Solar Photo Voltaic System Study and Installation Optimization Using Matlab and Simulink

[#]Dr. J.p. Kesari, [*]Varij kumar, [*]Vikas kumar
[#]*professor*, [*]*student*
[#]*Dept. of Mechanical Engineering*
**Dept. of Electrical Engineering*
Delhi Technological University, Bawana Road, Delhi, India

Abstract
As we know significance of blood to body, energy is significant for mankind, hence to keep getting uninterrupted powerful supply of energy or electricity is the basic necessity. To achieve quality continuous energy by solar panel we need to increase the efficiency of the solar panel and to reduce the losses during storage conversion and transmission to maximum possible amount in every condition to make solar energy a reliable source of energy in today's energy demanding era. For this we need to study the whole process of solar energy production.

This paper revolves around the solar power system its study, efficiency and the mathematics involved in the modelling using MATLAB AND SIMULINK.

Keywords — *Fill Factor, Module, Controller, Inverter, Panel.*

I. INTRODUCTION

As we know that the demand of the power is accelerating at high pace and as per prediction we will ran out of coal and other fossil fuel by 2050. To meet our demands of energy and more importantly to save our mother earth which is being harm by continuous exploitation of natural resources and global warming by the most advance living creature we the HUMAN BEINGS. We need to work in a direction to make transition from pollution causes ill methods of energy production to clean and green methods of energy sources which will not cause any harm to our mother earth and also have availability for a long time (like solar for upcoming billions of years).

As we know that we can produce energy from the sun rays which is non-polluting and abundant source of energy. All over the world the steps have been taken in direction to bring solar energy in practical use of a common man and residential apartments for the welfare of mother earth and to be independent of fossil fuel to meet the demand in future. Being an equatorial country India has tons of solar potential in it which can be utilized for contributing a major of its overall energy demand. As projected by MINISTRY OF NEW RENEWABLE RESOURCES (MNRE) India is set to contribute 25% of its total energy production by solar energy till 2030.

II. WHAT IS MEANT BY SOLAR ENERGY & ITS IMPORTANCE?

Amount of energy in the form of heat and light radiation is called solar energy. In 2011, the International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It will increase countries' energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating global warming, and keep fossil fuel prices lower than otherwise These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared"

III. SOLAR CELL & ITS WORKING PRINCIPLE

Solar cells are basically made up of semiconductors like silicon which are doped with different kinds of impurities. These impurities produce unequal distribution of free electrons (n-type) on opposite side holes (p-type). Solar light radiations have photons which hit the solar panel and excite the loosely bound electrons which are projected to move only in one direction in solar cell and thus electron hole pair is established in respected junctions and electricity is obtained in external circuit. Irrespective of size of solar cell, generally a solar cell produces 0.5-0.6-volt DC under no load and open circuit condition.

IV.SOLAR ENERGY SYSTEM COMPONENT

- ***SOLAR PANEL***
- Solar panels are constructed from an array of solar cells, known as photovoltaic cells. Constructed of semiconductors, which absorb light and knock electrons loose, solar panels vary widely in size. Most solar energy systems are comprised of a number of solar panels lined up, either on a roof or in a large, clear outdoor space. A group of solar panels is called a solar array

- ***SOLAR PANEL MOUNT***
- Depending where your solar energy system is installed, you will need a solar panel mount that can handle the weight of the panels. The majority of roof-based solar panel mounts are constructed from extruded aluminium rails. In general, for every 100 watts of panels, one mounting bracket should be used for support

- ***CHARGE CONTROLLER***
- If you've ever wondered, "how does solar energy work," you have likely heard about the importance of a charge controller. Without a charge controller, your solar energy system lacks stability. The charge controller is a key player in your system, ensuring that the system isn't overloaded

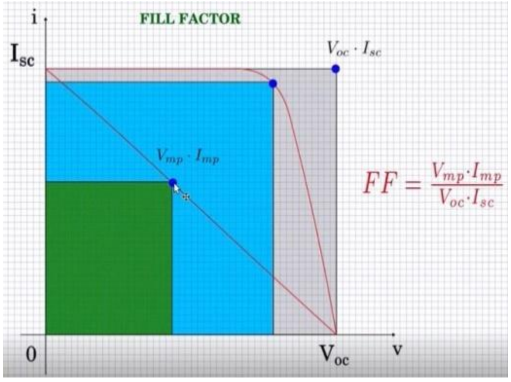
- ***INVERTER***
- When your panels collect sunlight, they convert that light into direct current (DC) electricity. Most homes, however, utilize alternating current, or AC, electricity. The inverter is in charge of turning DC electricity into usable AC. Inverters vary widely in size as well as watt-hours and amp output.

- ***UTILITY METER***
- Most homeowners with solar panels are connected to the power grid. This is often referred to as a grid-intertied system. Even if you have a backup battery bank, the majority of homes remain tied to the public grid. Thus, the power company uses a utility meter to measure and regulate the energy collected by your solar panels

V. PARAMETERS OF SOLAR CELLS

(i) Short circuit current density (I_{sc})
The current flow through the external circuit when anode and cathode are short circuited. The short circuit current of a solar cell depends on the incident of photon flux which is depending on the spectrum of incident light. It is the maximum current which solar cell can deliver.
(ii) Open circuit voltage (V_{oc})

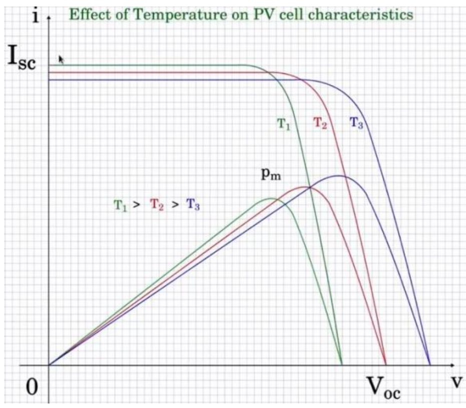
The voltage when no current flows through the external circuit. V_{oc} depends on the saturation current density of the solar cell and photo generated current. It is the maximum voltage that solar can deliver.
(iii) Maximum current power point (I_{mmp})
The maximum current solar panel is delivering in practical environment which define the power output and efficiency of the solar panel.
(iv) Maximum voltage power point (V_{mmp})
The maximum solar panel is delivering in practical environment which define the power output and efficiency of the solar panel.



(v) Fill factor (FF)
The ratio between the maximum power generated ($P_{max} = I_{mmp} * V_{mmp}$) by the solar cell and the product of V_{oc} & I_{sc}.
(vi) Conversion efficiency
The conversion efficiency is calculated as the ratio between the maximum power generated and the incident power.

VI CHARACTERISTICS OF PHOTOVOLTAIC CELL

Like all other semiconductor devices, solar cells are sensitive to temperature. Increases in temperature reduce the band gap of a semiconductor, thereby effecting most of the semiconductor material parameters. The decrease in the band gap of a semiconductor with increasing temperature can be viewed as increasing the energy of the electrons in the material. Lower energy is therefore needed to break the bond. In the bond model of a semiconductor band gap, reduction in the bond energy also reduces the band gap. Therefore increasing the temperature reduces the band gap.



VII. MATHEMATICS INVOLVED

1. PHOTO CURRENT is defined as current produced by solar panel after the photoconductive nature of diode when the energy is incident on the photo diode depletion layer.
   I_{PH}= [I_{SC} +k_i (T-298)]*(G/100)
2. SATURATION CURRENT
   I_0=I_{RS}*((T/T_M) ^3)*EXP (Q*E_{G0}*((1/T_N)-(1/T))/n*K)
3. REVERSE SATURATION CURRENT is the maximum possible current that can flow in reverse direction due to minority charge carriers when forward biased.
   I_{RS}=I_{SC}/ (EXP (Q*V_{DC}/ (n*N_S*K*T))-1)
4. CURRENT THROUGH SHUNT RESISTOR
   I_{SH}= (V+I*R_S)/R_{SH}
5. OUTPUT CURRENT
   I=I_{PH}-I_0[EXP (Q*(V+I*R_S)/(n*K*N_S*T))-1]-I_{SH}

I_D= I_{RS}*(EXP (Q*V_{DC}/ (N*N_S*K*T))-1) diode current expression derived from **SCHOCKELEY DIODE EQUATION**. The link of simulation of these equations is given alongside.

VIII. SOLAR PV SYSTEM DESIGN MATLAB PROGRAM

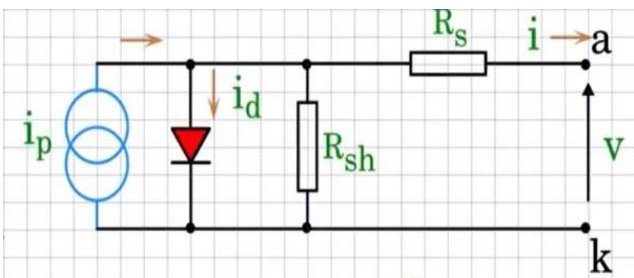
```
%SOLAR PANEL DESIGN INSTALLATION
%CREATED BY VARIJ KUMAR,2K17/EE/229,DELHI TECHNOLOGICAL UNIVERSITY
%DATE : 07/10/2019, TIME:11:38
clearvars;
load=input('ENTER THE LOAD VALUE TO BE OPERATED IN WATTS   ');
backup_time=input('ENTER BACKUP TIME IN HOURS OF BATTERY OPERATION   ');
%TILL NOW WE HAVE TAKEN THE INPUTS OF LOAD VALUES AND BACKUP TIME
%INVERTER RATING CALCULATION
%Inverter rating should be greater by 25percent of the total load
%for the future load as well as taking losses in consideration
inv_l=input('\n enter known fractional inverter loss otherwise enter zero');
if inv_l==0
   invv_l=.25;
else
   invv_1=inv_l;
end
inverter_rating=load+(invv_l*load);
fprintf('\n Inverter Rating is %f watts\n ',inverter_rating);
%CALCULATION OF NUMBER OF BATTERIES REQUIRED
fprintf('\n CALCULATION OF NUMBER OF BATTERIES REQUIRED');
v_batt=input('\n voltage rating of battery in volts is given by   ');
ah_batt=input('\n ampere hour rating of battery in AH is given by   ');
wh_batt=v_batt*ah_batt;
fprintf('\n watt hour rating of one battery is    %f WH',wh_batt);
bkt_1=wh_batt/load;
fprintf('\n backup time of one battery is    %f HOURS',bkt_1);
n_batt=backup_time/bkt_1;
fprintf('\n Hence nnumber of batteries required is   %f',n_batt);
fprintf('\n ***BATTERIES ARE CONNECTED IN PARALLEL SO AS TO INCREASE CURRENT RATING***');
% recheck if no. of batteries and load is given then backup time can be
% calculated easily
recheck_backup=(ah_batt*n_batt)/load;
%Now the Required Charging Current for these two batteries.
%Charging current should be 10% of batteries Ah
cf=input('\n enter known charging current fraction otherwise enter zero');
if cf==0
   cff=.10;
else
   cff=cf;
end
charg_i=cff*ah_batt;
fprintf('\n charging current is given by    %f amperes',charg_i);
neti=(n_batt*charg_i);
fprintf('\n NET CURRENT DRAWN FROM PANEL = %f',neti);
%Charging Time required for Battery
charg_t=ah_batt/charg_i;
fprintf('\n charging time ideally is given by    %f hours',charg_t);
% due to some losses, (it has been noted that 40% of losses
% occurred during the battery charging)
bat_l=input('\n enter known net fractional battery loss otherwise enter zero');
if bat_l==0
   batt_l=.40/n_batt;
else
   batt_1=bat_l;
end
nah=ah_batt+(ah_batt*batt_l*n_batt);
net1i=(charg_i*(1+batt_l));
ct=(nah/net1i);
```

```
fprintf('\n Charging time covering battery losses is given by  %f hours',ct);
fprintf('\n Since batteries are connected in parallel then net voltage is %f',v_batt);
fprintf('\n Since batteries are connected in parallel then net current is %f',neti);
p=v_batt*neti;
panel_i=input('\n enter the current ratings of the panel in amperes  ');
panel_w=input('\n enter the power ratings of the panel in watts  ');
Ni=neti/panel_i;
Np=p/panel_w;
ni=round(Ni);
np=round(Np);
n=(ni+np)*0.5;
fprintf('\n REQUIRED NO. OF %f WATTS,%f AMPERES,%f VOLTS SOLAR PANEL CONNECTED IN PARALLEL TO RUN A LOAD of %f IS %f',panel_w,panel_i,v_batt,load,n);
```

IX. EFFICIENCY OF SOLAR CELL

It is defined as the ratio of maximum electrical power output to the radiation power input to the cell and it is expressed in percentage. It is considered that the radiation power on the earth is about 1000 watt/square metre hence if the exposed surface area of the cell is 'A' then total radiation power on the cell will be 1000 A watts. Hence the efficiency of a solar cell may be expressed as

$$Efficiency(\eta) = \frac{P_m}{P_{in}} \approx \frac{P_m}{1000A}$$



CONCLUSIONS

Many people are resistant to having solar panels installed on their homes because they believe the installation costs are too high. Initial installation costs of residential solar panels vary depending on a number of factors. The size of both the home and the system are the main determining factors of the initial installation costs.

A common myth decriers of solar energy like to claim is that it takes 25 years before you will see a return on investment in solar energy, but the truth is far different. Depending on the size of your project and the initial investment, you could start seeing an ROI immediately,

One of the most damaging solar energy myths is that your home needs to be located in a warm and sunny climate for solar panels to work properly. In reality, solar panels harness the sun's energy — not its temperature. Therefore, solar panels work just as well, if not better, in colder climates as opposed to areas with high year-round temperatures.

Solar panels can only produce energy when there is sunlight. So, while solar energy cannot be produced at night, most systems produce enough energy during the day that it creates a surplus. This surplus is due to the system producing more energy than what the household actually uses.

In grid-tied systems, this surplus energy is sent back to the grid for homes to draw on as a credit when needed, like at night. The energy surplus also eases the demand that other households have for conventional energy.

A common misconception about the technology behind solar power systems is that they need to have a tracking system installed. Instead, the truth is that solar panels are properly positioned to maximize the sun's energy when they are first installed. Therefore, they don't require an additional tracking system to follow the sun's pattern.

ACKNOWLEDGMENT

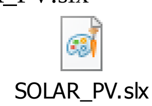
We hereby acknowledge the efforts of my colleagues and thankfulness is bestowed towards IJME for providing us a golden opportunity to represent our college at international level.

ENCLOSED

SOLAR_PANEL_DESIGN_INSTALLATION.m –

MATLAB PROGRAM FILE

SOLAR_PV.slx – SIMULINK DESIGN



FILE the subsystems of given Simulink file contains proper equations and their modelling.

REFERENCES

[1] IISc. NPTEL Solar Energy tutorials.
[2] www.pveducation.org
[3] www.electronics4u.com
[4] MATHWORK INCORPORATION.
[5] STUDENT SOLAR AMBASSADOR PROGRAM