International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

Design & Control of Low Cost Solar Tree for Optimizing a PV System

Arun Kumar Rath, Gouri Sankar Nayak , R.K.Jena

Abstract: *This concept shows the design and control of a solar tree PV system for charging cell phones, supplying electricity for street lighting on open urban areas and charging of electric bike on the road side when the charge is decaying. Based on the above applications, a 7 feet height-tree was built. It has three section of branches, each branches contains 5 sub stem over which leaves made of acrylic with solar panels on the top (1.5 feet × 1feet) mounted. The energy storage capacity is 30 Amp. It has 2 USB ports to connect mobile devices and two 12V-300 W electrical outlets to connect those devices to the electricity. The solar tree was designed according to the environmental conditions of Gunupur, Odisha and for optimizing the output power a flow chart with programming developed. The result was compared with the C language programme. At the last, the PV system's availability to satisfy the energetic requirements was verified. Due to population growth and energy demands, the solar energy is the 2nd best source of non conventional energy which is cause pollution free in nature. By using the concept of the series and parallel connection of panel with the help of sub branch of the main stem the efficiency of the system can be improved. As compared to normal PV system in area point of view the Solar tree becomes more efficient. There is no systematic stimulation for usage of solar panels, purely relying on individual cases of installation on different types of objects. Solar tree may be very much helpful for creating awareness about solar resource. This concept elaborates the possibility of building a solar tree in GIET campus odisha, India, covering technical, social and economic aspects. Benefits and potential drawbacks are elaborated, while special emphasis is given to the specifics of its utilization due to the geographical position of odisha and corresponding number of sunny hours/days per year.*

Index Terms: *Bearing, C programming, long tower, Solar Cable, Stems for connecting panels, Solar panel, Solar Energy.*

I. INTRODUCTION

One of the major problems facing the world is climate change and the magnitude and scope of the manifestations of this problem have been the main drivers for governments to begin to react to this, which has raised the need to count with sustainable solutions for the energy sector that contribute to this problem [4-7]. In this scenario, electricity production by solar energy can reduce the emission of greenhouse gases (GHGs), because of being clean, renewable, secure and abundant power is solar energy [1-3] .For future energy needs the solar tree is the best solution [1]. We need to catch the energy from sun because sun is always sending energy to earth continuously [8,11]. It is an artificial tree with photo-voltaic cells arranged in Fibonacci series manner in place of leaves [1]. As compared to normal flat array of solar cells the solar tree will produce more energy [1,9,10]. The energy available from sun is unpredictable and considered as easiest and cleanest means of tapping the renewable energy [1,8,9,10].

The amount of solar energy incident on the earth's surface is approximately1.5 x 10^{18} kWh/year [1]. The density of power radiated from the sun (referred to as solar energy constant) is 1.373 kW/m^2.[8]

The solar panels are installed on poles to produce electricity by absorbing solar energy, but the space around the pole and below the solar panel is a huge potential to increase the solar power by many folds, suitably named to form a Solar Tree [1]. This paper aims to build an array of solar panels on a welded stem to the pole. Depending upon coordinates of the local area of installation the tilt angle and other parameters of solar panel can be calculated [1,8,11]

II. PROPOSED MODEL OF SOLAR TREE

A. Model of Solar Tree

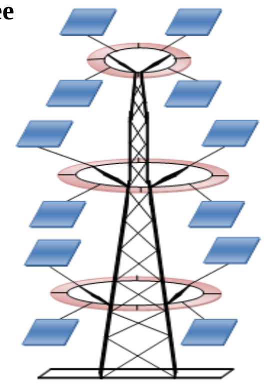


Fig 1.Model of Solar Tree

B. Block diagram for solar tree installation

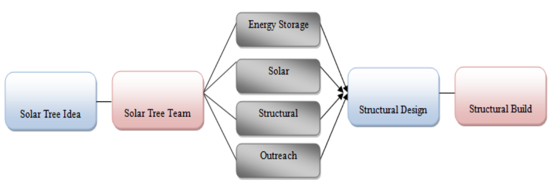


Fig 2.Block diagram for solar tree installation

Revised Manuscript Received on 30 July 2019.
***** Correspondence Author
Arun Kumar Rath, EEE Department, GIET University, Gunupur, India,
Gouri Sankar Nayak, CSE Department, GIET University/ Gunupur, India,
Dr R.K.Jena, EE Department, BPUT University, Rourkela, India.

III. DESIGN OF SOLAR TREE

Components:

- High Efficiency PV panels
- Non corrosive structure designed to bear strong wind loads
- Tracking for maximum energy output
- Small ground footprint.
- General Specifications:
- Model No : SAG36020
- PV Panel Rating : 300Wp
- Annual Yield : 438000Wh
- System Type : Off-Grid PV Systems
- Output : 12/24 DC
- Suitable Locations : Can be installed at any location for any Latitude
- Safety :Overvoltage / Current protection
- Remote Monitoring : optional
- Mechanical Design
- Structure Material : Hot Dip Galvanized Steel
- Max Wind bearing capacity :100Km/hr
- Tracking :Optional Fully Automated East to West Tracking
- Ground Footprint (LxW) :2x1.feets.(2feet2)
- PV Panel Clearance(at top)(LxW) :5x2feets(10 feet2)
- Height of Panel from Ground : 1.5feet. (Typical)
- Material of Consumption :Steel

The ground is the suitable place for solar tree but no shadow falls on the panels. The figure 1 shows the model of a typical solar tree by series and parallel connections. of solar panel, the panel 1 is connected in parallel to panel 2 while panel 3 is connected to panel 4 in a parallel connection. Both the parallel connections are connected in series. The whole circuit of panels (LB1 13003680) stores energy in a battery rated at 12 volts. The specifications of the panels are as given in table 1. At an inclination of 350 (Latitude is28035'). S-W the panels are installed.

Table 1. Specifications of solar panel LB1 13003680

CHARACTERISTICS	SPECIFICATIONS
Pmax	5W
Imp	0.35A
Vmp	10.5V
Voc	10.5V
Tolerance	+-5%
Isc	0.35A

Table 2.Specification Of Solar Panel

SL. NO	NAME OF PARAMETERS	RATING & UNITS
1	Maximum Power (Pmp)	20Wp
2	Open Circuit Voltage (Voc)	21.6 V
3	Short Circuit Current (Isc)	1.318 A
4	Voltage at maximum power (Vmp)	17.0 V
5	Current at maximum power (Imp)	1.176 A
6	Maximum system voltage	600 VDC
7	Maximum reverse current	2 A
8	Nominal operating cell temperature	470C+20C & 470C-20C
9	Temperature coefficient-Power	0.00157%/^{0}C

Table 3. Specification Of Solar Tree

SL. NO	EQUIPMENT REQUIRED	QUANTITY	RATING/ITEM	TOTAL
1	Solar panels	15	20 Wp	300 Wp
2	Long tower	1	7'	1
3	LED"s	24	2.0 V, 20 mA	12 W, 12 V (4 SET)
4	Stems for connecting panels	15+1	12'' & 7'	16
5	Solar Charge Controller	1	390 W (12 V)	780 W (24V)
6	DC & AC Loads	30	10 W (12 V)	300 W (12)
7	Solar Cable	30 feet	25A, 12V	NA
8	Bearing	3	6307	NA
9	Batteries			

IV. STATISTICAL STUDIES OF VARIOUS PARAMETERS OF THE SOLAR TREE

Table 4 Voltage vs. Power

VOLTAGE(VOLTS)	POWER(WATTS)
16	15
18	17
21	18
21.6	20
19.5	19
17.5	16

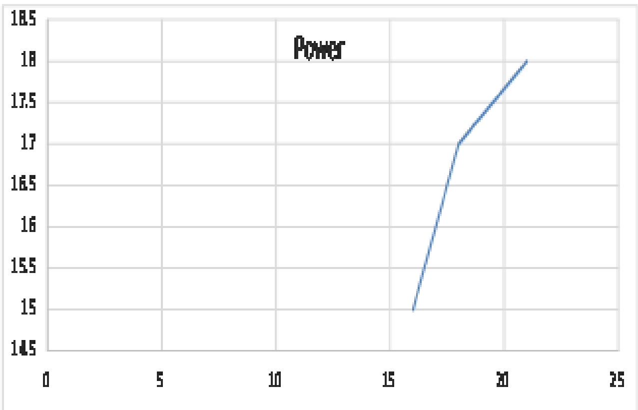


Fig 3. Voltage vs Power characteristics

Retrieval Number: B3836078219/19©BEIESP
DOI: 10.35940/ijrte.B3836.078219
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Table 5. Irradiance vs Power

IRRADIANCE(WATT/M2)	Power(watts)
900	15
960	17
1000	18
1100	20
900	19
700	16
600	14

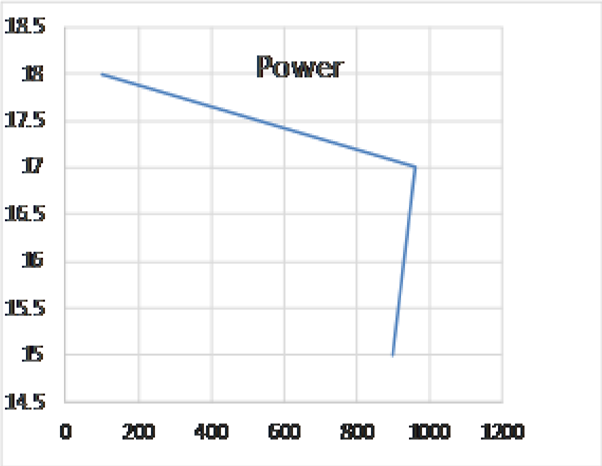


Fig 4. Irradiance vs Power characteristics

Table 6. Voltage vs Current

VOLTAGE(V)	CURRENT(A)
16	1.06
18	0.99
21	0.857
21.6	0.92
19.5	0.97
17.5	0.914

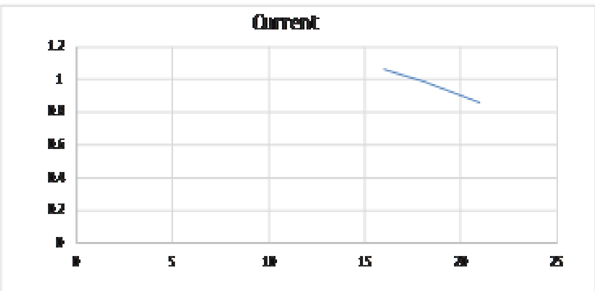


Fig 5.Voltage vs Current characteristics

V. THE AVAILABLE SOLAR IRRADIANCE ON AN INCLINED SURFACE:

Extraterrestrial radiation of the sun

Iext = 1367*(1+0.033*cos(360*355/365)) = 1411.4 W/m2 (1)

At 6am, beam radiation is given by the formula

Ib = IN cos θz (2)

= 860*cos(100.97) = 163.65 W/m2

diffuse radiation is given as

Id = (1/3)*[Iext – N]*cos θz (3)

= (1/3) *[1411.4860]*cos(100.97) = 34.98 W/m2=2.03

conversion factor of beam radiation is given as Rb= (INcos θi) / (INcosθz) (4)

conversion factor of diffuse radiation is given as Rd = (1 + cosβ) / 2 = 0.909 (5)

conversion factor of reflected radiation is given as

Rr = (1 - cosβ) / 2 = 0.09 (6)

Insolation or total radiation is given by the formula

IT= IbRb+ IdRd+ρ Rr(Ib+Id)=163.65 *2.03 + 34.98*0.909 + 0.2*0.09*(163.65+34.98) (7)

IT = 367.58 W/m2

At 12 noon

Ib = 860*cos(52.03) = 529.114 W/m2

Id = (1/3)*[1411.4 – 860]*cos(52.03) =113.083 W/m2

Rb =1.34

Substituting the values in equation (7), IT = 823.364 W/m2

At 5pm,

Ib = 860*cos(88.96) = 15.61 W/m2

Id = (1/3)*[1411.4 – 860]* cos(88.96) = 3.336 W/m2

Substituting the values in equation (7), IT = 823.364 W/m2

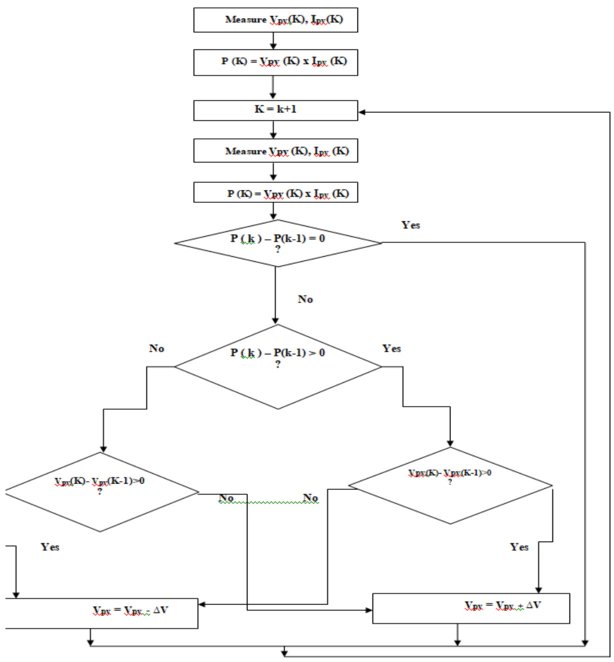
Rb = 31.38

Substituting the values in equation (7), IT = 493.24 W/m2

Table 7. calculated values of hour angle and different radiations

Radiation on horizontal surface (W/m2)					Calculated radiation on inclined surface (W/m2)
Time on Dec 21, 2017	Total	Diffuse	Beam	Hour angle ω (deg)	
6am	198.63	34.98	163.65	-90	367.58
12 noon	642.194	113.08	529.114	0	823.364

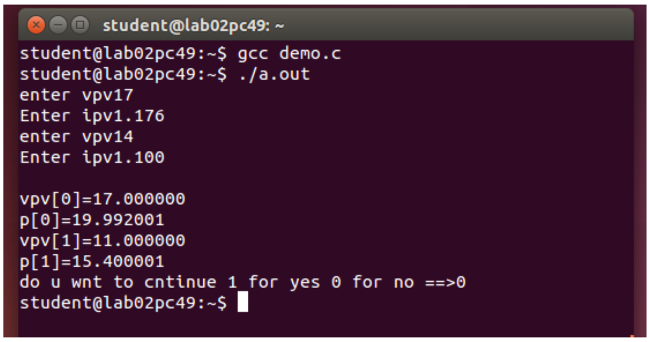
VI. FLOWCHART FOR SOLAR TREE



Flow Chart Code:→

```
#include"stdio.h"
void main()
{
        int ch=0,k=0;
        float p[100],v[100],ipv[100],vpv[100];
        printf("enter vpv");
        scanf("%f",&vpv[k]);
        printf("Enter ipv");
        scanf("%f",&ipv[k]);
        p[k]=vpv[k]*ipv[k];
        k=k+1;
        do
                {
                    printf("enter vpv");
          scanf("%f",&vpv[k]);
          printf("Enter ipv");
          scanf("%f",&ipv[k]);
          p[k]=vpv[k]*ipv[k];
          if((p[k]-p[k-1])!=0)
            {
              if((p[k]-p[k-1])>0)
             {
          if((vpv[k]-vpv[k-1])>0)
          {
             vpv[k]+=(vpv[k]-vpv[k-1]);
          }
          else
          {
             vpv[k]-=(vpv[k]-vpv[k-1]);
          }
           }
         else
         {
          if((vpv[k]-vpv[k-1])>0)
          {
             vpv[k]-=(vpv[k]-vpv[k-1]);
          }
          else
          {
             vpv[k]+=(vpv[k]-vpv[k-1]);
          }
         }
          printf("\nvpv[%d]=%f",k-1,vpv[k-1]);
        printf("\np[%d]=%f",k-1,p[k-1]);
               printf("\nvpv[%d]=%f",k,vpv[k]);
               printf("\np[%d]=%f",k,p[k]);
               k++;
        }
            else
              {
               k++;
          }
         printf("\ndo u wnt to cntinue 1 for yes 0 for no =>");
         scanf("%d",&ch);
         }while(ch==1);
}
```

OUTPUT


student@lab02pc49: ~
student@lab02pc49:~$ gcc demo.c
student@lab02pc49:~$ ./a.out
enter vpv17
Enter ipv1.176
enter vpv14
Enter ipv1.100

vpv[0]=17.000000
p[0]=19.992001
vpv[1]=11.000000
p[1]=15.400001
do u wnt to cntinue 1 for yes 0 for no ==>0
student@lab02pc49:~$

VII. CONCLUSION

In this Paper the available solar radiation on an inclined surface in GIET campus was calculated, Statistical studies of various parameters of the solar panel and Solar tree was taken by using P&O method and the mechanical design for Solar tree was performed. The voltage and power was controlled by control unit. It sounds like the suitable method for the upcoming generation.. It is a great challenge for undeveloped area because different reading was taken by exposing a single solar panel towards the sun , then accordingly the Solar tree designed and irradiance verses power, voltage verses power and voltage verses current was plotted. From the different characteristics it is observed that the electrical efficiency becomes more than the normal PV system. By studying different papers related to this concept although some of places implemented but not broadly used due to lack of technicality so it helps the society for proper utilization of solar energy with small land. It can produce more power by the proper designing and the extra energy can be supplied to the local grid. Solar tree is more sophisticated than the general PV system and also more efficient because never produce any harmful gas like CO_2 and other SOx products.

REFERENCES

1. V. Renugadevi, An Approach to Solar Power Tree' International Conference on Electrical, Instrumentation and Communication Engineering 2017
2. Rohini Jadhao, Solar Power Tree, International Conference On Emanations in Modern Technology and Engineering, 2017.
3. W. Cao, Z. Li, Y. Yang, Y. Zheng, W. Yu, R. Afzal, J. Xue, "«"Solar tree": Exploring new form factors of organic solar cells»", Renewable Energy, vol. 72, pp. 134-139, 2014.
4. R. Rajesh, M. C. Mabel, "«A comprehensive review of photovoltaic systems»", Renew. Sustain. Energy Rev., vol. 51, pp. 231-248, 2015
5. Ali Q. Al-Shetwi, "«Design and Economic Evaluation of Electrification of Small Villages in Rural Area in Yemen Using Stand-Alone PV System»", Int. J. Renew. Energy Res. IJRER, vol. 6, no. 1, pp. 289-298, 2016
6. Arun Kumar Rath,"Design and testing of low cost Solar Power Inverter",International Journal of Application or innovation in Engineering and Management, Volume 2,Issue 8, August 2015,pp.173-178.
7. Ali Rachini, Iman Mougharbel, Hadi Y. Kanaan, Stathis Tselepsis, J. Nicoletatos, Evangelos Rikos, "On the Connectivity of PV Panels to the Grid – Monitoring Systems", International Journal Of Renewable Energy Research, IJRER, Vol 1,No.3, pp25- 30 , 2011.
8. Boyo A.O, Adeyemi K.A,"Analysis of Solar Radiation Data from Satellite And Nigeria Meteorolgical Station", International Journal Of Renewable Energy Research, IJRER, Vol.1, No.4, pp 314-322, 2011.

9. J. C. Mourmouris, C. Potolias, J. G. Fantidis, " Evaluation of Renewable Energy Sources Exploitation at Remote Regions, using Computing Model and Multi-criteria Analysis: A case study in Samothrace, Greece", International Journal Of Renewable Energy Research, IJRER, Vol. 2,No.2, 2012.
10. Abhishek Agarwal, Vineet Kumar Vashishtha, S.N. Mishra," Solar Tilt Measurement of Array for Building Application and Error Analysis", International Journal of Renewable Energy Research, IJRER, Vol. 2,No. 4, 2012.
11. G N Tiwari, "Solar Energy Fundamentals, Design, Modelling and Applications" Narosa publishing house, pg 16-24, ISBN 978-81-8487-277-4.

AUTHORS PROFILE

Arun Kumar Rath pursuing PhD in Control of Photovoltaic Power system under BPUT received his M.Tech Degree in Power Electronics & Drives from GIET, Gunupur under BPUT and also B.Tech from BPUT. He is working as Asst. Professor in EEE Department at GIET University. He is having 6 years in industrial and 10 years teaching fields experiences. His areas of interest are Control of Photovoltaic Power System, Microgrid, Smart grid and Power Electronics Technologies.

Gouri Sankar Nayak received the MCA degree in 2011 from Gandhi Institute of Engineering & Technology (GIET), Odisha, India, where he is currently pursuing the M.Tech degree in Computer Science from Gandhi Institute of Engineering & Technology University (GIETU).

R.K.Jena received PhD degree from Sambalpur University in the field of Electrical Engineering, ME and BE from REC, Rourkela under Sambalpur University. Presently working as Professor in EE department at Center for Advanced PG studies, BPUT Rourkela. He is having overall 26 years teaching experience. His areas of interest are Solar Energy, Power System Engineering, Power Electronics, Microgrid, Smart grid and Image Processing Technologies.