Review Paper on Efficiency Improvement of Photovoltaic Panel by using Thermoelectric Effect

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Abstract— In this paper, the photovoltaic panel were used to integrate the extraction of light energy and thermal energy. The need of this setup is to study the effect of thermoelectric cooling effect to remove the heat in photovoltaic. The experimental result were subsequently analyzed and compared with power generation efficiency of the examined photovoltaic. The use of thermoelectric cooling system improves the power capacity of the photovoltaic by 2% - 20% and enhance the power generation efficiency of photovoltaic by 2.29% -3.37% through the combined application of photovoltaic and thermal technologies, the total energy of the overall system can be improved by 37% - 60%.

Key words: Photovoltaic panel (PV cell), solar energy, thermoelectric effect, peltier module, efficiency improvement

I. INTRODUCTION

Now – a – days solar plants getting the wide importance all over the country. To overcome the problems like energy deficiency, global warming and detoriation of environment and energy sources. In abandon quantity of solar energy is available in environment with free of cost. Solar energy can be converted into electricity by using PV effect.

Currently many developed countries have busy in search and development of renewable energy sources. Development of renewable energy sources reduces the pollution and promotes the energy security [1].

For directly conversion of sunlight into electricity, use electronic device which contains the solar PV cells. A complex relationship between voltage and current is exhibited by the P-

N junction in the solar cell. A complex relationship between voltage and current is exhibited by the P-N junction in the solar cell. Both voltage and current being a function of the light falling on the cell, there exists a complex relationship between insolation (sunlight) and output power. Solar cells capture slow-moving low energy electrons. The saturated effect cause a fixed energy loss under bright light condition. However, on an overcast day i.e. at lower insolation levels these mechanisms show an increasing percentage of the total power being generated. Too much insolation causes saturation of cells, and the number of free electrons or their mobility decreases greatly [7] [8].Therefore, several papers on cooling systems and improvement of efficiency in solar-cell applications [1]-[6] have been published in last few years.

In [1], water cooling system improves the solar energy utilization by using the combine concentrator photovoltaic. Simon Lineykin and Shmuel Ben-Yaakov, [2] proposed the modelling and analysis of thermoelectric effect by considering the thermoelectric generator. In [3]-[5], the different cooling system is explained with their efficiencies. [6] Explains the improvement in efficiency in polycrystalline solar panel with water cooling system with detailed methodology. In [9] Pradhan Arjyadhara, Ali S.M, Jena Chitralekha explains the behaviour of irradiance and temperature on solar PV panel. Arati Kane, Dr.Vishal Verma in their conference paper explains the thermoelectric cooling effect on integrated photovoltaic module [10]. [11] and [12] also explains the temperature effect on photovoltaic panel and the thermoelectric cooling criteria respectively.

II. PHOTOVOLTAIC CELL (OR PV PANEL)

The direct conversion of solar cell into electricity is called as the photovoltaic effect. Solar cells are present to convert the solar energy or sunlight into electric energy. A single cell is called as the solar cell while in bunch of cells called as the photovoltaic cell. Generally the PV panel is made up of semiconductors which produce electricity by observing sunlight. The theoretical efficiency of this device is about 25% but in actual the efficiency of this device is the half of the theoretical and decreases with increase the temperature. In general PV cell shows the efficiency above 12 to 15 percent. Normally solar cell consists of p-n junction semiconductor. This p-n junction usually obtained by putting p-type base material into a diffused furnace containing gaseous n-type dopant.

The term Irradiance is defined as the measure of power density of sunlight received at a location on the earth and is measured in watt per m/sq. whereas irradiation is the measure of energy density of sunlight. The term Irradiance and Irradiation are related to solar components. As the solar insolation keeps on changing throughout the day similarly I-V and P-V characteristics varies with the increasing solar irradiance both the open circuit voltage and the short circuit current increases and hence the maximum power point varies. Temperature plays another important role in determine the solar cell efficiency. As we know temperature is directly proportional to the rate of photon generation, thus reverse saturation current increases rapidly and this reduces the band gap. Hence this leads to marginal changes in current but major changes in voltage. The voltage of cell reduces by 2.2Mv per degree rise of temperature.

III. THERMOELECTRIC EFFECT OR PELTIER MODULE

Performance of solar panel decreases with increase in the temperature of the panel. Output power of PV module drops by 0.45% per oC rise in temperature if heat is not removed. To remove the heat from PV panel use peltier module or thermoelectric effect. Thermoelectric module can convert heat energy into electrical energy directly. The main phenomenon of peltier or thermoelectric module is come from the Seebek effect.

There are two dissimilar metals denoted as material A and material B. The junction temperature at A is used as a reference and is maintained at a relatively cool temperature (TC).The junction temperature at B is used as temperature higher than temperature TC. With heat applied to junction B, a voltage (Eout) will appear across terminals T1 and T2 and hence an electric current would flow continuously in this closed circuit. This voltage as shown in Figure (1) known as the Seebeck EMF.

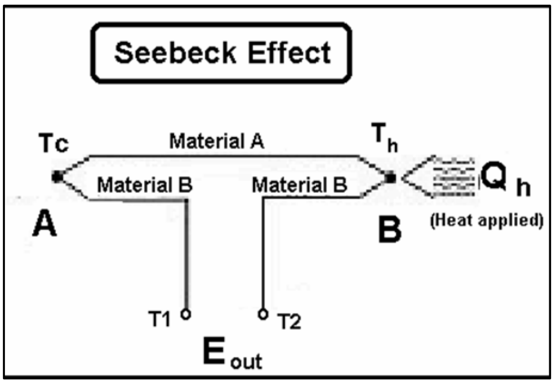


Fig. 1: Seebeck effect

In the peltier module or in the thermoelectric module there is totally opposite phenomenon is consider. In thermoelectric effect thermal energy could be absorbed at one dissimilar metal junction and discharged at the other junction when an electric current flowed within the closed circuit. In Figure (2), the thermocouple circuit is modified to obtain a different configuration that illustrates the Peltier Effect, a phenomenon opposite that of the Seebeck Effect. If a voltage (Ein) is applied to terminals T1 and T2, an electrical current (I) will flow in the circuit. As a result of the current flow, a slight cooling effect (QC) will occur at thermocouple junction A (where heat is absorbed), and a heating effect (QH) will occur at junction B (where heat is expelled).

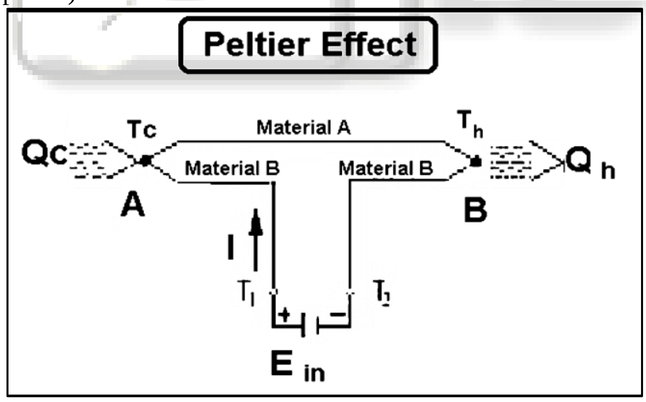


Fig. 2: Peltier effect

IV. PRINCIPLE OF OPERATION OF THERMOELECTRIC EFFECT

In the construction of thermoelectric module, there are two thin ceramic wafers with a series of P and N doped bismuth telluride semiconductor material sandwiched between them as shown in Figure (3). The N type material has an excess of electrons, while the P type material has a less number of electrons. The couple consist of single P and N type of material, as shown in Figure (4). The thermoelectric couples are electrically in series and thermally in parallel. A thermoelectric module can contain one to several hundred couples. When electron move from lower energy level to higher energy level that is the electron move from p-type material to n-type material and absorb the thermal energy. The situation where the thermal energy absorbed called as the cold side. For heat sink or hot side of thermoelectric effect is totally opposite to the cold side that is there is the n-type electrons move or jump to the p-type and discharge or release the energy.

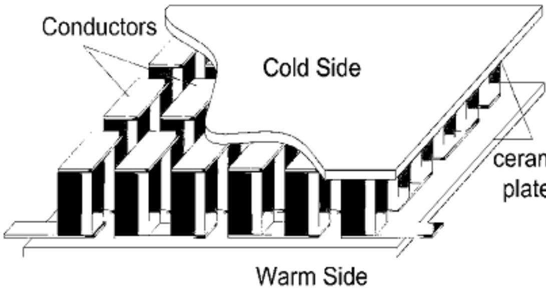


Fig. 3: Principle of operation

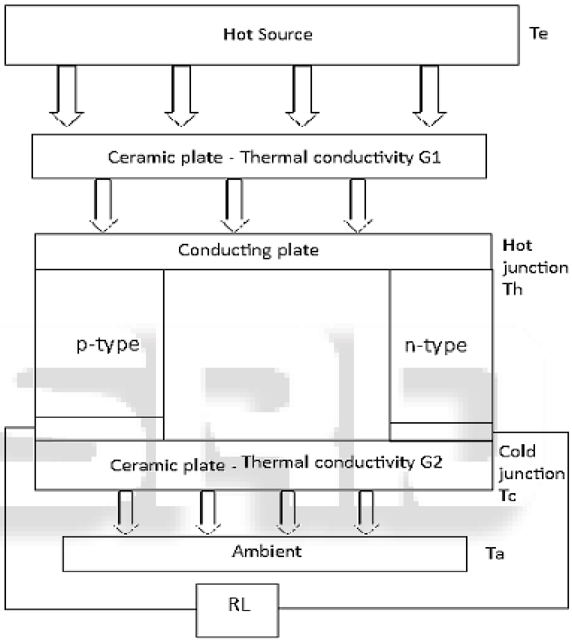


Fig. 4: A single thermoelectric couple

V. NEED OF PELTIER MODULE

The heat sink and cold side mounting surface should be made out of materials that have a high thermal conductivity to promote heat transfer. However, insulation and assembly hardware should be made of materials that have low thermal conductivity to reduce heat losses and if it combines with PV panel it improves the efficiency. Also it operates in wide range of temperature with highly precious temperature control.

VI. SYSTEM CONFIGURATION AND CONTROL MODEL

The block diagram of the system and control model is shown in below fig. 5. In the block diagram of system mainly consist of temperature sensor, solar panel, analog to digital converter, solar panel, microcontroller, LCD display and relay. In this system when solar panel reached at certain temperature it get hot and senses the temperature to the temperature sensor and at that point the voltage is also recorded to the voltmeter. And in the next step both result forward to the A to D converter after that microprocessor plays an important role to sense the relay or in the operation of relay. And the final stage is for the LCD display.

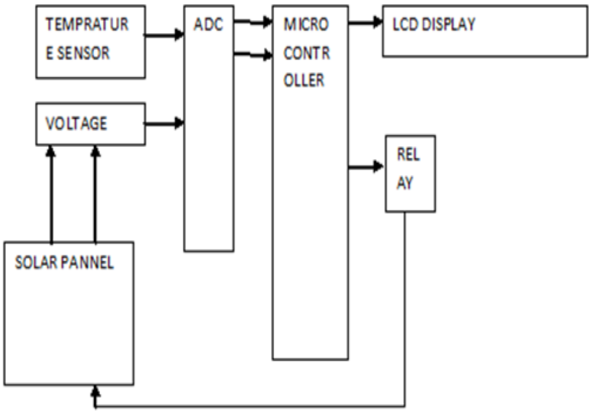


Fig. 5: System Configuration and Control Model

VII. SIMULATION RESULT

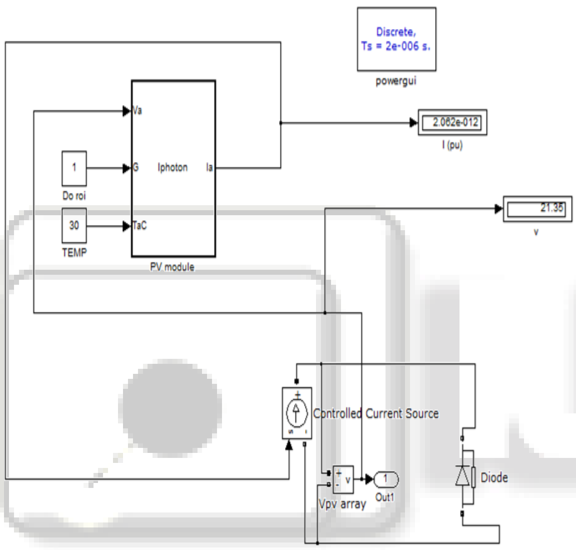
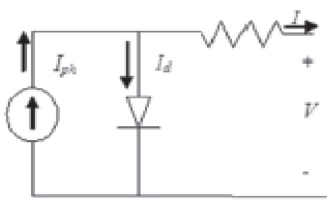


Fig. 6: MATLAB simulation for PV- module

In the simulation of PV module mainly consist of controlled current source, diode and pv array voltmeter. The above MATLAB model is implemented from the following circuit diagram of PV module.



In the above diagram *Iph* is the photon current, *Id* is diode current. t and diode is connected in antiparallel with light generated current source.

By Kirchhoff law we obtain the output current *I* which is given by:

$$I = Iph - Id \tag{1}$$

Id proportional to saturated current and it is given by,

$$Id = Io[\exp\left(\frac{V}{A.Ns.Vt}\right) - 1] \tag{2}$$

In reality it is possible to neglect the series resistance Rs and parallel resistance Rp because of their impact of efficiency of PV cell and PV module. When RS is taken into consideration, above equation should take the next form:

$$Id = Io[\exp\left(\frac{V + I.Rs}{a}\right) - 1]$$

Where,

$$a = \frac{Ns.A.K.Tc}{q}$$

Or

$$a = Ns.A.Vt$$

In MATLAB module,

Tac is value of cell temperature.

G is value of Radiance.

All the terms by which, V is divided in diode current which is inversely proportional to cell temperature and vary with varying conditions. Similarly with voltage.

The simulating result of system must give the efficiency improvement of photovoltaic panel and also shows the P-V and I-V curve for solar panel.

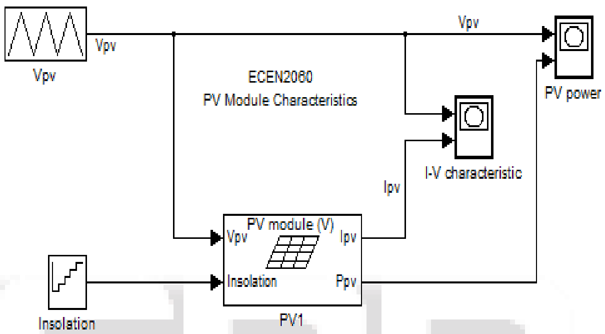


Fig. 7: SIMULINK model for P-V module

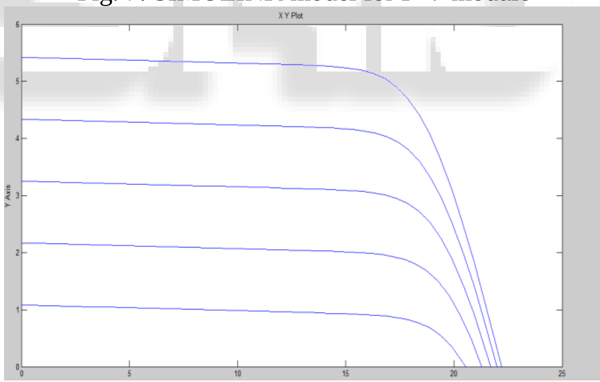


Fig. 8: I-V characteristics

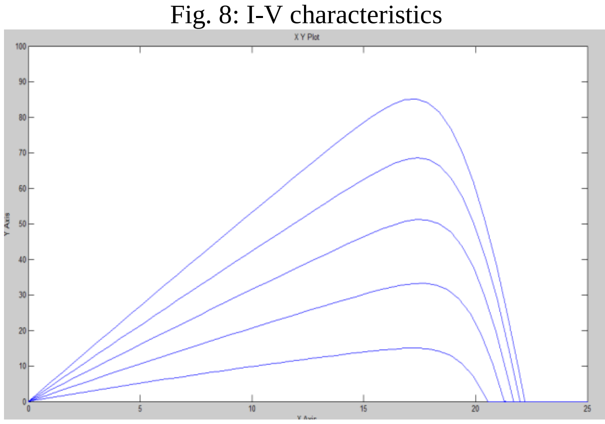


Fig. 9: PV power

The model assists in expecting the behaviour of the PV cell for different reverse saturation currents of the diode. The curves of Figs.8 and 9 were plotted for three different values of *Is*: 100nA, 10nA and 1nA. The influence of an increase in *Is* is evidently seen as decreasing the open-circuit voltage *Voc*.

VIII. CONCLUSION

With the increase in temperature the rate of photon generation increases thus reverse saturation current increases rapidly and this results on reduction in band gap. Hence this leads to marginal changes in current but major changes in voltage.

The actual working of the system will explain with hardware model in next phase.

IX. ACKNOWLEDGMENT

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