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**Enhancement of Perturbation and Observation Algorithm for Maximum Power Point Tracking of PV Solar System**

By

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**ABSTRACT**

Renewable energy technologies has been an area of intensive research and have been experiencing a rapid growth and improvement over the years which have made them attractive to the global energy agencies because of its environmental friendliness and its affordable cost of implementation. In this paper, we present an improvement of Perturbation and Observation (P&O) Maximum Power Point Tracking (MPPT) algorithms that improves the maximum power point of a Photovoltaic (PV) solar system under fast rapidly changing atmospheric condition. Simulation results show that the 59.25W of maximum power of photovoltaic array when using normal P&O algorithm was stepped up to 59.70W using improved P&O algorithm with 95% reduction in overshoot. The results were interpreted using MATLAB/Simulink as a means of validation and it is evident that the improved perturbation and observation algorithm recorded an improvement of 0.50W of maximum power of the photovoltaic array as compared to the normal P & O algorithm.

**Key words:** Renewable Energy, Perturbation and observation algorithm, MPPT and Photovoltaic solar**INTRODUCTION**

Renewable energy is the energy which comes from different natural resources such as sunlight, wind, rain, tides and geothermal heat. These resources are renewable and can be naturally replenished. Renewable energy technologies have been experiencing a rapid growth in improvement which has made them attractive to the global energy agencies as a result of its many benefits (Energy, 2015). There are different sources of renewable energy such as biomass, geothermal, hydropower and solar power.

Biomass is organic matter produced by photosynthesis, existing on the earth surface (Shahidehpour, 2005). Recent research shows that Biomass is the only other naturally occurring energy-containing carbon resource that is large enough in quantity to be used as a substitute for fossil fuel. However, direct combustion of biomass can be harmful to the environment which causes global warming and possible climate change. Geothermal energy is the thermal energy which is generated and stored within the layers of the earth. Hydropower on the other hand is a renewable form

of energy source where power is derived from falling water from higher to lower elevations (Akinboro F.G, 2011).

Power generation through sunlight has been the most widely common ways of generating electricity through photovoltaic cells that is globally considered to be environmental friendly. The photovoltaic (PV) power technology uses semiconductor cells and these cells convert the sunlight into electricity. Numerous cells are assembled in a module to generate required power depending on the desired output. It's noise and pollution free generations have made it surpasses the other renewable energy technologies (Fesharaki, et al., 2011). Photovoltaic (PV) system have been installed in almost every part of the world with optimizing its energy generation in such a way that it will operate at maximum power point (MPP) which corresponds to its maximum efficiency (Jiang, et al., 2005).

The aim of this paper is to develop a high performance Perturb and Observation (P&O) maximum power point tracking (MPPT) algorithms that will improve the maximum power point of a

Photovoltaic (PV) solar system under fast rapidly

changing atmospheric condition

The reminder of this work is divided into different sections: section one is all about the introduction, section two cover reviews of related works. Section three covers the methodology, design and simulation. Section four covers Implementation of Perturbation and Observation Based MPPT Algorithm, and section five presents results discussion and conclusion.

changing and partial shading. Simulation results show that the fuzzy controller successfully finds MMP for all the different weather conditions under observation.

### **Review of related works**

An intensive research has been carried out on renewable energy to determine maximum power point of photovoltaic (PV) in order to ascertain its maximum efficiency but the review of key once are presented.

The Literatures reviewed reveals that Perturb and Observation (P&O) Maximum Power Point Tracking (MPPT) algorithms has been the most common and widely used MPPT algorithms due to its cost effectiveness and ease of implementation. Under normal atmospheric changes, the tracking of maximum power point of this algorithm shows excellence result. However, this method exhibits unacceptable behavior under fast rapidly changing irradiance level, besides its slow response and high oscillation around MPP, which hereby causes incorrect or slow maximum power tracking and reduction in the efficiency of PV module. There is need to improve the performance of perturb and observation algorithm in order to overcome the drawbacks of the conventional P&O algorithm and hence the contribution of this research work.

Subudhi and Pradhan 2012 studied and compared two most commonly used MPPT algorithms; perturbation and observation method, and Incremental conductance, using Simulink models. A solar cell was modeled together with the converter and interfacing them with two different MPPT algorithms separately to obtain the MPP operation. However, this work was only restricted to constant and slow changing irradiance level for both the methods. Koutroulis, (2012), developed a new method to track the maximum power under partial shading conditions. This was done based on controlling a dc/dc converter connected at the PV array output, such that it behaves as a constant input-power load. The researcher claimed that the proposed method has great advantage and can be applied in either standalone or grid-connected PV system.

### **METHODOLOGY**

This research was carried out by first designing PV panel module under varying solar irradiance and change in temperature using MATLAB/Simulink. The design of boost converter using Simulink was also done for interfacing the designed PV module and the boost converter. Also, MATAB function is coded in order to mimic the operation of perturb and observation method. And finally we use MATLAB/simulink to obtain the performance results for both the improved Perturb and Observation Method and the conventional Perturb and Observation method as a means of validation.

Srivastata et al. (2015), Presents the design and performance of present standalone solar photovoltaic energy system with Perturb and observe based MPPT algorithm using solar PV panels of 72 cells. The proposed system was simulated using MATLAB/ Simulink model and the results reveals that the system has good dynamic response and good tacking accuracy.

Maximum Power Point Tracking (MPPT) techniques are primarily used in photovoltaic (PV) system to maximize the PV array output power by tracking the continuity of maximum power point (MPP) which depends on panels' temperature and on irradiation conditions (Killi and Samanta, 2015). For the purpose of this research, a boost converter is used as a source, which is connected to a solar panel in order to improve the output voltage. By

The research conducted by Allataifeh et al. (2015), Proposed a fuzzy system for tracking the maximum power point of a PV system for solar panel using MATLAB/ Simulink. The simulation was carried out using uniform irradiation, sudden

changing the duty cycle of the boost converter appropriately the source impedance is matched with that of the load impedance.

#### ***The Improved Perturb and Observe algorithm***

It was proved by Suryakumari J. et al, 2013 that the P&O MPPT control system sometimes deviates from the maximum operating point in case of rapidly changing atmospheric conditions, such as during cloudy, the solar irradiation can vary many times and quickly (Verma, et al., 2016). Another disadvantage is that this simple tracking method has difficulty in providing good performance in both dynamic and steady-state responses. This disadvantage and famous tradeoff problem between faster response and steady-state oscillations is integral (Suryakumari, 2013).

In order to avoid loss of great quantities of energy in order to achieve a good dynamic response for the system, high performance P&O technique is proposed to address this draw backs. The basic principle of the algorithm proposed is to adapt the perturbation amplitude to the actual operating conditions. In particular, far from the MPP, large perturbation amplitudes are chosen, whereas small ones are used in proximity to the maximum (Subudhi and Pradhan, 2012). In order to ensure that the MPPs are tracked under sudden changes of the solar irradiation, an adaptive P&O algorithm is proposed with a variable perturbation step size which depends on power. This means that the perturbation step size varies and adapts continuously under varying atmospheric conditions.

#### **DESIGN AND SIMULATION**

In this research work, MATLAB/Simulink software had been applied to model PV system. Thus, performance of MPPT controller to be operated with PV system was verified by simulation. The PV array has to be modeled first, followed by the MPPT controller. MPPT controller is connected to the system to measure the optimum PV current and voltage in order to calculate the MPP of PV system. Then, signal in term of duty cycle are sent to Pulse Width Modulation (PWM) controller for switching of DC- DC converter (Verma, et al., 2016).

The simulation is carried out to a cell surface temperature of 25°C, 54 solar cells in series and 1 row of solar cell in parallel. The irradiation, shown in the Figure 3 varies from 600W/m rise to 800W/m then to 1000W/m and then falls to 400W/m, which is closed to the day values of solar radiation received on the earth's surface. The simulation is run for a total of 1 second, with the irradiation taking up a new value at every 0.25 second and staying constant for another 0.25 second.

#### **RESULTS AND DISCUSSION**

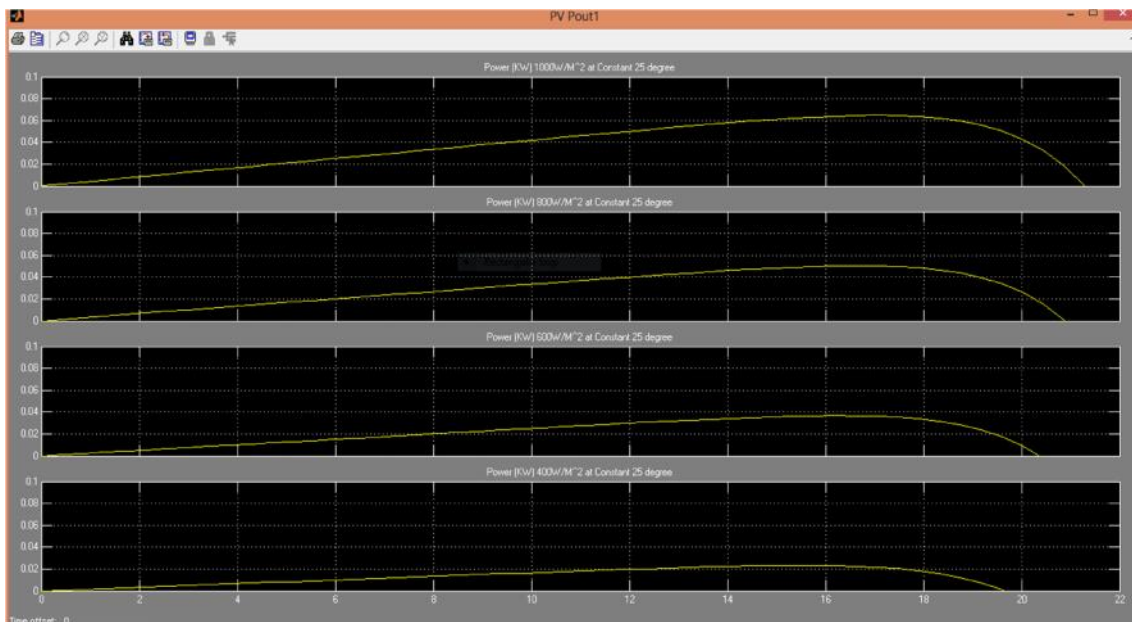
This section deals with the discussion of results obtained after simulation. The waveforms obtained from the model by varying the solar insolation and temperature of the photovoltaic module is shown Figure 1. This shows the current voltage curves at 25°C for different irradiance levels.



**Figure 1:** I-V Curves Obtained at 25°C for Various Irradiance Levels.

From Figure 1, it can be observed that by increasing the solar radiation at constant temperature the voltage and current output from

Photovoltaic array also increase. Hence, at higher insolation we can get our required level voltage.



**Figure 2:** Temperature level at constant irradiance.

From Figure 2, it can be seen clearly that by increasing the temperature level at constant irradiance, the output from Photovoltaic array

decreases but current output increases slightly with respect to voltage and, hence the power output from photovoltaic array decreases.

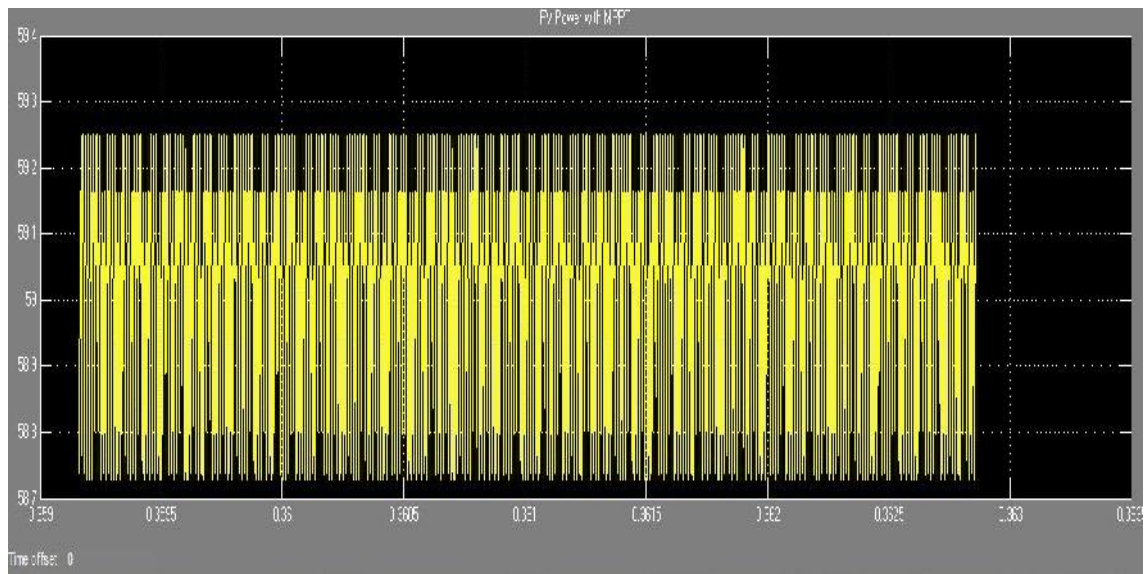


Figure 3: Output Power Using P&O MPPT under Various Solar Irradiance Levels.

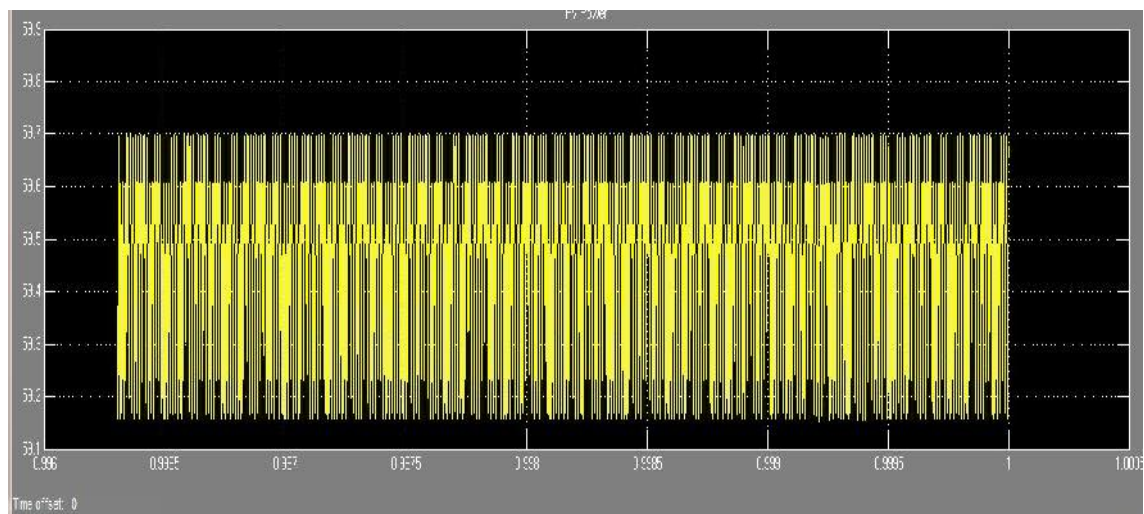


Figure 4: Output Power from Boost Converter Using Improved P&O MPPT under Various Solar Irradiance Levels.

From Figures 3 and 4, it can be observed that there is a change in output voltage and consequently, an output power for all the changes in solar irradiance level. The improved P&O MPPT has moved very close to maximum power point

allows solar array to produce a power with a slight change of 0.45W. Considering that more PV solar arrays are considered, more power will be definitely saved through this new algorithm.



Figure 5: Output Voltages from Boost Converter Using P&O MPPT under Constant Solar Irradiance, 1000W/M<sup>2</sup> and Temperature 25°C

## CONCLUSION

The design of improved P&O controller to control boost converter by using MATLAB 7.5 in order to track the Maximum Power Point of a Photovoltaic cell has been successfully achieved. As shown in Figure 14, the 59.25W of maximum power of photovoltaic array when using normal P&O algorithm was stepped up to 59.70W using improved P&O algorithm with 95% reduction in overshoot. Based on the simulation results obtained

## REFERENCES

- Akinboro F.G, A.L.A. M.V., (2011). 'Solar Energy Installation in Nigeria: Observations, Prospects, Problems and solution'. *Transnational Journal of Science and Technology*, 2 (4):73, 84.
- Allataifeh, A.A., Bataineh, K. and ALkhedreh, M., (2015). 'Maximum power tracking using Fuzzy logic controller under partial conditions'. *Smart grid and Renewable Energy*, 5:1, 13.
- Energy, B., (2015). 'Renewable energy sources'. *Ergon Energy*.
- Fesharaki, V.J., Dehghani, M., Fesharaki, J.J. and Tavasoli, H., (2011). 'The effect of temperature on photovoltaic cell efficiency'.
- the improved algorithm is a very efficient algorithm. However, this work is strictly based on various rapidly change in solar irradiance and change in temperature is not consideration during the implementation of this research. Further work can consider improving other available tracking algorithms apart from perturbation and observation algorithm in order to yield better efficiency, most especially in the case of fast changing levels of irradiance and when the solar panels are partially shaded.
- Proceedings of the 1st International Conference on Emerging Trends in Energy Conservation ETEC, Tehran, Iran, 20-21.*
- Han, Y., Zhang, D., Zhang, H. and Gao, Q., (2016). 'Survey of Maximum Power Point Tracking Techniques for Photo-Voltaic Array'. *International Journal of Control and Automation*, 9 (8):49-58.
- Jiang, J.-A., Huang, T.-L., Hsiao, Y.-T. and Chen, C.-H., (2005). 'Maximum power tracking for photovoltaic power systems'. 8 (2):147-153.
- Jordehi, A.R., (2016). 'Maximum power point tracking in photovoltaic (PV) systems: A review of different approaches'.

- Renewable and Sustainable Energy Reviews*, 65:1127-1138.
- Killi, M. and Samanta, S., (2015). 'Modified perturb and observe MPPT algorithm for drift avoidance in photovoltaic systems'. *IEEE Transactions on Industrial Electronics*, 62 (9):5549-5559.
- Koutroulis E, a.B.F., (2012). 'New Technique for Tracking the Global Maximum Power Point of PV arrays Operating Under Partial Shading Conditions'. *IEEE Journal of Photovoltaic*, 2 (7):184-190.
- Nigam, A. and Sharma, A.K.G.S., (2016). 'Simulation of Modified P&O MPPT Technique for Solar PV Cell Using MATLAB/SIMULINK'. *International Research Journal of Engineering Technology*, 03 (04):2364, 2367.
- Rezvani, A., Izadbakhsh, M., Gandomkar, M. and Vafaei, S., (2015). 'Investigation of ANN-GA and modified perturb and observe MPPT techniques for photovoltaic system in the grid connected mode'. *Indian Journal of Science and Technology*, 8 (1):87-95.
- Ropp, H.a., (2000). 'Comparative Study of MPPT Algorithms'. *South Dakkota State University*.
- Shahidehpour, N.S.a.M., (2005). 'Renewable Biomass Energy'. *IEEE*, 1,5.
- Singaravelu, B.a., (2012). 'Fuzzy Logic Controller for the Maximum Power Point Tracking in Photovoltaic System'. *International Journal of Computer Application*, 4:0975-8887.
- Srivastava, M., Agarwal, S. and Sharma, E., (2015). 'Design and Simulation of Perturb and Observe MPPT Algorithm for 72 Cell Solar PV System'. *International Journal of Soft Computing and Engineering (IJSCE)*, ISSN, 4 (5):2231-2307.
- Subudhi, B. and Pradhan, R., (2012). 'A comparative study on maximum power point tracking techniques for photovoltaic power systems'. *IEEE Transactions on Sustainable Energy*, 4 (1):89-98.
- Suryakumari, J., (2013). 'Analysis and Simulation of Modified Perturb and Observe MPPT Technique for PV System'. *International Journal of Energy Trends in Electrical and Electronics*, 9.
- Verma, D., Nema, S., Shandilya, A.M. and Dash, S.K., (2016). 'Maximum power point tracking (MPPT) techniques: Recapitulation in solar photovoltaic systems'. *Renewable and Sustainable Energy Reviews*, 54:1018-1034.

