© 2017 IJNRD | Volume 2, Issue 4 April 2017 | ISSN: 2456-4184

CALCULATION METHODOLOGY AND DEVELOPMENT OF SOLAR POWER GENERATING SYSTEM FOR HOUSEHOLD APPLIANCES

Jayesh S. Barad[1], Mahesh S. Chauhan[2], Dharmesh S. Barad[3], Prof. Hitesh Parmar [4]
[1]M. E. Electrical Engineering B. H.
Gardi College of Engineering & Technology

Abstract— Stand-alone solar power generating systems have become broadly adopted as trustworthy opportunity of electrical energy generation to meet certain demand round the earth. The purpose behind developing project is to develop and design standalone solar generating system for household appliances. Working in this direction 40W solar module is used as solar power generation and a common LA battery, 12V, 30Ah, applied for the backup system. Correct voltage is delivered to battery aimed to improve battery life; charge controller is incorporated between solar module and battery. Load we have used is DC as well as AC load. Input to charge controller is 18.43V from solar panel specified with around 22.28V OC voltage and SC current of 2.44A. Output voltage is regulated at 14.3 V and current will limited to 2.22A. The charge controller designed to protect battery life from overcharging and undercharging. For that purpose indicators are use. A simple square wave inverter is incorporated. Calculation procedure is made to determine specifications for battery, panel and charge controller also for inverter. I gave tried to develop MPPT concept using linear components.

Keywords— Stand-alone, off-grid, charge controller, inverter, solar PV system design

I. INTRODUCTION

Being a developing country with enormous load of fuel import, the essential of solar energy exploration and development in India cannot be ended highlighted. The environmental location of India is also fairly satisfactory for solar energy application. However, a thickly populated country like India, with a split electricity market, carriages endless encounters to the scientists and entrepreneurs. The environment of Indian electricity market is fairly exclusive, and cannot be associated directly with further countries. Unlike USA or Japan, India has abundant villages and islands separate from the main grid altitudinal and cyclical variation in agricultural demand, and cottage- to industrial areas. Our country, therefore, requires solar energy development at unlike scales such as, small watt to large megawatt, grid-connected to islanded, added with certain energy-storage to no-storage proficiencies. Solar photovoltaic is a commercially obtainable technology in India. Also significant is by development of solar energy by additional renewable sources. Since this Socio-economic scenario, the current state of solar energy skill in India stands distant from being satisfactory, but numerous initiatives are being scheduled.

A solar power generating system change incident solar energy to electricity by using semiconductor devices can be used as electrical power for home to encounter its daily energy necessity. The solar photovoltaic device schemes for power generation had been arranged in the numerous portions in the country for electrification wherever the grid connectivity is whichever not possible or not price effective

as moreover some times in aggregation with diesel based generating stations in remote spaces and communication transmitters at distant locations. Acceptance of this technology resolve in meeting the electricity demands to a better level. The best portion is that they are sectional in nature i. e. the depending on the altering necessity of the house; the solar units can be altered to encounter the electricity demand.

A. Stand-alone solar power generating system

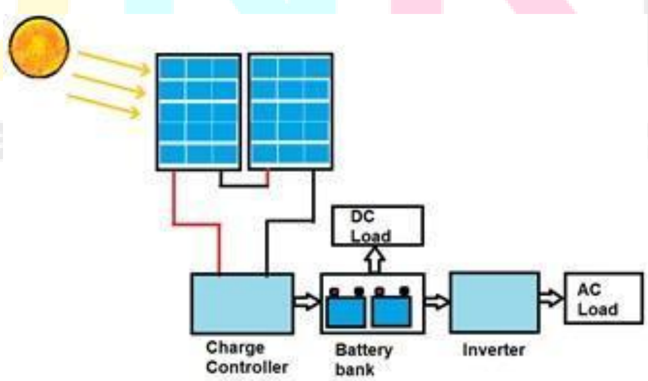

Fig. 1 Stand-alone Solar power generating system

Stand-alone solar power generating system is a group of organized electrical apparatuses, which can produce electricity from sun-light plus please our daily energy necessities deprived of disturbing about any intermission when the sun- light may not be accessible.

This type of system is significant only when there is essential of load to run in night time or when daylight is not accessible for particular time. The power generating system comprises of the subsequent modules;

- **i.** Solar PV panel
- **ii.** Battery Storage
- **iii.** Charge controller
- **iv.** Inverter
- **v.** Load

Above diagram show interconnection of apparatuses of a typical stand-alone solar power system. Contingent on load necessity and radiation strength at the site, the apparatuses of the system will have to be identified. Below is a brief review of the apparatuses.

i. Solar PV Panel:

Photovoltaic cell which produces electricity from the daylight is the main constituent in a PV system. Current and voltage produced depend on the range of the cell. A

13.5‖x13.5‖ size Photovoltaic cell can produce voltage of about 0.55volts and a current density of 30–35mA/cm^2. A solar board is the gathering of this elementary Photovoltaic cell which can be called solar cells. To meet the power necessities of a specific system, a number of panels are linked in the following form;

(1) Series connection is made to increase voltage

(2) Parallel connection is made to increase current

While its groupings form a solar PV array.

ii. Battery Storage

Storage battery is the vigorous constituent of a stand-alone solar power generating system. It is to stock energy during daylight periods and resource current to load throughout non-sunshine periods. There are various types of batteries, valve regulated LA battery, Li-battery, etc. that can be used in solar power generating system. The recommended battery that should be used in stand-alone solar power generating system is lead-acid batteries because of its high performance.

iii. Charge controller

This is use to adjust and control the current movement among PV array and battery. The purpose for charge controller is used is to control the flow at which current is supplied to battery or taken from batteries. It avoids overcharging and defends battery from voltage variation.

iv. Inverter

This is also identified as power conditioning component. Most of the appliances work on AC source and battery and panel are DC source. Work of Inverter is to converts DC power into AC power in a solar power generating system.

v. Load

Load is a Power consumption unit for a PV system to be scheduled. Load may be AC type or DC type. Proper load approximation is essential in designing stand-alone solar power generating system. While designing solar generating power system, the nature of the load may be resistive or it may be inductive. Resistive loads do not require any substantial surge current when it is energized. Like bulb, heaters etc. On the other hand, large amount of surge current is required in inductive load at the time of starting which is normally near around 3.5 times the standard energy supplies such as; electric fan, motor, etc. liable on the load approximation of a structure if correct design can be employed.

II. CALCULATION METHODOLOGY FOR SOLAR POWER GENERATING SYSTEM

This chapter presents explanation of the numerous apparatuses of a standard solar energy system sizing & design containing the panel module, a battery, a charge controller development and load.

A. Determine power demand

Load speaks of somewhat that uses electricity. By taking an example of a toaster which acts as electrical load draws huge quantity of current whereas an iPhone charger requires less current. We famine to recognize how much energy is important every day, and how rapidly that energy requirements to be distributed. Always work in kilowatt Hours for the quantity of energy desired and kilowatts aimed at the degree at which the energy desires to be delivered. For scheme a Solar generating system, the leading step is to look out total energy and power requirement. Step 1: Calculating overall Watt-hours day meant for every single appliance. First of all to get overall watt-hour for day we require adding all appliances watt-hour requirement. Step 2: Calculating overall Watt-hours day desired from the panel. The losses include wiring and connection losses about 10%, losses in the battery about 20%. Now adding up all losses will be around 30%, hence we essential to produce 30% enough WH/Day including loads to balance the losses. Hence we want to produce 130% of load requirement. Hence multiplying 1.3 time total load we will get total power which is required from the module

B. Calculation of panel requirement

The power produced by different size solar panel is different. Peak-watt for a panel produced is governed by Panel size & weather condition of site. We require studying Panel Generation Factor (PGF) that is dissimilar in each site. For India, the panel generation factor is nearly about 3.8. To find the sizing of PV modules, we need to follow these steps: First step: Calculation of Overall Watt-Peak of Solar Module To acquire the total Watt-Peak of solar module we require dividing the overall Watt-hours each day required from the Panel by 3.8 to operate appliances. Second step: Calculation of quantity of panels for the system. Quantity of panels required for the system can be found by dividing overall watt-peak of solar module which is previously calculated by standard available module rating. If whole number is not obtained, just simply round off it to highest number.

C. Battery sizing

Generating solar PV system the battery kind suggested is LA battery. The battery should be bulky & sufficient to stock sufficient energy to function the applications at nighttime and dull days. To determine parameter of battery, the following steps are involved: Step 1: Calculating overall power necessity for a day. Step 2: Overall power per day used is divided with 0.85 factors which are for battery loss. Step 3: Divide above obtained answer with 0.6 for DOD. Step 4: Divide above obtained answer by battery nominal voltage. Step 5: Days of autonomy are then multiply by above obtained answer which results in required capacity of battery in Ampere-hour.

Capacity of Battery in Ah

= overall power necessity for a day x Days of autonomy (0.6 x0.85 x battery nominal voltage)

D. Solar charge controller sizing

The charge controller must characteristically value in contradiction of Ampere and Voltage capacities. Choice of the charge controller to tie the voltage of PV module and battery and then recognize which type of charge controller is exact for your request. It is necessary that charge controller stays accomplished to handle SC current from a panel. In practice, charge controller magnitude is determine by the SC current from panel, and then multiply it with 1.3 Rating of charge controller= 1.3 x Total SC current from a panel.

E. Calculation of VA rating of the inverter

It is Volt-ampere rating of transformer. The output from inverter will be voltage & current to the apparatus. Ideal transformer efficiency will be cent percentage. But practical transformer will operate nearly 60 to 80 percentages. Inverter will supply same amount of power as of load when it is cent percentage. Talking practically inverter has to supply 30 % more. Power rating of transformer = total AC load/ efficiency or power factor. We will consider efficiency or power factor = 0.7

F. Calculating Panel generation Factor

For my locality month wise Solar Radiation is depicted in table given below

Table 1: Month wise solar radiation of my zone

MONTH	**SOLAR RADIATION (KWH/M2/DAY)**
1	6.45962286
2	7.0536375
3	7.40845394
4	7.37190723
5	6.81079483
6	5.54507542
7	4.18471956
8	4.74270058
9	6.17625713
10	6.64119911
11	6.12629271
12	5.81129599
Total	74.33195686

Average solar radiation (KWh/m2/day) is (74.33/12) = 6.19. Suppose the lowest month solar has a daily average of 6.19. That is equivalent to 6.19 hours of 1000 W/m2 sunlight every day. Loss calculation for temperature will be 15%, daylight not arresting the panel will be nearly 5%, MPP loss will be nearly about 10%, and dust will add up loss of 5%, aging effect will have loss of 10%. Hence in total overall power = 0.95 x 0.90 x 0.90 x 0.85 x 0.95= 0.62 of original panel rating. PGF= 6.19 x 0.62 = **3.83.**

G. Calculate fix tilt Angle

To calculate fix tilt angle use below given methods to find the finest angle from the plane at which the module should be tilted:

Table 2: Latitude and fix tilt angle relation

Latitude	**Fix Tilt Angle**
latitude< 25°	Latitude x 0.87
25°<Latitude< 50°	(Latitude x 0.76) + 3.1°

III. SOLAR POWER GENERATING SYSTEM SIZING CALCULATIONS

Modeling a house which has the following electrical appliance usage:

Table 3: Modeling of household applications

Appliances	**Quantity**	**Rating**	**No. of hours use/day**	**load**
LED Lamp(AC)	2	9W	4	72W
Fan(DC)	1	15W	2	30W

A. Determine power consumption demands

Overall appliances used for hours are

= (9W x 4 hrs) + (15W x 2 hrs) Total energy required from the solar panel is

= 102Wh/day =102 x 1.3 =**132.6 Wh/day**.

B. Calculation of panel requirement

Total watt-peak solar panel capacity required is

= 132.6/3.8

=36.83 Wp

Quantity of solar panels required= 36.83/40

=0.9208 modules

=1 module

In Short Panel required to supply load is formulated in table

Table 4: Panel Requirement

No. of Panel required(Minimum)	**Rating of Panel**
1	40Wp

C. Battery sizing

Total wattage need to be supplied

= (18 W x 4 hrs) + (15 W x 2 hrs)

For system battery Voltage (Nominal) use = 12 V

Autonomy Days = 2 days

Battery capacity

= [(2x9 W x 4 hrs) + (15 W x 2 hrs)] x 2

(0.85 x 0.6 x 12)

=33 Ah

Battery specification required is listed in table

Nominal voltage	**Ampere-Hour**
12	33Ah

Table 5: Battery specifications

D. Solar charge controller sizing

Solar panel specifications:

Max Power = 40 Wp

Maximum output Voltage = 18.43 Vdc

Maximum output current = 2.22 A
Open circuit Voltage = 22.28 V
Short circuit current = 2.44 A
Solar charge controller rating
= (1Module x Short circuit current) x 1.3
=1 X 2.44A X 1.3
= 3.172
So, charge controller should be rated **4 A** at 12 V or greater.

E. Fix tilt angle
For my locality:
Latitude 20.83oN
Longitude 70.55oE
According to formula we need to multiply Latitude with 0.87 as latitude is below 25o.
Fix tilt angle= 20.83 x 0.87
=18.12o
So we require fixing our solar module at nearly about **18o**.

F. Inverter
Power of inverter (VA) = 18W/0.7
=26W
So, nearly **26W** inverter is required for AC loads.

IV. DEVELOPMENT OF SOLAR POWER GENERATING SYSTEM FOR HOUSEHOLD APPLICATION
A. Solar Panel

Table 6: Solar panel specifications

Manufacturer	Lubi Electronics, Ahmedabad
Type	Polycrystalline
Peak Power	40W
OCV	22.28
Vmp	18.43V
SCC	2.44A
Imp	2.22A
Maximum System voltage	600V
No. of cells	36
Dimensions	485x675x10
Cell efficiency	16.60%
Weight	4Kg

Fig. 2 Front side of solar panel

B. Solar charge controller

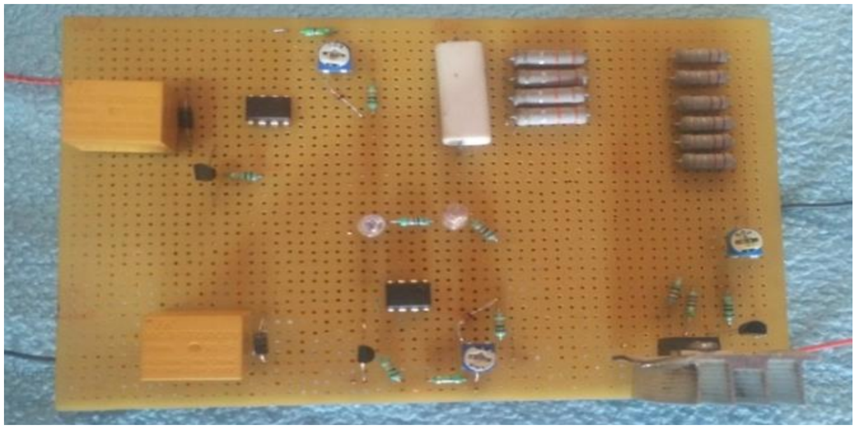

Fig. 3 Solar charge controller

C. Inverter

V. CONCLUSION

We have successfully designed a Stand-alone Solar power Generating System for household applications. We have made calculations and sized different parameters like panel size, number of panel required, required battery Ah capacity, charge controller specification and inverter. Prototype model of solar charge controller and inverter is made according with calculated specifications. A successful experiment was carried out of the prototype model from solar panel to charge controller to battery and from battery to inverter as well as DC loads. LED indicator shows level of battery thus according relay operates. Red LED indicates full charged Battery level and Green LED indicated low/charging battery.

REFERENCES

[1] Al-Mamun, K. Sundaraj, N. Ahmed, N. U. Ahmed, S.A.M. M. Rahman, R. B. Ahmad and Md. H. Kabir, ―*Design and Development of a Low Cost Solar Energy System for the Rural Area*‖, IEEE Conference on Systems, Process & Control, Kaula Lumpur, Malasia, 13-15 December 2013.

[2] A. Mellit, ―Sizing of photovoltaic systems: a review‖, Revue des Renouvelables, Vol.10, No4, page 463-472, 2007.

[3] Nupur Khera, Nancy Rana, Narendiran S, Sarat Kumar Sahoo, Balamurugan M, S. Pabhakar Karthikeyan and I. Jacob Raglend, ―Design of Charge Controller for Solar PV Systems‖, International Conference on Control, Instrumentation, Communication and Computational Technologies, 2015.

[4] M. Subashini and M. Ramaswamy‖ A novel design of charge controller for a standalone solar photovoltaic system‖, 3rd International Conference on Electrical Energy Systems, 2016.

[5] John W. Stevens and Garth P. Corey, ‖A Study of Lead-Acid Battery Efficiency Near Top-of-Charge and the Impact on PV System Design‖, 25th PVSC, Washington, D.C., May 13-17 1996.

[6] Ishaq M, Ibrahim U. H, Abubakar H,‖ Design of an off Grid Photovoltaic System: A Case Study Of Government Technical College, Wudil, Kano State ―IJSTR, Vol. 2, issue 12, Dec 2013.

[7] Ajan A. and K. Prem Kumar, ―Performance Analysis of OFF-GRID Solar Photo Voltaic System‖, International Conference on Circuit, Power and Computing Technologies, 2015.