International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Numerical Simulation of Effect of Cooling on Energy Enhancement of Solar Photovoltaic System

Nisha Singhal[1], Mukul Varshney[2]

[1]M. Tech (Scholar), Mechanical Engineering, Laxmi Devi Institute of Engineering and Technology,Alwar, Rajasthan, India
[2]Assistant Professor,Department of Mechanical Engineering, Laxmi Devi Institute of Engineering and Technology, Alwar, Rajasthan, India

Abstract

PV panels are the most efficient technique to transform solar energy into electricity while emitting no greenhouse gases. Photovoltaic (PV) technology has been the popular choice for energy production and consumption due to its commercial acceptance, economic compatibility, increasing efficiency, renewable nature, environmental friendliness, and ease of maintenance. PV's efficiency is the only roadblock to its expansion. When PV panels are exposed to greater temperatures, their efficiency begins to deteriorate. Because of this issue, PV systems are less efficient, have longer payback times, and are less popular. PV cooling, whether through water or air, is the most efficient technique to increase efficiency. Water and air can be used in a variety of ways to reduce the temperature of PV panels. Another technique to boost PV plant output is to make sure the accessories are working properly. To acquire the best output from the PV plant, several accessories such as a solar inverter, charge controller, MPPT, and so on should be carefully chosen. To get optimal output, a PV plant can be configured with the above outputs.PV panel output begins to decrease when the temperature exceeds the maximum permissible temperature. The PV Plant's efficiency suffers as a result of the fall in production. This functions as a stumbling block to solar energy's rapid expansion. Neglecting the relevance of solar accessories such as inverters, MPPTs, and charge controllers in the plant has a significant impact on the plant's efficiency. The wrong accessory layout reduces the PV plant's performance. All of these factors reduce the plant's efficiency, lengthening the payback period, which contributes to solar energy's lack of popularity.

Key Words: DCT, DWT, OFDM, MSE, AWGN, GUI, BER, MIMO OFDM, FFT OFDM, QPSK, PAPR, FDM, SLM, PTS.

1.Introduction

A solar photovoltaic (PV) device is an electronic device that converts light energy into electricity. The “Hoffman electronics” launched the first solar panel power satellite in 1958. One of the better possibilities is solar power. because the sun's rays never diminish. Solar radiation, on the other hand, is free and available in our atmosphere. The constant rise in fuel prices, as well as global warming and pollution, encourages the usage of renewable energy sources. A solar PV system is made up of numerous components, including solar panels that absorb and convert sunlight into electricity, a solar inverter that converts DC to AC electric current, as well as mounting, cabling, and other electrical accessories. The phrase "photovoltaic" is made up of two words: "photo" refers to light, and "volt" refers to voltage. Photovoltaic cells transform sunlight directly into electrical energy in the photovoltaic system under consideration. The material is crystalline silicon. Photovoltaic (PV) cells are another name for solar cells. There are no moving parts in this gadget. The photovoltaic system is intended to supply electricity to the load. It doesn't matter if the load is AC or DC. It occurs during the day, at night, or twice. Photovoltaic systems can only operate during daylight hours. Because we have batteries and electricity that can be stored and used, we require consumables. Electronic processes occur naturally in particular types of materials called semiconductors, and this is how solar photovoltaic (PV) systems create electricity directly from sunlight. Solar energy releases electrons in these materials, which can be detected by electrical circuits to operate electrical equipment or create electricity for the grid..

2.SOLAR PHOTOVOLTAIC SYSTEM

The process of direct conversion of light into electricity is called photovoltaic effect. Some semiconductor material like Si or Ge exhibits the property of photovoltaic effect which causes them to absorb the light photon and release electrons. A French physic Edmund Bequerrel in 1839 found that some material when exposed to light produced small amount of electric current. Later on Albert Einstein described photovoltaic effect and nature of light in 1905.The first Photovoltaic module was built by Bell laboraties in 1954.Figure 2.1 shows the basic diagram of Photoelectric effect. In solar cell manufacture electric field is created by specially treating a thin semiconductor wafer .When light falls on solar cell electrons are knocked out from the atoms in semiconductor material. If electrical conductors move to positive and negative sides, they form electric circuit and there will be a flow of electrons which result in to electric current. When a number of solar cells are electrically connected to each other and are mounted on a frame, they form PV module. Modules are specially designed to produce voltage at a specific volt. However produced current will then depend upon the amount of light striking the module. Ideally the solar cell is represented by a current source in parallel with a diode but practically there is no ideal solar cell, so the effect of series and shunt resistance must be taken into account. The Equivalent circuit and Schematic representation of solar cell is shown in the figure 1.4 [1]The current flowing through the solar cell is equal to that produced by current source minus the current which flows through the diode minus the value of current through shunt resistor [2][3]

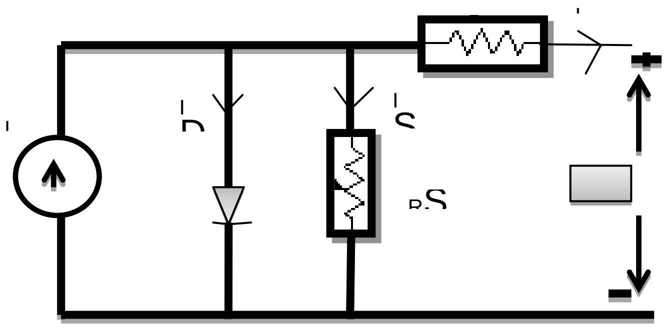

Figure 2.1 Equivalent Circuit of Solar Cell

$$I = I_L - I_D - I_{SH} \qquad (2.1)$$

Where I is the total current generated by diode, I_L is photo generated current, I_D is the diode current and I_{SH} is the current through the shunt resistance.

Voltage across these elements will give the value of current so

$$V_{jun} = V + IR_S \qquad (2.2)$$

Where V_{jun} is the voltage across the diode and shunt resistance R_{SH}

V=output terminal voltage

I=output current

R_s =series resistance

The value of current through diode which is given by Schokley diode equation is-

$$I_D = I_0 \left\{ \exp\left[\frac{qV_{jun}}{nkT} \right] - 1 \right\} \qquad (2.3)$$

Where I_0 =Reverse saturation current

n=diode Ideality factor

q=elementary charge

K=Boltzmann's constant

T=absolute Temperature

The value of current through shunt resistance is given by

$$I_{sh} = \frac{V_{jun}}{R_{sh}} \qquad (2.4)$$

Substituting the values in Equation , we get

$$I = I_L - I_o \left\{ \exp\left[\frac{q(V + IR_S)}{nKT} \right] - 1 \right\} - \frac{V + IR_S}{R_{SH}} \qquad (2.5)$$

The characteristic equation is affected by the temperature directly via T in exponential term and indirectly via I_0.With the increase in value of T, the magnitude of exponent in the characteristic equation reduces while I_0 increases exponentially with T. The net effect of these two conditions is the reduction in open circuit voltage (V_{OC}) linearly with increase in temperature. The magnitude of reduction is inversely proportional to V_{OC} i.e. the cells with higher values of V_{OC} suffer smaller reductions in voltage with increasing temperature .The change in V_{OC} for most of the crystalline silicon solar cell with temperature is about -0.50%/°C though the rate for the highest-efficiency crystalline silicon cells is around -0.35%/°C. By way of comparison, the rate for amorphous silicon solar cells is -0.20%/°C to 0.30%/°C, depending on how the cell is made.to keep the temperature of Photo Voltaic panel with in the Maximum Allowed Temperature (MAT, 25°C under STC) its cooling is very necessary. In this a cooling medium is used for lowering the temperature. The cooling medium may be air, water, PCM (Phase Changed Materials). Broadly cooling can be in two different ways. If external energy source is used for cooling purpose it is known as Active cooling, if not it is Passive cooling.

3. COOLING METHODOLOGY OF SOLAR PV SYSTEM

Front surface cooling by water- Water is used as coolant. Water is made to flow on the panel at natural or gravitational flow. A pipe of 56cm with 10 no of holes is placed at the top of the panel. Water is allowed to flow at three different rates such as 1L/minute, 1.5L/minute and 2L/minute. Output of the panel at three different water flow rates are compared. Flow rate of 2L/minute is found to be most effective.

Figure 3.1 Front Surface Cooling by water

Back surface cooling by dry grass &water- In the PV Panel stand net of iron is made on which dry common grass are spread. A pipe of 3mm is used with holes at a certain distance to wet the grass. There is also path for air flow to the grass.

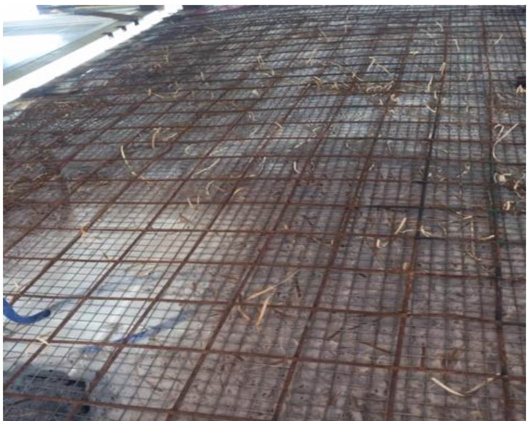

Figure 3.2 Front &back view of Back surface cooling by common grass and water

First of all the water flow rate for the cooling panels has been determined by testing four different rates of cooling with a without cooling panel. Four types of water flow rate such as 1L/minute, 2Litre/Minute, 3Litre/Minute, 4Litre/Minute are applied to a panel for 30minutes of interval. Their voltage, current, power and temperature are studied for comparison.

All the PV panels operate at the same time individually. They are 1PV Panel with front surface cooling, 1PV panel with back surface cooling by common grass and water, 1PV Panel by Sand and Water, 1PV Panel without any cooling method. All the panels operate from 6AM to 6PM. The values of voltage, temperature and irradiation are logged into the data logger at an interval of 7minutes.

The flow rate of water is compared for 1L/Minute, 2L/Minute, 3L/Minute, 4L/Minute at an interval of 30minutes.

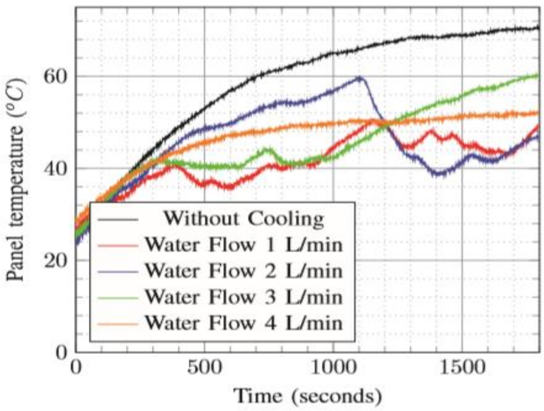

Figure 3.3 Effect of Water Flow rate on panel temperature

The voltage of PV panel without cooling continuosly shows a low value as compared to other panels. Cooling by using water and sand, water and grass doesnot show large difference in output voltages. Panel with front surface cooling by water gives maximum output voltage except cloudy days.

4. Simulation & Result

The results of this research work can be listed as follows:

- Performance Analysis of Power at Various Temperature.
- Analysis of Cooling System for Tempearature Regulation of Solar Panels
- Power Output Analysis of Cooling System Coupled Solar PV System

This is done to study the effect of temperature and irradiation individually and then combine effect. First temperature is kept constant at 25°c but irradiation varies and then vice versa. After that both irradiation and temperature varies to study the IV and PV characteristics.Keeping Temperature constant and varying irradiation. To study the effect of Irradiation, temperature is kept constant at 25°C in the above shown PV simulation model and simulation is done. The Simulation has been done with three different time of day. Effect of cooling has been observed during morning, noon and evening respectively. The performance plot of characteristic has been moduled with respect to scaled down model of solar photovoltaic system. The analysis has been explained with help of simulink model explained in figure. Figure 4.1 indicates the simulink diagram of proposed system. The simulation has been performed for three different condition. The first case is panel having no cooling facilty incorporated. The second case is panel having cooling with water and third case is cooling with water and grass respectively.

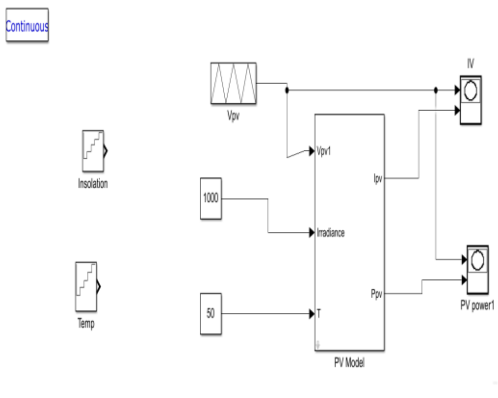

Fig.4.1 Simulink Diagram of Proposed System with Parametric Variation

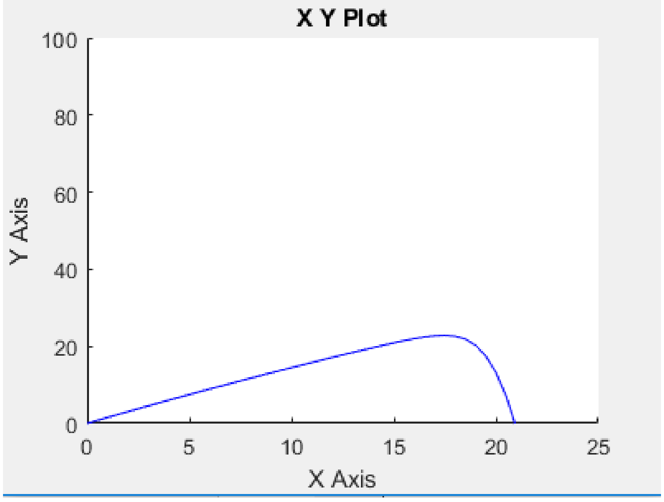

Fig.4.2 Power Voltage Waveform of Photovoltaic System without Cooling

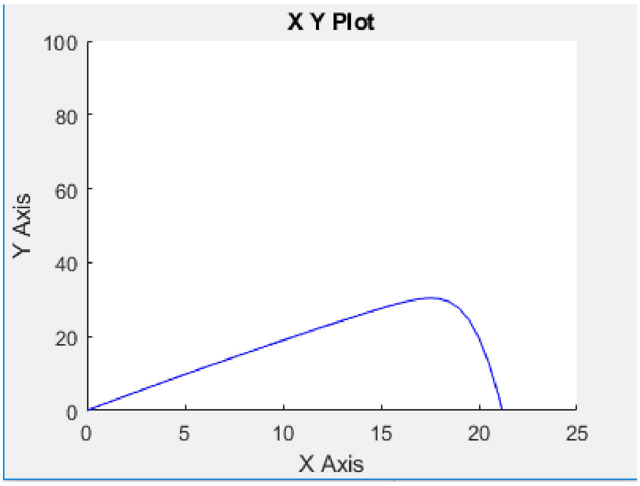

Fig.4.3 Power Voltage Waveform of Photovoltaic System with grass at back surface

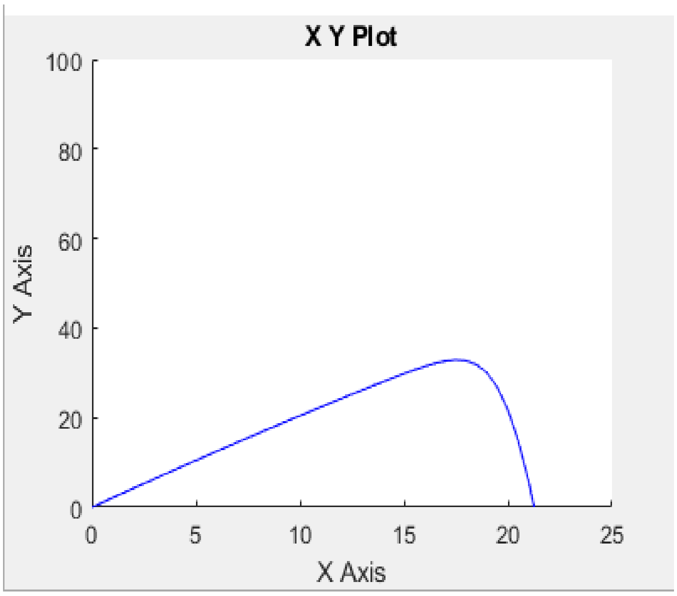

Fig.4.4Power Voltage Curve of Photovoltaic System with Front Cooling System

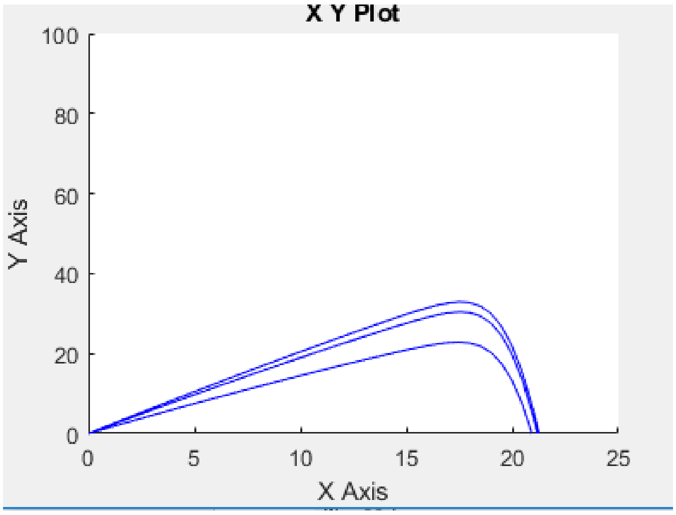

Fig.4 Comparative Analysis of Three Cases for Validation of Cooling System

The proposed research has been implemented for three cases of the cooling system with water, grass with different orientaton of front cooling system incorporated with back surface grass cooling system. The contemporary analysis of three cases prove that there is significant increase in the performance of the photovoltaic system after the installation of cooling system. The system with front cooling perform best in the comprehensive analysis of the propsoed sytem.

4. Conclusion

PV panel output begins to decrease when the temperature exceeds the maximum permissible temperature. The PV Plant's efficiency suffers as a result of the fall in production. This functions as a stumbling block to solar energy's rapid expansion. Neglecting the relevance of solar accessories such as inverters, MPPTs, and charge controllers in the plant has a significant impact on the plant's efficiency. The wrong accessory layout reduces the PV plant's performance. All of these factors reduce the plant's efficiency, lengthening the payback period, which contributes to solar energy's lack of popularity. The research conducted is effective in improving the system's performance under high-temperature conditions..

References

[1] Subhash Kumar, Tarlochan Kaur, "Solar PV performance-issues and challenges", *International Journal Of Innovative Research In Electrical Electronics Instrumentation And Control Engineering*, vol. 2, no. 11,pp. 2168-2172, November 2014 .

[2] Deethumol Augustin, Rani Chacko, Joffie Jacob, "Canal top solar energy harvesting using reflector", *Global Research and Development Journal for Engineering*, vol. 1, no. 8, pp. 26-31, July 2016.

[3] Ramkumar, R., M. Kesavan, C. M. Raguraman, and A. Ragupathy. "Enhancing the performance of photovoltaic module using clay pot evaporative cooling water." In *Energy Efficient Technologies for Sustainability (ICEETS), 2016 International Conference on*, pp. 217-222. IEEE, 2016.

[4] Jianping, Sun. "An optimum layout scheme for photovoltaic cell arrays using PVSYST." In *2011 International Conference on Mechatronic Science, Electric Engineering and Computer (MEC)*. 2011.

[5] Sannasiraj, S. A., and V. Sundar. "Assessment of wave energy potential and its harvesting approach along the Indian coast." *Renewable Energy* 99 (2016): 398-409.

[6] Suresh, V., S. Naviynkumar, and V. Kirubakaran. "Improved power output of PV system by low cost vaporative cooling technology." In *Green Computing, Communication and Conservation of Energy (ICGCE), 2013 International Conference on*, pp. 640-643. IEEE, 2013.

[7] Arshad, Rizwan, Salman Tariq, Muhammad Umair Niaz, and Mohsin Jamil. "Improvement in solar panel efficiency using solar concentration by simple mirrors and by cooling." In *Robotics and Emerging Allied Technologies in Engineering (iCREATE), 2014 International Conference on*, pp. 292-295. IEEE, 2014.

[8] Sandhya, S. "Study on performance enhancement of PV cells by water spray cooling for the climatic conditions of Coimbatore, Tamilnadu." In *Innovations in Information, Embedded and Communication Systems (ICIIECS), 2015 International Conference on*, pp. 1-5. IEEE, 2015.

[9] Babu, B. Chitti, and Suresh Gurjar. "A novel simplified two-diode model of photovoltaic (PV) module." *IEEE journal of photovoltaics* 4, no. 4 (2014): 1156-1161.

[10] Breitenstein, Otwin. "An alternative one-diode model for illuminated solar cells." *IEEE Journal of Photovoltaics* 4, no. 3 (2014): 899-905.

[11] Sridhar, Yadavalli Venkata. "Case study of grid connected PV plant feeding power to electrical submersible pumps." In *Power and Renewable Energy (ICPRE), IEEE International Conference on Power and*, pp. 547-552. IEEE, 2016.

[12] Jianping, Sun. "An optimum layout scheme for photovoltaic cell arrays using PVSYST." In *2011 International Conference on Mechatronic Science, Electric Engineering and Computer (MEC)*. 2011.

[13] Kumar, Nitin, PriyaYadav, and S. S. Chandel. "Comparative analysis of four different solar photovoltaic technologies." Energy Economics and Environment (ICEEE), 2015 International Conference on. IEEE, (2015)

[14] Irwan, Y. M., et al. "Stand-alone photovoltaic (SAPV) system assessment using PVSYST software." Energy Procedia 79,596-603, (2015)