

Effect of Shading on the Output Power of Photovoltaic Array

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Abstract

The utilisation of photovoltaic conversion of solar energy to power water pumps is today an emerging technology, characterised by gradually declining costs and increasing acquaintance with the technology. Since the first installations in the end of the seventies, solar water pumping systems for providing domestic, livestock and irrigation water supplies in remote areas have gained enormously in acceptance, reliability and performance and nowadays belong most significant applications of photovoltaic energy [8]. Utilities are finding it more economical to use a photovoltaic powered pump than to provide and maintain a distribution line to remote area. In this work MATLAB simulink software is used for modeling PV cell which is further modified to develop a PV array model [4]. Shading is created when a physical object such as tree, cloud and a telephone pole is physically obstructing the sunlight, creating shadow on the photovoltaic array which affects the response of the whole system. The output declines proportionally to the amount of shading [9]. A small amount of shading can have huge impact on the performance of the solar photovoltaic panel system. If the entire cell is shaded, then no current will flow through the cell and its voltage output will collapse.

Keywords: Photovoltaic panel system, Output Power, Photovoltaic Array, MATLAB simulink software

INTRODUCTION

Solar energy refers primarily to the use of solar radiation for practical electricity generation. However, there are other renewable energies like natural gas, coal and bio fuel. Solar radiation along with other secondary solar powered resources such as wind, geothermal, tidal and wave power, hydroelectricity and biomass, account for most of the available renewable energy on the earth. Only minuscule fraction of the available solar energy is used [10].

Over the years, solar energy has been gaining ground as a source of electricity. Photovoltaic cells convert sunlight directly to electricity. Photovoltaic (PV) cells utilize semi – conductor technology to convert solar radiation directly into an electric current which can be used or stored.

Photovoltaic is a combination of two words “Photo” from Greek root meaning, light and “Voltaic” from volt which is the unit used to measure Electric potentials at a given point. The Photovoltaic effect was first noted by a French Physics that certain material would produce small amount of Electric field, ALBERT EINSTEIN described the nature of light and photovoltaic technology that it was too expensive to gain wider spread use in 1954.

Sunlight is made up of tiny particles called photons which are being converted to electrical energy. Every hour, enough of this energy reaches the world to meet the world's energy demand for the whole world. Photovoltaic panels consists of many solar cells, these are made of materials like silicon, one of the most common elements on earth.

The individual cell is designed with a positive and a negative layer to create an electric field, just like in a battery [7]. As photons are absorbed in the cell, their energy causes electrons to become free, the electrons move toward the bottom of the cell, and exit through the connecting wire.

The flow of photons is what we call electricity. By combining solar cells and photovoltaic panels, we can produce just the right amount of electricity to perform a specific job, no matter how large or small, Solar energy is the energy derived from the sun through a form of solar radiation. Solar powered electricity generation relies on photovoltaic cells and heat engines.

A partial list of other solar applications include space heating and cooling through solar architecture, day lighting, solar hot water, solar cooking, and high temperature

process heat for industrial purposes. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favourable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

Photovoltaic (PV) cells convert sunlight directly to electricity. They work any time the sun is shining, but more electricity is produced when the sunlight is very strong and strikes the PV cells directly. The basic building block of PV technology is the solar cell.

The PV cell consists of two or more layers of semi-conducting material, most commonly silicon. When the silicon is exposed to light, electrical charges are produced and can be conducted away by metal contacts as Direct Current (DC). The current from a single cell is small, so, multiple PV cells are connected together and sealed behind glass to form a module known as SOLAR PANEL.

PV allows you to produce electricity, without noise, air pollution and fuel. Most PVs have a life span of 25 – 50 years. Solar power in rural areas is a viable alternative for providing electricity for telecommunications, telemetry, water pumping, lighting, television, DC refrigeration and other low power non-heating applications Heating appliances such as kettles, toasters, stoves, geysers and heaters are consuming too much energy and therefore cannot be used on a solar system].

The basic components for this solar energy system are; solar panel, charge controller, battery, inverter, wiring, and connected loads. **See figure 1.**

BASIC CONNECTION METHODS OF SPVA AND ASSOCIATED PROBLEMS

As with the connection of cells to form modules, a number of modules can be connected in series string to increase the voltage level, in parallel to increase the current level or in a combination of the two. The exact configuration depends on the current and voltage requirements of the load.

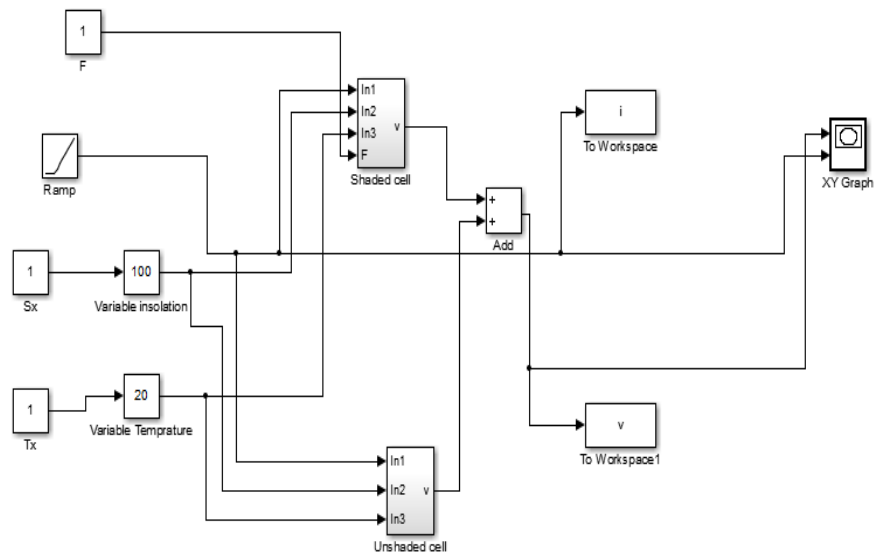


Fig. 1 Series connection under shading for I-V and P-V characteristics

Matching of the interconnected modules in respect of their outputs can maximize the efficiency of the array. The conventional SPV module is constructed of several SPV cells (normally 36 cells) connected in series [3]. In the SPV power generation system, multiple SPV modules are generally connected in series in order to obtain sufficient dc voltage. If there is one shaded module in a series connected array, it can then act as a load to the array. It may cause damage to the module due to the heavy current passing through it. To prevent this damage, bypass diodes are connected in anti parallel with each module, and, in case of the module is shaded; the current may flow through the bypass diode rather than through

the module. In series connected array, even the slightest shadow falling on a SPV module causes a significant drop in generated power.

In parallel connected modules, if one module is severely shaded, or if there is a short circuit in one of the module, the blocking diode prevents the other strings from sending current backwards down the shaded or damaged string. Diodes placed in series with modules can perform the function of blocking currents from flowing back to the modules thus preventing the modules from becoming loads [12]. When the non shaded SPV modules and the shaded SPV modules are connected in parallel, the

generation voltage is fixed for each SPV module and is uniform throughout the entire SPV generation system, and the current generated from each SPV module flows without restriction. In other words, the output voltage of the SPV system becomes the voltage of a single module, and the output current becomes the sum of the currents in each module.

In contrast, when each PV module is connected in series, the same current flows through each module and the output voltage becomes the sum of the voltages across each of the modules. However, the voltage of

each module is decided according to the generation current, which depends on the generation/shaded conditions. Therefore, the optimal generation voltages are not always obtained for each SPV module.

In particular, when some of the SPV modules do not have sufficient generation current, the voltage of the SPV modules is greatly decreased and the resultant generation power is also greatly decreased. The performance analysis for series and parallel connected SPV modules is analyzed in the following sections through consideration of the operating point.

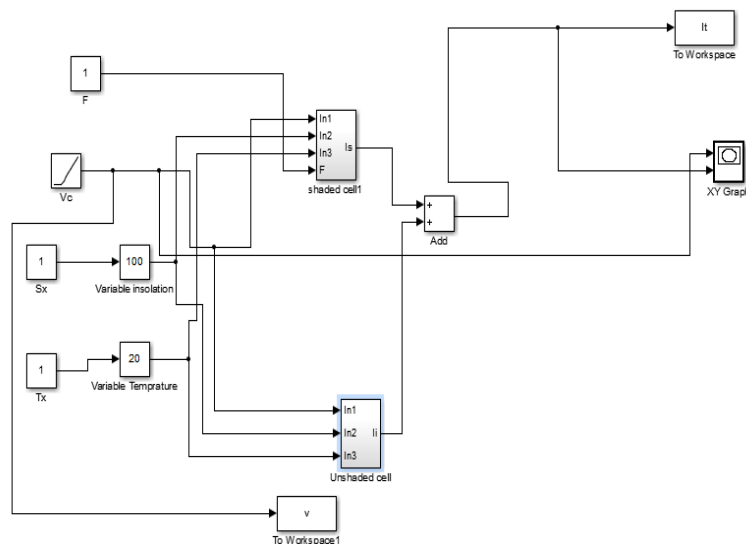


Fig.2 Parallel connection under shading for I-V and P-V characteristics

The resulting i-v and p-v curves of the PV for various temperatures and solar

irradiation levels are illustrated in Figure 9 (a, b, c, d). The PV cell output voltage and current are sensitive to change in solar

radiation and ambient temperature thus the effect of changes in the ambient conditions are taken in the proposed PV cell model.

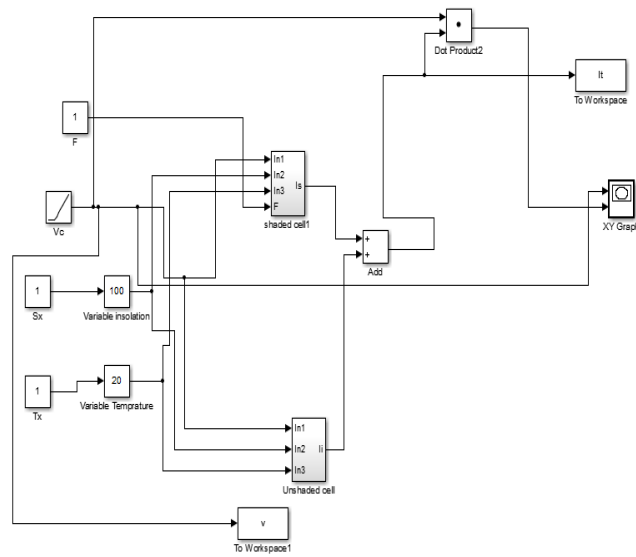


Fig 3 Details of parallel connection under shading for P-V characteristics

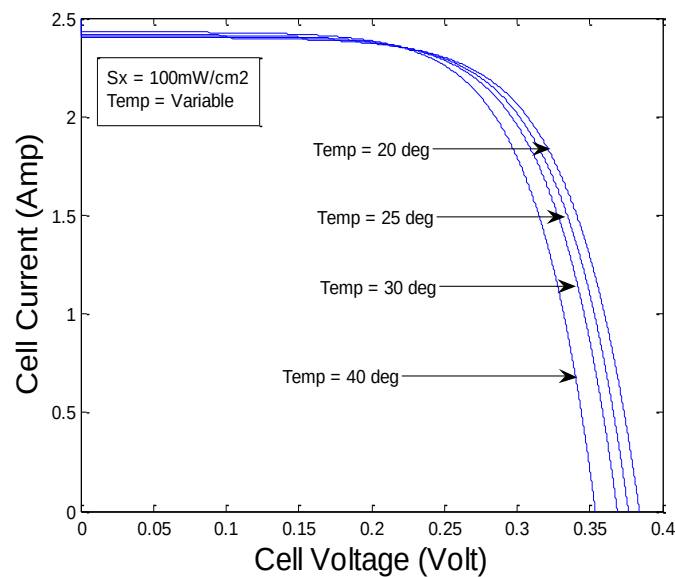


Fig 4 i-v characteristics at variable Tx

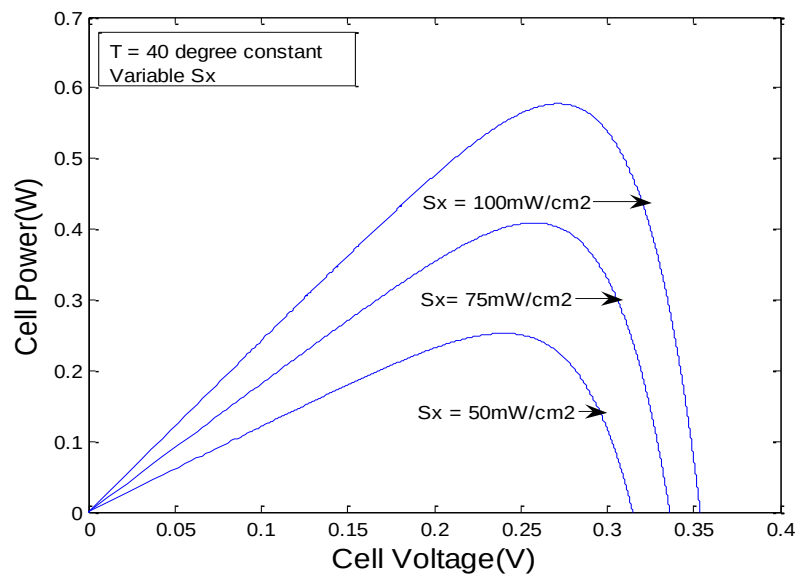


Fig 5 P-V characteristics at variable S_x

SOFT COMPUTING OPTIMIZATION TECHNIQUES FOR PHOTOVOLTAIC ARRAYS

In recent years intelligence techniques have been used widely in the MPPT process. specially under non uniform and partially shading conditions, where there is a difficulty to track MPP. Therefore, for a satisfactory result, all environmental conditions (especially instantaneous climate changes and partial shading) must be taken into account in the design process of MPPT. Artificial intelligence can produce appropriate solutions for these conditions. Artificial intelligence-based MPPT algorithms are the most advantageous systems in terms of electrical efficiency. In

this chapter three different optimization technique viz; Genetic algorithm (GA), Differential evolution (DE) and Particle Swarm optimization (PSO) techniques have been used for GMPP tracking. These techniques are compared in respect of their tracking time and accuracy.

CONCLUSION

In this paper an empirical relation has been established through a series of experiments on varying shading factor of different values. Reverse biased characteristics of a SPV cell are required to model the partial shading conditions of the SPVA. During reverse bias the shunt resistance R_{sh} is an important parameter affecting the behavior

of the cell. Most of the researchers have either taken R_{sh} as constant or have neglected it. The proposed model is more accurate when applied to analyze SPV module characteristics under partial shaded conditions. The developed model can be interfaced with power electronics circuits to see the impact of shading and can be used to develop new methods to reduce the adverse effects of partial shading. The proposed electronic load method is a simple circuit for display and recording of the characteristics in field conditions [11]. Series connection of solar cells in an array is essential to get practically utilizable voltage. In series connection, the shaded cells may get reverse biased, acting as loads, draining power from fully illuminated cells. The impact of partial shading on series connected cells, series connected modules and parallel connected modules have been carried out.

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