

Performance Enhancement of DC Load and Batteries in Photovoltaic System

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ABSTRACT

To avoid the pollution and to save the non-conventional resources, use of renewable energy sources such as wind energy, bio-gas, hydro and solar potential has increased and become essential to adopt a low-cost generating system in remote areas. Besides the variety of energy sources, solar power advantages are easy to make apparent compared to other methods. For many years, solar energy is the series source of vast amounts of freely available energy, but modern technology has harnessed it. In this paper a proper battery charge controller used in the Standalone Photovoltaic (PV) system. The power is transfer to the dc load and manages storage level available in this proposed technique. From the PV array the maximum power is extracted by using three different methods. In this proposed technique 'perturb and observe' and the 'incremental conductance' control methods and algorithms are analyzed. The system modelling as well as simulation results are presented.

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KEYWORDS: Renewable energy, solar panel, photovoltaic cell, modelling and control, MPPT

INTRODUCTION

Non-renewable energy sources such as fossil fuels and nuclear ores have a rate of replenishment on the order of millions of years, and are currently being used at a rate significantly greater than that of replenishment. Consequently, there is a finite reserve of non-renewable energy sources, and once these reserves have been emptied, alternative sources of energy must be used.

Renewable energy sources are those which are replenished at a rate greater than they are consumed. Renewable energy sources include solar energy, some forms of biomass, tidal and hydropower and wind. Due to increasing concerns about climate change and energy security, nations are making an effort to increase energy efficiency and switchover to renewable sources of energy. In some cases they argue that nuclear energies have poorer performance than the fossil fuel and renewable energy sources used today Renewable energy sources are generally considered to be climate-friendly, and allow countries with no fossil fuel reserves to gain energy.

Solar energy, as the name implies, exploits the energy from solar radiation to produce usable energy. There is significant potential in this source of energy: the total solar radiation intercepted by Earth is on the order of 8000 times greater than the human primary energy demand. Unfortunately, the

ability of humans to effectively collect and transform this energy remains severely limited.

Currently, two methods of harnessing solar energy exist: concentrated solar power (CSP) and solar photovoltaic (PV). The former involves focusing, or concentrating, solar energy to heat a working liquid to produce steam which in turn powers a turbine. The latter, photovoltaic, uses cell arrays to capture solar energy and convert it into direct current electricity. Only photovoltaic energy is considered in this work. Various PV technologies currently exist and the area is still developing rapidly. High-purity silicon is usually the material of choice in solar PV cells. The general concept behind solar PV is that the incoming solar radiation is absorbed by a solar cell. The energy in the photons promotes electrons in the solar cell, creating an electric potential. Cell arrays may be grouped in large collection to form a sun farm, or installed on rooftops and building facades as a decentralized source of energy.

The technology used to convert the sun's power into electricity does not produce smoke (carbon dioxide and other air pollutants). Tapping the sun's energy does not usually destroy the environment. Unfortunately, the sun does not available in the night, and in some days, clouds and rains and other natural conditions prevent the sun's powerful rays to reach us. This means that it is not always

available. This a why we cannot rely on solar energy alone. In general, the Earth has two global movements that affect the reception of the solar energy to its surface: the rotation that it does once on itself per day and the yearly revolution that it does around the sun. The combination of these movements implies daily changes in the receipt of the solar light to particular places. The reason for which the energizing flux received to soil hardly passes 1000 W/m² is that the atmosphere modifies in an important way the direct radiance of the sun. The phenomenon named "photovoltaic effect" consists mainly in transforming the solar light in electric energy by means of the semiconductor devices named photovoltaic cells.

The solar panel, or photovoltaic generator, is itself constituted of an association of series and parallel of the necessary number of modules to assure the requisite energy. Maximum Power Point Trackers (MPPTs) play an important role in photovoltaic (PV) power systems because they maximize the power output from a PV system for a given set of conditions, and therefore maximize the array efficiency. Thus, an MPPT can minimize the overall system cost. MPPTs find and maintain operation at the maximum power point, using an MPPT algorithm. Many such algorithms have been proposed. However, one particular algorithm, the perturb-and-observe (P&O) method, continues to be by far the most widely used method in commercial PV MPPTs.

TRACKING ARRAYS

Solar array follows the path of the sun and maximizes the solar radiation incident on the photovoltaic surface. The two most common orientations are:

- One-axis tracking: In this tracking mechanism, the array tracks the sun east to west. It is used mostly with flat-plate systems and occasionally with concentrator systems.
- Two-axis tracking: In this tracking mechanism, the array points directly at the sun at all time. It is used primarily with PV concentrator systems.



Fig1. Mounted tracking solar array

A compromise between fixed and tracking arrays is the adjustable, in MPPT method where the array tilt angle is adjusted periodically (usually seasonally) to increase its output. This is mostly done manually. The mounted tracking solar array is as shown in Fig. 1

PHOTOVOLTAIC SYSTEM MODELLING

A photovoltaic cell is basically semiconductor diode whose p-n junction expose to light. Photovoltaic cell are made from different types of semiconductors using different

manufacturing processes. The mono crystalline and polycrystalline are generally used in commercial level. When light fall on the cell it generate the charge carriers that originate the electrical current if the cell is short-circuited.

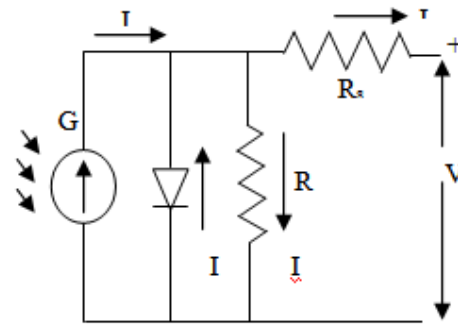


Fig. 2 Equivalent circuit of photovoltaic system

To draw the real model photovoltaic cell it is necessary to take into the account the losses due to leakage current in the diode and losses due to connection and contacts. That why two resistors are added in model on resistor is in series and second one is in parallel. The value of series resistant is very low but the value of parallel resistant is infinity. The equivalent circuit diagram of real photovoltaic is shown in Fig. 2.

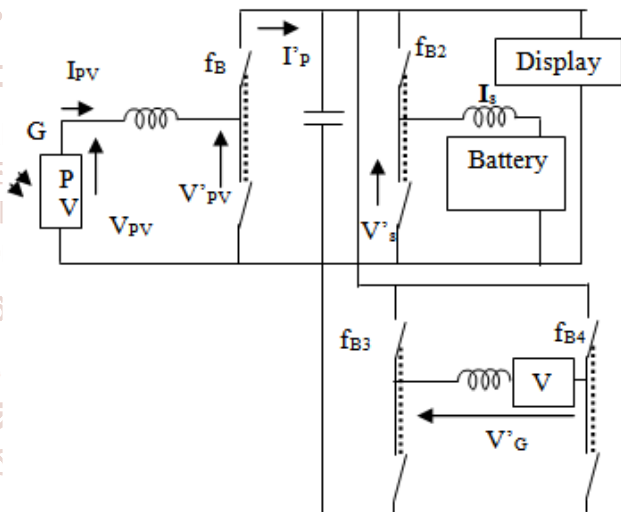


Fig. 3 Proposed circuit diagram of solar system for controlling the batteries and DC load Simple PV output current is,

$$I = I_{p/h} - I_0 * \left(e^{\frac{q*(V+I*R_s)}{n*k*T}} - 1 \right) - \frac{V + I * R_s}{R_{sh}} \tag{1}$$

R_{sh} is parallel leakage resistance and is typically large, > 100kΩ in most modern PV cells. This component can be neglected in many applications except for low light conditions. Current through the diode is represented by equation (2).

$$I_0 * \left(e^{\frac{q*(V+I*R_s)}{n*k*T}} - 1 \right) \tag{2}$$

Where:

- I₀ = Diode saturation current,
- n = Idealist factor (from 1 to 2),
- q = Electron charge (1.6x10⁻¹⁹ C).
- T = Temperature (°K),
- k = Boltzmann constant (1.38x10⁻²³J/K)

PROPOSED MPPT METHODS

The output power of a PV panel is a function of temperature, radiation and the position of panel. It is also the function of product of voltage and current. By varying these parameters the power can be maximize. To maximizing the output power generally MPPT used. This paper compares 3 different control methods along with algorithms of two of the methods. These methods include:

1. Perturb and Observe
2. Incremental Conductance
3. Constant Voltage
4. Open Circuit Voltage
5. Short Circuit Current
6. Temperature
7. Temperature Parametric

Perturb and Observe

Perturb and Observe (P and O) searches for the maximum power point by changing the PV voltage or current and detecting the change in PV power output. The direction of the change is reversed when the PV power decreases. P and O can have issues at low irradiance that result in oscillation. There can also be issues when there are fast changes in the irradiance which can result in initially choosing the wrong direction of search.

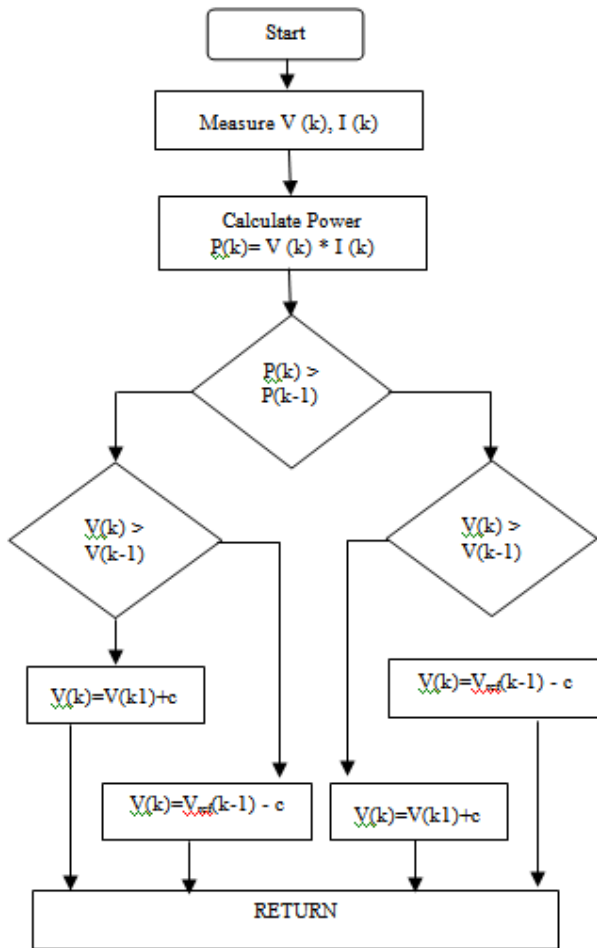


Fig. 4 Flow Chart for P&O Method

Incremental Conductance

This method consists of slope of derivative of the current with respect to the voltage to reach the MPP. To obtain this maximum point dI/dV should be equal to the $-i/v$. By applying the variation in the voltage towards the biggest

value or smallest value it affect the power value. If power increasing then should continue in the same direction, if power decrease then should reverse the direction. The flow chart of incremental conductance method is shown in Fig. 5.

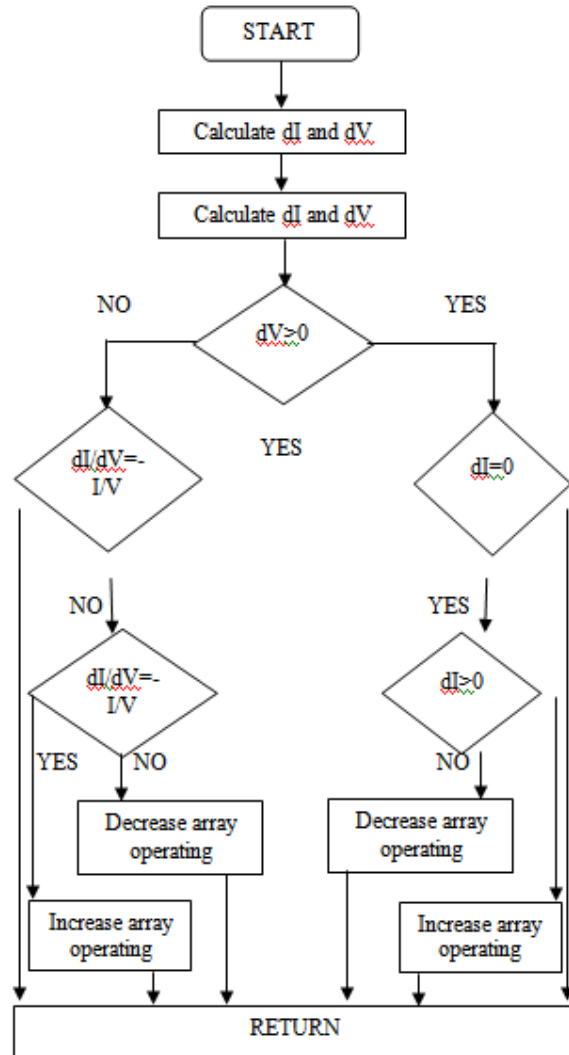


Fig. 5 Flow Chart of Incremental Conductance Method

This condition simply states that the maximum power point is located when the instantaneous conductance, $\frac{I_{pv}}{V_{pv}}$, is equal to the negative value of incremental conductance, $\frac{dI_{pv}}{dV_{pv}}$. The

IC uses a search technique that changes a reference or a duty cycle so that V_{PV} changes and searches for the condition of equation 3 and at that condition the maximum power point has been found and searching will stop.

The IC will continue to calculate dI_{pv} until the result is no longer zero. At that time, the search is started again. In some cases, a non-zero value is used for comparison so the search will not be triggered by noise. When the left side of equation 3 is greater than zero, the search will increment V_{PV} .

Constant Voltage

The constant voltage method is the simplest method. This method simply uses single voltage to represent the VMP. In some cases this value is programmed by an external resistor connected to a current source pin of the control IC. In this case, this resistor can be part of a network that includes a

NTC thermistor so the value can be temperature compensated. This method an overall rating of about 80%. This means that for the various different irradiance variations, the method will collect about 80% of the available maximum power. The actual performance will be determined by the average level of irradiance. In the cases of low levels of irradiance the results can be better.

SIMULATION RESULTS

To verify the validity of the control strategies, simulation and experiments are conducted. The simulation results for input voltage, current and power are shown in Fig. (6).

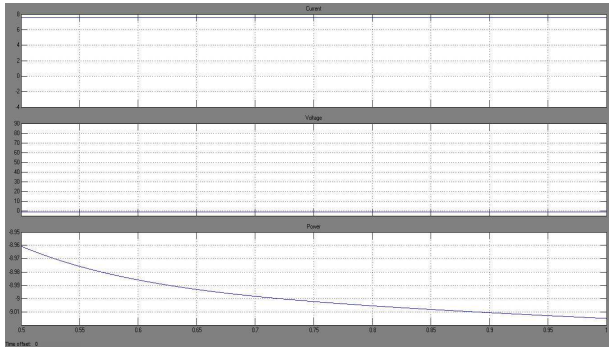


Fig.6 Input Voltage, Current and Power to the system

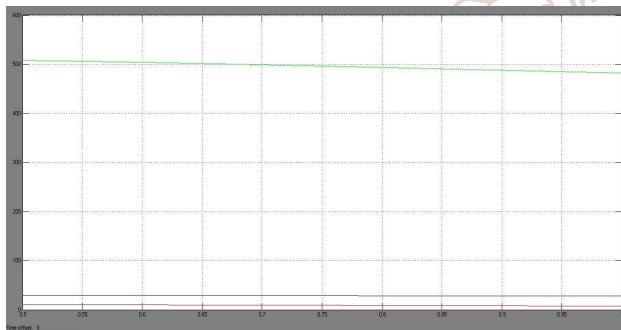


Fig. 7 Battery efficiency waveform

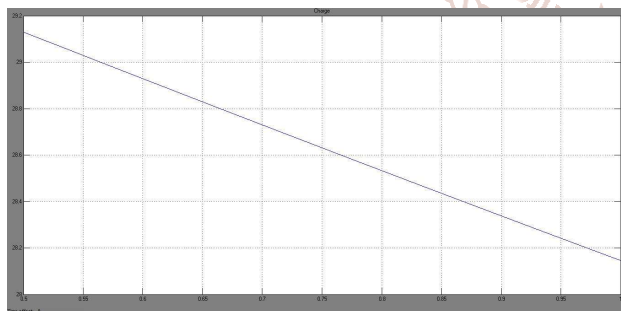


Fig. 8 Charge or discharge waveform

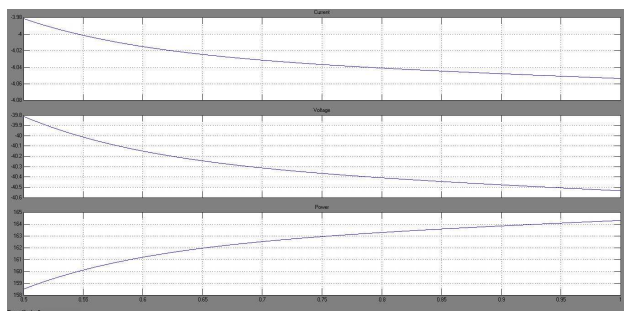


Fig. 9 Output voltage, current and power for the solar system

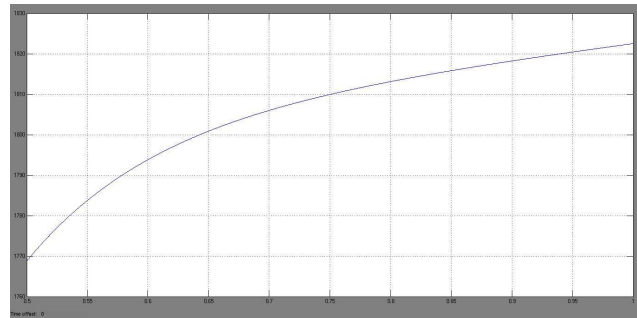


Fig. 10 Overall efficiency of the system

Battery efficiency during charge time and charge or the discharge of the storage during the PV power production are as shown in Fig. (7) and Fig. (8), the output voltage, current and power are as shown in the Fig. (9), the overall system efficiency is linear, which is shown in Fig. (10).

CONCLUSION

In this paper, we proposed a standalone solar system is modelled. The maximum power output efficiency is over 90%, which is simple and convenient. A simultaneous supply of a dc load to the system is allowed. During PV power production, the charge or the discharge of the battery storage is proposed. Solar system with DC load and battery charge controller have been proposed in this paper. To extract maximum power from the sun by using three control methods are analyzed. A simple and quick control to implement both PV systems. The modelling, algorithms and control methods are verified by using simulations results.

References

- [1] A.K. Abdelsalam, A.M. Massoud, S. Ahmed and P.N. Enjeti, 'High-performance adaptive perturb and observe MPPT technique for photovoltaic-based micro grids' *IEEE Trans. Power Electron.*, Vol. 26, No. 4, pp. 1010-1021, June 2011.
- [2] F. Blaabjerg, R. Teodorescu, M. Liserre and A.V. Timbus, 'Overview of control and grid synchronization for distributed power generation systems' *IEEE Trans. Ind. Electron.*, Vol. 53, No. 5, pp. 1398-1409, April 2006.
- [3] S.L. Brunton, C.W. Rowley, S.R. Kulkarni and C. Clarkson, 'Maximum Power point tracking for photovoltaic optimization using ripple-based Extremum seeking control' *IEEE Trans. Power Electron.*, Vol. 25, No. 10, pp. 2531-2540, July 2010.
- [4] M. Kolhe, 'Techno-economic optimum sizing of a stand-alone solar photovoltaic system' *IEEE Trans. Energy Convers.*, Vol. 24, No. 2, pp. 511-51, May 2009.
- [5] DB. Nelson, MH. Nehrir, C. Wang, 'Unit sizing and cost analysis of stand-alone hybrid wind/PV/fuel cell power generation systems'. *Renewable Energy*, Vol.31:1641-56, 2006.
- [6] R. Ramakumar, J. J. Bzura, J. Eyer, J. Gutierrez-Vera, T. E. Hoff, C. Herig, J. Iannucci and M. R. Milligan: 'Renewable technologies and distribution systems', *IEEE Power Eng. Rev.* :5-14, November 1999.
- [7] S. Jain, and V. Agarwal, 'An Integrated Hybrid Power Supply for Distributed Generation Applications Fed by Non-conventional Energy Sources', *IEEE Transactions on Energy Conversion*, Vol. 23, June 2008.

- [8] L. Pang, H. Wang, Y. Li, J. Wang, and Z. Wang, 'Analysis of Photovoltaic Charging System Based on MPPT', Proceedings of Pacific-Asia Workshop on Computational Intelligence and Industrial Application 2008 (PACIIA '08), Dec 2008, pp. 498-501.
- [9] S. Diaf, M. Belhamel, M. Haddadi, A. Louche, 'Technical and economic assessment of hybrid photovoltaic/wind system with battery storage in Corsica Island', *Energy Policy*, Vol.36:743-754, 2008.
- [10] S. J. Chiang, K. T. Chang, C. Y. Yen, 'Residential photovoltaic energy storage system', *IEEE Trans. Ind. Electron.* Vol.45, (Issue 3):385-394, Jun. 1998.
- [11] S. Wakao, R. Ando, H. Minami, F. Shinomiya, A. Suzuki, M. Yahagi, S. Hirota, Y. Ohhashi, and A. Ishii, 'Performance analysis of the PV/wind/wave hybrid power generation system', in *Proc. IEEE World Conf. Photo volt. Energy Conv.*, pp. 2337-2340, 2003.
- [12] F. Locment, M. Sechilariu and I. Houssamo, 'Batteries and DC charge control of stand-alone photovoltaic system. Experimental validation' in *Proc. 14th Int. Power Electron. Motion Control Conf*, pp. T12-43-T12-48, 2010.
- [13] D. D. Lu and V. G. Agelidi, 'Photovoltaic-battery-powered DC bus system for common portable electronic devices' *IEEE Trans. Power Electron.*, Vol. 24, No. 3, pp. 849-855, 2009.
- [14] M. Sechilariu, F. Locment and I. Houssamo, 'Multi-source power generation System in semi-isolated and safety grid configuration for buildings' in *Proc. IEEE Mediterranean Electro tech. Conf*, 2010.

