before, instead of using numerical variables, fuzzy logic uses linguistic variables for processing information. But since the inputs to the Fuzzy Logic Controller are in the form of numerical variables (or in other words, crisp sets), they need to be converted into linguistic variables. This function of converting these crisp sets into fuzzy sets (linguistic variables) is performed by the Fuzzifier.

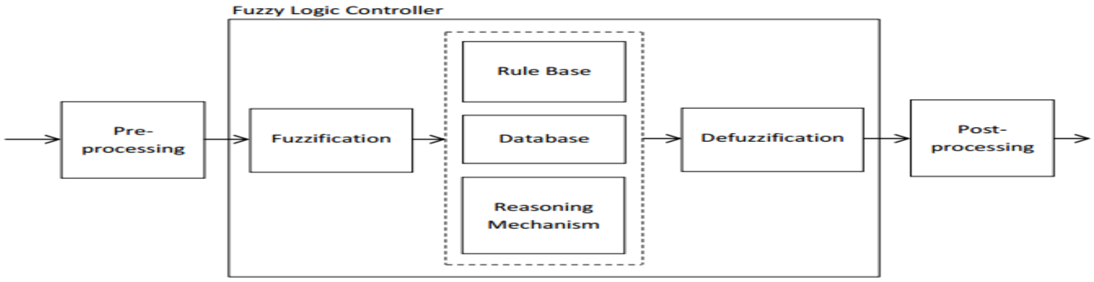

Fig. 2fuzzy system and fuzzy controller

In fuzzy logics we write IF - AND - THEN rules '*If Input1and Input2 and Then Output'* Here in this project time is input and then angle is output.

2.2 project data processing

The processing happens in the Plant

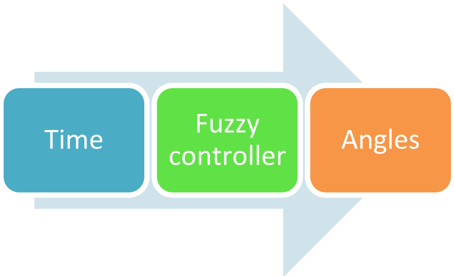

Fig. 3 Data processing diagram

Tabel 1
Zenith angle and time.

S.no	Time	Zenith angle
1	9 AM	45^O
2	10 AM	58^O
3	11AM	67^O
4	12PM	72^O
5	1 PM	80^O
6	2 PM	90^O
7	3 PM	102^O
8	4 PM	128^O
9	5 PM	135^O

Source: survey data

Tabel 2
Azimuthangle and time.

S.No	Month	Azimuth Angle
1	January	55^O
2	February	75^O
3	March	95^O
4	April	125^O
5	May	145^O
6	June	165^O

7	July	145^{O}
8	August	125^{O}
9	September	95^{O}
10	October	75^{O}
11	November	55^{O}
12	December	35^{O}

Source: survey data

2.3 If then rules

If then rules for Zenith angle:

1. If it is 9 o'clock then angle is 45^{O}
2. If it is 10 o'clock then angle is 58^{O}
3. If it is 11 o'clock then angle is 67^{O}
4. If it is 12 o'clock then angle is 72^{O}
5. If it is 1 o'clock then angle is 80^{O}
6. If it is 2 o'clock then angle is 90^{O}
7. If it is 3 o'clock then angle is 102^{O}
8. If it is 4 o'clock then angle is 128^{O}
9. If it is 5 o'clock then angle is 135^{O}

If then rules for Azimuth angle:

1. If it is January then angle is 45^{O}
2. If it is February then angle is 45^{O}
3. If it is march then angle is 45^{O}
4. If it is April then angle is 45^{O}
5. If it is may then angle is 45^{O}
6. If it is June then angle is 45^{O}
7. If it is July then angle is 45^{O}
8. If it is August then angle is 45^{O}
9. If it is September then angle is 45^{O}
10. If it is November then angle is 45^{O}
11. If it is October then angle is 45^{O}
12. If it is December then angle is 45^{O}

2.4 Fuzzy controller:

Fuzzy controller means program a ordinary microcontroller with fuzzy logic programs, here we use a knowledge set are Rule base in the microcontrollers database as matrix. In this project we have two inputs and two outputs, time and month are inputs and zenith and Azimuthangle. Matrix will help to write fuzzy logic programs for any input in column one will have column two as its outputs, there is now mathematical models are needed.

2.5 If the data to matrix

Zenith Matrix

(INPUT,OUT)
(9 AM,45)
(10 AM, 58)
(11AM, 67)
(12PM,72)
(1 PM, 80)
(2 PM, 90)
(3 PM,102)
(4 PM,128)
(5 PM,135)

The above matrix will help to control Zenith of solar panel

Azimuth Matrix

(INPUT, OUT)
(January, 55)
(February, 95)
(march, 95)
(April, 125)
(may, 145)
(June, 165)
(July, 145)
(August, 125)
(September , 95)
(November, 75)
(October, 55)
(December, 35)

III. PROJECT DESIGN

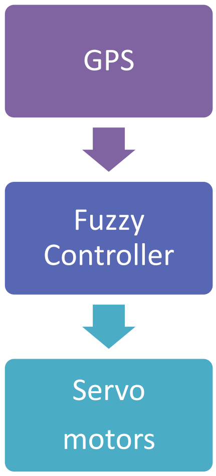

Fig. 4 Project block diagram

The project is developed on Arduino microcontroller and two servomotors for two axis control and input time is taken from GPS module.

IV. PROGRAM

```
// include the library code:
#include <Servo.h>
#include <TinyGPS++.h>
#include <SoftwareSerial.h>


static const int RXPin = 7, TXPin = 6;
static const uint32_t GPSBaud = 9600;
SoftwareSerial ss(RXPin, TXPin);


Servo Xservo;  // create servo object to control a servo
Servo Yservo;  // create servo object to control a servo

// Fuzzy matrix or knowledge

int  Azimuth_Angle[] =
 { 50, 50, 70,90,100,120,140,120,100,90,70,50};

int Zenith_Angle[] =
```

```
 {0,0,0,0,0,0,0,0,0,45,55,72,85,95,102,110,122,135,
0,0,0,0,0,0,0};

int h=0, m=0, s=0;
int D=0, M=0, YY=0;

//*******************Setup******************

void setup()
{

  Serial.begin(9600);
  ss.begin(GPSBaud);

}

//******************Loop******************
void loop()
{

int X = Zenith_Angle[gps.time.hour()]

Xservo.attach(X);

intY = Azimuth_Angle[gps.date.month];

Yservo.attach(Y);
}

//*******************End*******************
```

Results:

Existing System Results for Six Months

Table3

Hours Static Panel Solar Tracking (Dual Axis)						
Time	**Jun-14**	**Jul-14**	**Aug-14**	**Sep-14**	**Oct-14**	**Nov-14**
08.00 AM	**8.3**	**8.1**	**7.9**	**8.3**	**8**	**7.8**
09.00 AM	**8.5**	**8.3**	**8.1**	**8.5**	**8.1**	**7.9**
10.00 AM	**8.6**	**8.8**	**8.3**	**8.6**	**8.3**	**8.1**
11.00 AM	**9.7**	**9.6**	**9.55**	**9.5**	**9.4**	**9.2**
12.00 PM	**9.9**	**9.8**	**9.6**	**9.9**	**9.6**	**9.3**
01.00 PM	**10.3**	**10**	**9.9**	**10.3**	**10**	**9.6**
02.00 PM	**10.5**	**10.1**	**10**	**10.5**	**10.1**	**9.8**
03.00 PM	**9.7**	**9.5**	**9.6**	**9.7**	**9.5**	**9.2**
04.00 PM	**8.6**	**8.8**	**8.6**	**8.6**	**8.3**	**8.1**
05.00 PM	**8.3**	**8.1**	**8.2**	**8.3**	**8**	**7.9**
06.00 PM	**8.1**	**7.8**	**7.8**	**8.1**	**7.6**	**7.5**
Average Voltage	**9.13636363**	**8.99090909**	**8.86818182**	**9.11818182**	**8.80909090**	**8.58181818**

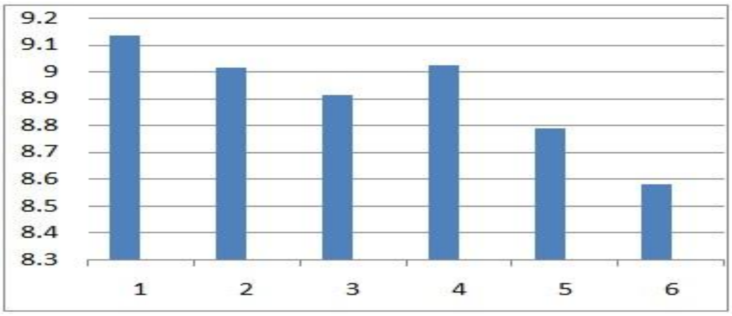

Fig.5 Existing System Months vs. Voltage

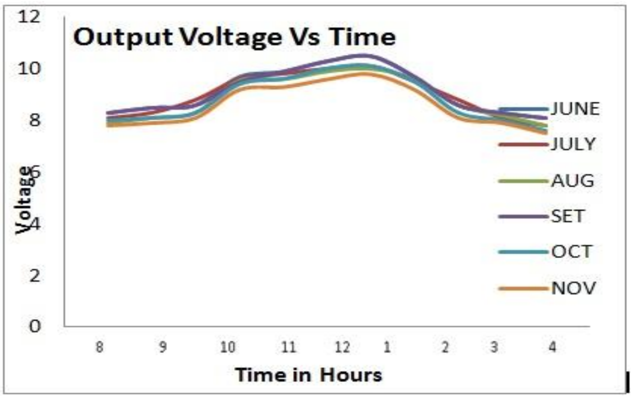

Fig.5Existing System Time vs. Voltage graph for Six months

Proposed System Results for Six Months of 2014:

Table4

Hours Static Panel Solar Tracking (Dual Axis)						
Time	**Jun-14**	**Jul-14**	**Aug-14**	**Sep-14**	**Oct-14**	**Nov-14**
08.00 AM	**10.2**	**10.1**	**10**	**10.2**	**10**	**9.8**
09.00 AM	**10.35**	**10.15**	**10.1**	**-10.35**	**10.1**	**9.9**
10.00 AM	**10.42**	**10.22**	**10.25**	**10.42**	**10.22**	**10**
11.00 AM	**10.51**	**10.31**	**10.3**	**10.51**	**10.36**	**10.1**
12.00 PM	**10.6**	**10.4**	**10.4**	**10.6**	**10.4**	**10.2**
01.00 PM	**10.8**	**10.6**	**10.5**	**10.8**	**10.6**	**10.4**
02.00 PM	**10.73**	**10.53**	**10.55**	**10.73**	**10.61**	**10.42**
03.00 PM	**10.4**	**10.29**	**10.4**	**10.4**	**10.36**	**10.2**
04.00 PM	**10.55**	**10.3**	**10.3**	**10.55**	**10.23**	**10.05**
05.00 PM	**10.36**	**10.31**	**10.2**	**10.36**	**10.11**	**9.8**
06.00 PM	**10.29**	**10.22**	**10.1**	**10.3**	**10**	**9.7**
Average Voltage	**10.4736363**	**10.3118182**	**10.2818182**	**10.47454545**	**10.2718181**	**10.0518182**

Fig.6Proposed System Months vs. Voltage graph

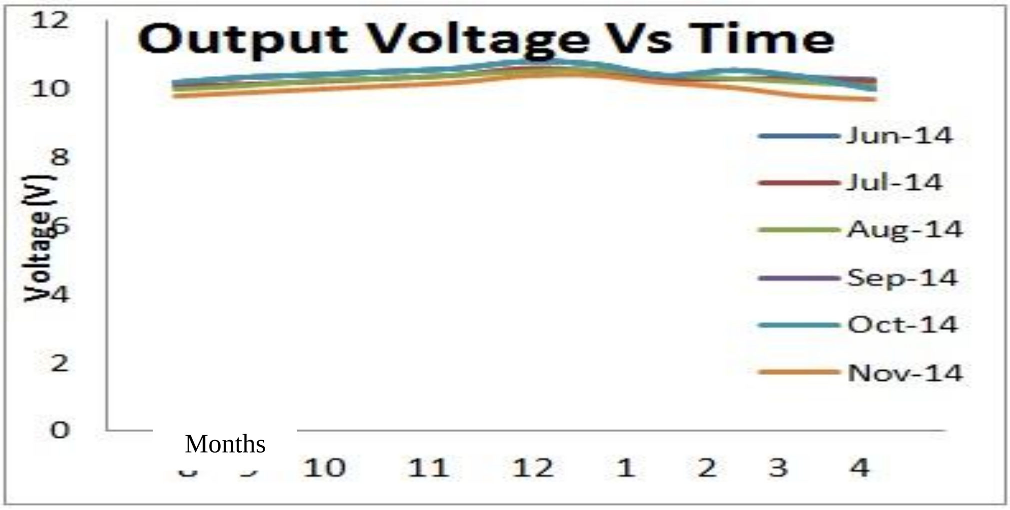

Fig.7 Proposed System Time vs. Voltage graph for Six months of 2014

From the above graphs it is very clear the proposed system has most linear curve when compared to the existing one. When we observe June 2014 the sun is almost normal so there is high intensity of light is absorbed on this month. The existed system generally grabs the energy at noon well but when we observe during early mornings energy is not absorbed well. And results show a semi curve. But by the proposed system the output graph shows linearity that means it absorbs energy all the time as identical. So the difference is clear with the output graph of proposed system and existed system that the proposed system enhanced the collection of sun energy more efficient than existed system. By the by it eventually shows linearity in the months of July 2014,August 2014,September 2014,October 2014 and November 2014 as well when we observe the above respective following months. But from the graphs average voltage coming down because of approaching of rainy and winter seasons which reduces the sun intensity. Even though the seasons vary, the panel shows better improvement compared to the existing system by the following results.

V. CONCLUSION

A prototype model is developed for tracking the sun which tracks exactly normal to the sun. The model is not depended on uncertain inputs like light and diffused radiation which are mainly affected by Shadow factor, Rain factor, Heavy winds, Leaves, Birds excreta etc. It mainly makes use of GPS where commands from GPS are fed back to the micro controller and this makes the two motors to rotate as per the Zenith and Azimuth angle. The stepper motor of the tracking system makes the panel to track at every angle and this makes high concentration of sun light directly over the panel. By this problems like Shadow factor, Rain factor, Heavy winds, Leaves, Birds excreta, Ice hales etc are overcomed and better efficiencies are observed better than the existing system. The voltage is 8 to 8.5V for the tracking system without GPS and 10 to 10.5V for the solar tracking system with GPS. Therefore the efficiency of the proposed GPS is increased up to 30-40% compared to existing one. Thus the GPS tracking system works year round and considered to be a better solution.

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