Controlling the ambient temperature of a PV panel to maintain high conversion efficiency

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Abstract – Photovoltaic systems have been increasingly used in the generation of electrical energy. Although being widely used, it has not reached the expectations needed to solve the energy demands of today and the near future. One of the disadvantages of PV panels is their temperature degradation. Therefore, this work focuses on investigating and controlling the effect that the ambient temperature exerts on the amount of electric energy produced by a PV panel. The ratio of solar energy to output electrical energy is considered as the conversion efficiency.

I. INTRODUCTION

Photovoltaic technology (PV) provides an attractive method of power generation and meets the criteria of clean energy and sustainability [1]. However solar energy remains an expensive technology and efficiencies of commercial modules have not risen significantly in recent year [2]. The sun delivers energy to the earth with a power of 1.2×10^5 TW, which is about 10^4 times higher than current energy production[3]. Moreover, solar energy is clean, reliable, renewable, and environmentally friendly [4].

A typical PV module is built as array of multiple interconnected solar cells, which convert solar energy into electrical energy. More than 80% of the solar radiation reaching the PV module is not converted into electrical energy; it is reflected or transformed into heat energy [5]. PV modules are widely used in many types of applications like small electronic devices (calculators) and bigger installations (spacecraft or households). Advanced research is still in progress to increase the efficiency of PV modules and optimize the production of energy through minimization of power losses and better utilization of incident solar irradiance [6]. Environmental conditions as well as system designs constitute the most important factors in the operation of the PV modules and these can have a significant impact on the overall efficiency and power quality response [7].

This paper focuses on controlling the ambient conditions of PV modules to ensure high conversion efficiency. The objective of this study is to use different cooling techniques for PV modules in order to provide optimum output power, thereby reducing dependence on traditional energy sources such as fossil fuels.

The solar installation consists of a sun module SW220 poly-crystalline PV panel with LM35 temperature sensors fixed at different points as shown in figure 1. Panel temperature is measured to understand its behavior with output power.

Figure 1: Position of a temperature sensor on PV panel.

II. PROPOSED SYSTEM

Figure 2 shows a block diagram of the practical setup, which comprises a PV panel, DC–DC converter, constant load and data acquisition equipment.

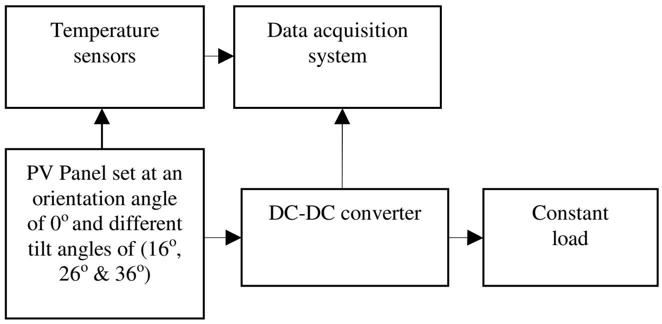

Figure 2: The practical setup.

The PV panel is placed at an orientation angle of 0^o and at three different tilt angles (16^0, 26^0 and 36^0). A LM35 temperature sensor which generates 0.01 V for every degree Celsius is mounted in a small box and sealed to protect it from water, thereby forming a temperature probe, allowing for flexible sensor placement on the PV panel. The data acquisition equipment consists of a data logging interface (DLI) circuit and a DAQPro 5300 data logger. The DLI is designed to protect the data logger from high input voltages, as it can only accommodate voltages below 10 V. The data logger input channels will be used for measuring voltage, current, and ambient temperature.

Figure 3 illustrates the basic schematic diagram of the measurement system. It also shows different positioning of the LM35 sensors connected to the panel.

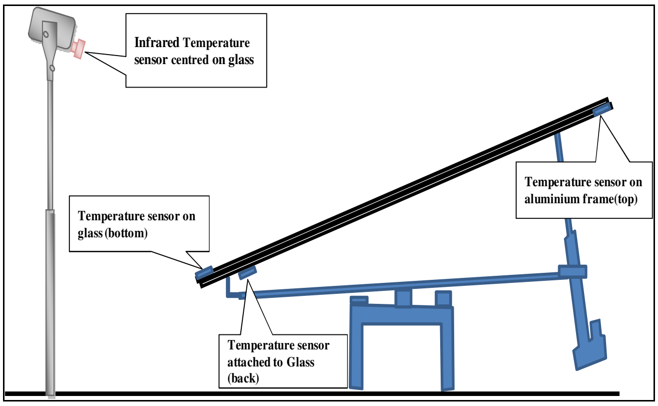

Figure 3: Position of temperature sensor on the PV panel.

The actual temperature inside the solar panel cannot be measured, and so the surface temperature at different points is measured jointly with the air temperature. The real significance of measuring the temperature of the modules is to evaluate how it changes with direct solar irradiance. Module temperature can change relatively quickly if the weather conditions change, so it has to be monitored on a continuous basis to establish its influence on the power output of a PV panel.

III. EXPERIMENTAL RESULTS

The following data has been captured for (2-9 March 2012):
1) Climatic data: Ambient temperature.
2) Electrical data: Voltage and Ampere.
3) Thermal data: PV module surface temperature.

The obtained result is presented graphically. Figure 4 presents the relation between the PV panel surface temperature and its output voltage. The difference between the surface cells temperatures, the ambient temperature and the output voltage for a period of one week is plotted. A direct correlation is observed between temperatures rise and voltage decrease.

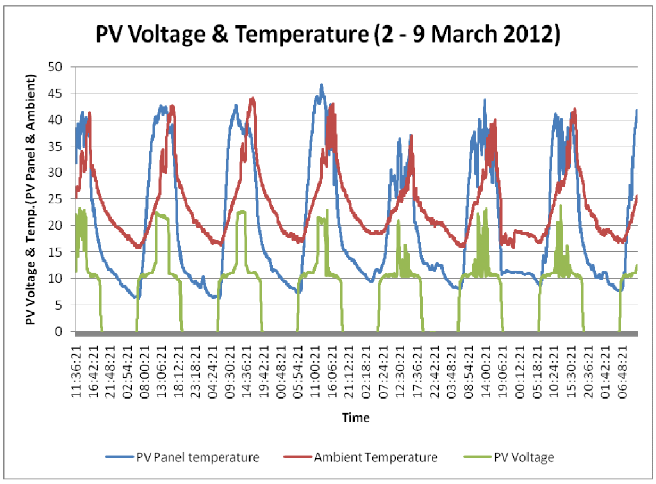

Figure 4: Output voltage vs. temperature.

This inverse relationship of output voltage (and subsequently output power) with temperature rise negatively affects the conversion efficiency. The negative effect of the temperature increase on the performance of the PV panel is therefore an important factor to consider.

IV. CONCLUSION

In review, the purpose of this study is to optimize the available output power from a PV panel by controlling the ambient temperature. This will enable a higher yield of solar energy, thereby reducing dependence on traditional energy sources such as fossil fuels. The conversion efficiency of PV module depends to a large degree on their surface temperature. Although the air temperature cannot be controlled, an extra cooling system can be used to cool down a PV panel. PV panels can be cooled actively or passively. An active system requires some external power source to run. A passive system requires no added power. However, special attention must be given to controlling the ambient temperature of the PV panel to ensure high conversion efficiency.

V. REFERENCES

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Ozemoya Austin received his undergraduate degree in 2011 from Vaal of Technology University, South Africa. And he is presently studying towards his Master degree in electrical engineering at the Vaal University of technology. His research interests include how to improve the efficiency of photovoltaic panel by controlling the ambient temperature.