A Grid Connected Hybrid Fuel Cell-Po Based Mppt For Partially Shaded Solar Pv System

K.Kiruthiga,
M.E.(Power Systems Engineering),
II Year,
Vivekanandha College of Engineering for women,
Tiruchengode, India.

A.Dyaneswaran,
Department of Electrical and Electronics Engineering,
Vivekanandha College of Engineering for women,
Tiruchengode, India.

B.Kavitha,
Department of Electrical and Electronics Engineering,
SSM college of engineering,
Komarapalayam, india.

Dr.R.Prakash,
Department of Electrical and Electronics Engineering,
Vivekanandha College of engineering for women,
Tiruchengode, India.

Abstract: *- In this paper a PO based MPPT is designed for solar photovoltaic system along with interleaved boost converter and boost converter is employed for fuel cell. Maximum power of the solar panel varies with respect to the temperature and solar radiation. By the manipulation of the duty cycle maximum power can be tracked. Then this hybrid photovoltaic- Fuel cell based system is studied under various load conditions for the mitigation of voltage sag in the power systems. The control strategy developed for the mitigation of voltage sag is by PI controller. The simulation is performed using MATLAB/SIMULINK under different load conditions and the results are presented.*

Keywords— *Fuel cell, Interleaved Boost Converter, Maximum Power Point Tracking (MPPT), Voltage sag.*

I.Introduction

Recently, renewable energy sources have attracted a great attention in research fields due to the fact that they provide the solution to the power demand problem without creating any pollution. Out of renewable energy sources solar energy based power production is most suitable in India as it lies nearer to the equatorial region and can get solar power mostly throughout the year. A solar panel converts only 30-40% of the incident solar radiations into electrical energy. This converted energy has to be effectively utilized. On the other hand, the 21st Century will be likely to be the century of the fuel cell, and as a result fuel cells will revolutionize the way to currently generate electric power offering the prospect of supplying the world with clean, efficient, sustainable electrical energy because they use hydrogen as a fuel. A fuel cell is defined as an electrical cell, which unlike other storage devices can be continuously fed with a fuel in order that the electrical power can be maintained. The fuel cells convert hydrogen or hydrogen-containing fuels, directly into electrical energy, heat, and water through the electrochemical reaction of hydrogen and oxygen. The output is literally small and has to be boosted i.e., increased in voltage to be supplied to the grid. This increase in voltage is performed by means of a boost converter.

Stand-alone system is employed in the remote areas where the access to the grid for the electricity is not possible.

But grid synchronization of these system is challengeable due to the fact that the Renewable energy sources are not very reliable. For example, the PV source is not available throughout the day, during the night or during cloudy conditions it is not available. Due of this problem, two or more renewable energy sources are required so that the reliability and cost effective solution for power demend is ensured. Now the combination of different types of energy sources is called a hybrid power system.

Renewable energy sources has attracted many reseachers due to the fact that the fossil fuel reserves is keep on depleading and global warming is increasing, so the sustainable energy solutions to preserve the earth for the future generations is likely to be met by renewable sources . Other than hydro power and thermal power, fuel cell and photovoltaic energy holds the most potential to meet our energy demands. Solar energy is present throughout the day but the solar irradiation levels vary due to sun intensity and unpredictable shadows caused by the environment conditions like clouds, birds, trees, etc. The common drawback of fuel cell and photovoltaic systems are their intermittent natures that make them unreliable. However, by combining these two system's power transfer efficiency and reliability of the system can be improved significantly.

Hybrid means utilization of two or more sources for the single load. So many advantages may be derived from Hybrid fuel cell-solar generation. They are continuous power can be supplied to the consumers. Environmental pollution can be reduced by using Hybrid solar- fuel cell generation system. The maintenance cost of hybrid solar-fuel cell generation system is less when compared to conventional generation system.

II. Photovoltic syatem

A.PV cell

A PV cell is the building block of a solar panel. A photovoltaic module is formed by connecting many solar cells in series and parallel. As per the requirement the cells can be connected in series so as to increase the voltage and when it is connected in parallel the current in the panel can be raised. Considering only a single solar cell, it can be modeled by utilizing a current source, a diode and two resistors. This model is known as a single diode model of solar cell. The single diode model is shown in the figure 1.

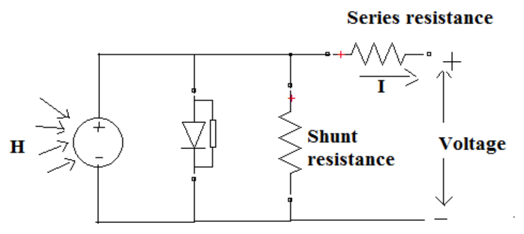

Figure 1. Single diode model of the PV Cell

The characteristic equation (1) and (2) of the solar cell shown in Figure 1 is

$$I = I_{lg} - I_{os} \times \left[\exp\left(q \times \frac{V+I\times R_s}{A\times K\times T}\right) - 1\right] - \frac{V+I\times R_s}{R_{sh}} \quad 1$$

$$I = \{I_{SCR} + K_i \times (T - 25)\} \times S \quad 2$$

Where,

I = Cell output current (Amperes)

V= Cell output voltage (in volts)

I_{lg}=light generated current(A)

I_{os}=Reverse saturation current(A)

R_{sh} = Shunt resistance(ohms)

R_s=Series resistance(ohms)

S=solar radiation(W/m^2)

q = Electron charge($1.602*10^{-19}$ Coulomb)

N = Ideality factor of the diode

K=Boltzmann's constant($1.381*10^{-23}$ J/K)

T = Junction temperature(Kelvin)

K_i=short circit current temperature coefficient

I_{scr} = Short circuit Current

It is seen that the characteristic equation of the solar cell totally depends on the number of cells connected in series and in parallel given by the following equation (3)

$$I = N_p \times I_{lg} - N_p \times I_{os} \times \left[\exp\left(q \times \frac{\frac{V}{N_s} + I \times \frac{R_S}{N_p}}{A \times K \times T}\right) - 1\right] - \frac{V \times \frac{N_p}{N_s} + I \times R_S}{R_{sh}} \quad 3$$

Where,

N_p=number of parallel cells

N_s=number of series cells.

Thus by increasing or decreasing the number of cells in series and parallel, the required voltage and current can be obtained. The standard testing condition refers to the Irradiation of 1000 W/m^2, AM1.5G global solar radiation, Cell or module temperature 25°C and with the Wind speed of 1 m/s.

Time(seconds).

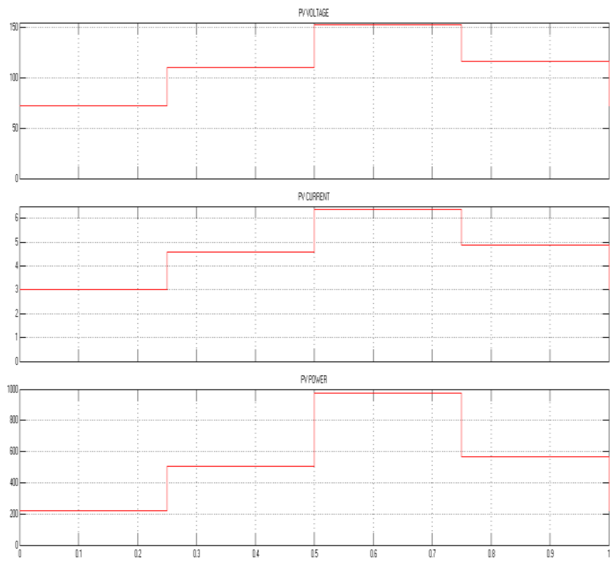

Figure 2. Voltage, Current and Power of a solar panel

B.MPPT algorithm.

The Perturb & Observe algorithm states that when the operating voltage of the PV panel is perturbed or disturbed by a small increment, if the change that results in the power ΔP is positive, then we are going in the correct direction of MPP and we can keep on perturbing in the same direction i.e., keep on increasing the duty cycle will help in tracking more power. If we obtain negative ΔP, we are going away from the direction of MPP or in wrong direction and the sign of perturbation applied has to be changed and the duty cycle has to be reduced so that the power tracked would be reduced. The important thing in this perturb and observe MPPT algorithm is that the algorithm keeps on changing the duty cycle and it never gets settled if it tracks the maximum power it keeps on oscillating around it. The perturb and observe algorithm is based on the four following conditions

If $\Delta P>0$ and $\Delta V>0$ then $D=D - \Delta D$.

If $\Delta P>0$ and $\Delta V<0$ then $D=D + \Delta D$.

If $\Delta P<0$ and $\Delta V<0$ then $D=D + \Delta D$.

If $\Delta P<0$ and $\Delta V>0$ then $D=D - \Delta D$.

Where D= duty cycle and ΔD is perturbation.

The flow chart for the perturb and observe algorithm is shown below

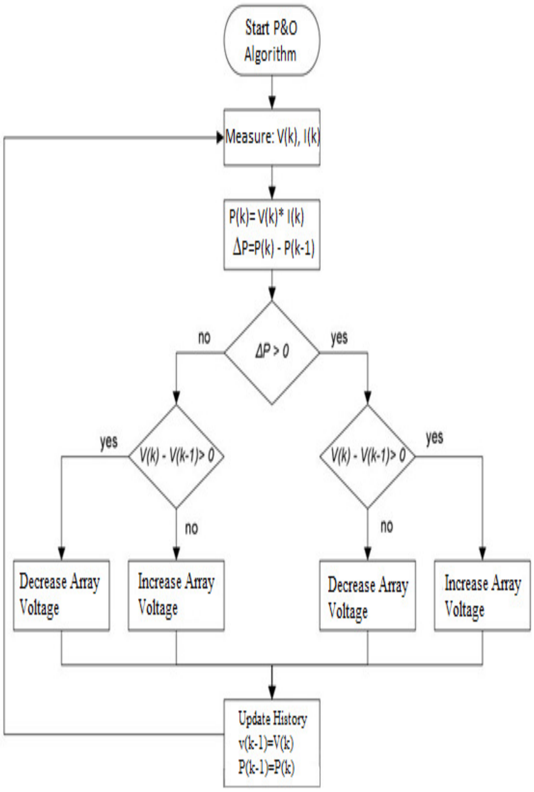

Figure 3. Flowchart for perturb and observe algorithm

III.INTERLEAVEDBOOST CONVERTER

An interleaved boost converter is an efficient dc-dc converter which is just the parallel connection of two ordinary boost converters with pulses 180° phase shifted. The interleaved boost converter consists of two MOSFET switches and two inductors and two diode the circuit diagram is shown in figure 4.

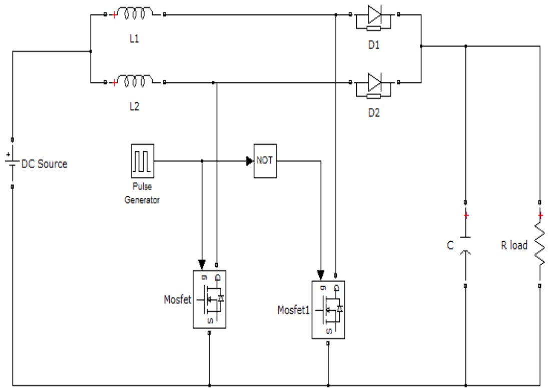

Figure 4. Circuit diagram of Interleaved Boost Converter

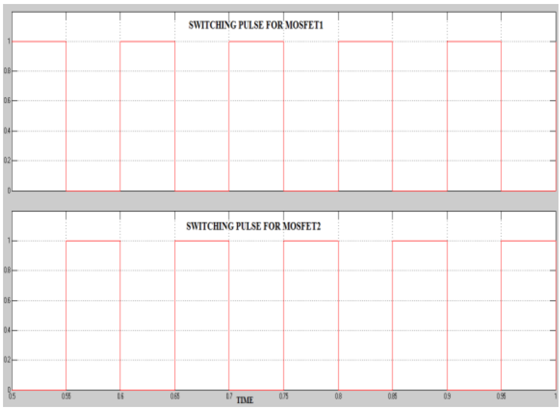

Figure 5. Switching pulses for MOSFET1 and MOSFET2

III. FUEL CELLS

Fuel cells are devices used for generating electric power from chemical energy. Continous operation requires fuel and oxidant, removal of water vapour and heat. Like a conventional primary cell(battery) it also has two electrode and electrolyte and it produce dc power. Similarly the characteristics of the fuel cells are same as that of a battery such that silent operation, stationary parts and generation of power is by an chemical reaction. It Produce electricity by the combination of hydrogen and oxygen over a catalyst. There are several different types of fuel cells but the most researched type is the proton exchange membrane (PEM) fuel cell, in which the catalyst is platinum. PEM fuel cells are capable of replacing batteries or generators in portable equipment and vehicles.

IV.PROPOSED SYSTEM

Block diagram of closed loop system is as shown in figure 6. Solar panel and fuel cell gives small range DC output and it is necessary to step up this output. In a DC to DC boost converter output side voltage is generally greater than the input side voltage which is fed from solar array or fuel cell or battery etc., This DC voltage is converted to ac voltage using PWM inverter and inverter gives 230 volts (RMS). The output thus obtained is controlled by a closed loop system with power quality improvement. The diagram shown in figure 6 shows block diagram for the closed loop model of the proposed system.

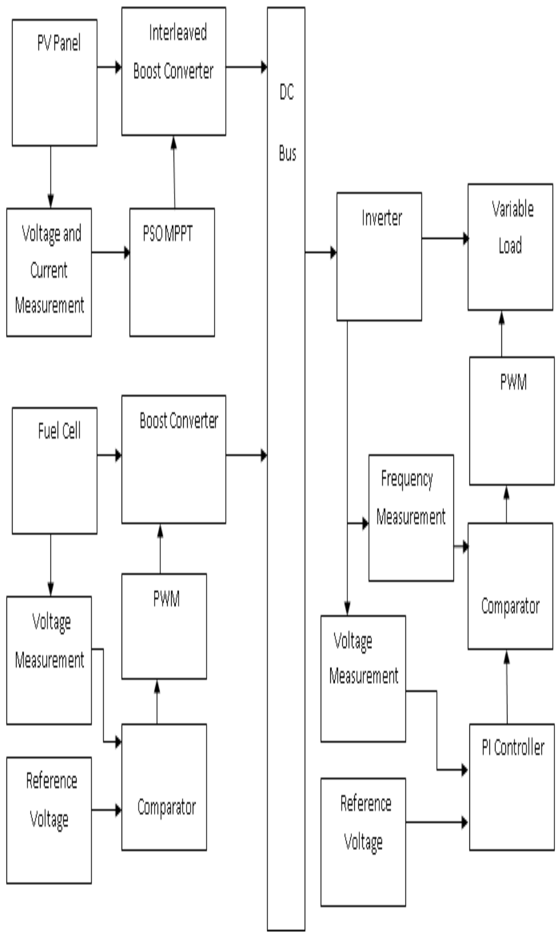

Figure 6. Block diagram of the proposed system.

V.MATLAB MODEL of the Project

The figure shows the MATLAB model of the project. The solar panel is modelled in Simulink with the basic equations of the solar panel whose voltage and current are sensed and given as the input to the perturb and observe algorithm based maximum power point tracking algorithm. The coding for perturb and observe algorithm based maximum power point tracking is done in embedded mat lab function which sends the duty cycle and checks the power. The fuel cel is modeled along with boost converter. The photovoltaic-fuel cell is then connected to a Dc bus from which an inverter is connected to convert dc to ac. With the help of phase locked loop frequency and the voltage is measured. The output from PLL is given to the PI controller by which the voltage sag can be reduced.

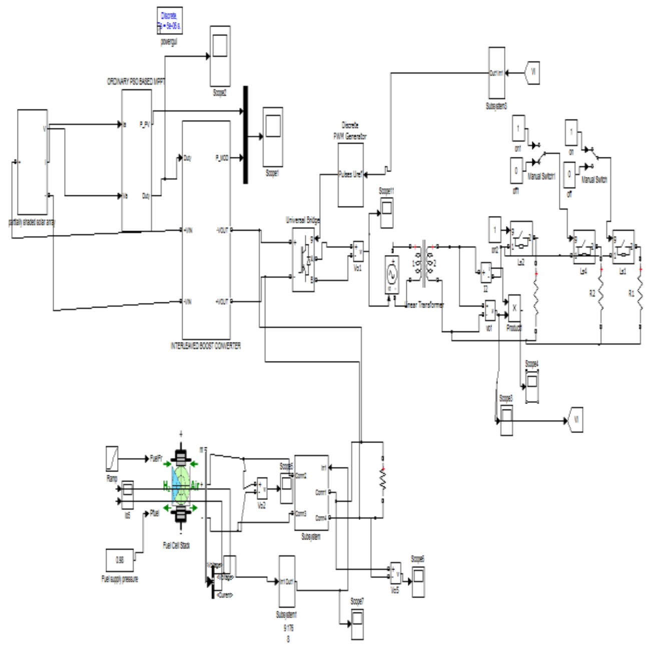

Figure 7. Matlab model of the proposed system

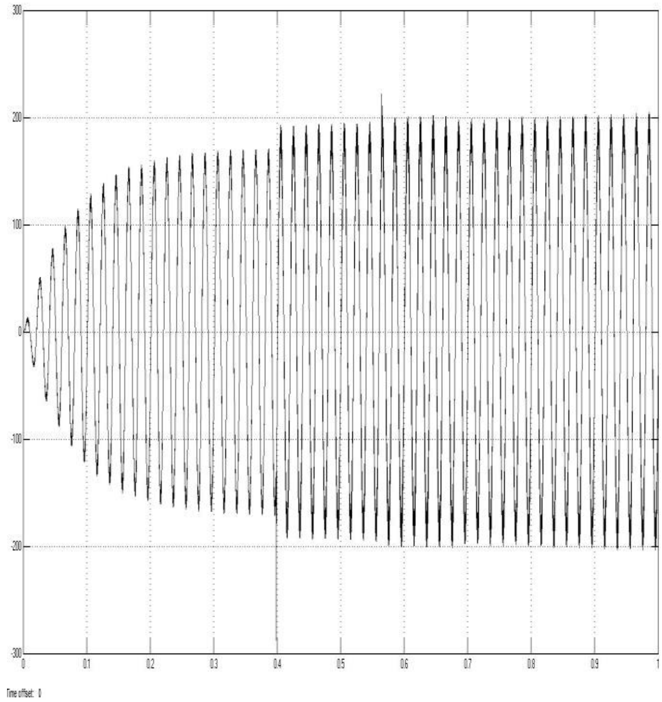

Figure 8. Output voltage during sag period

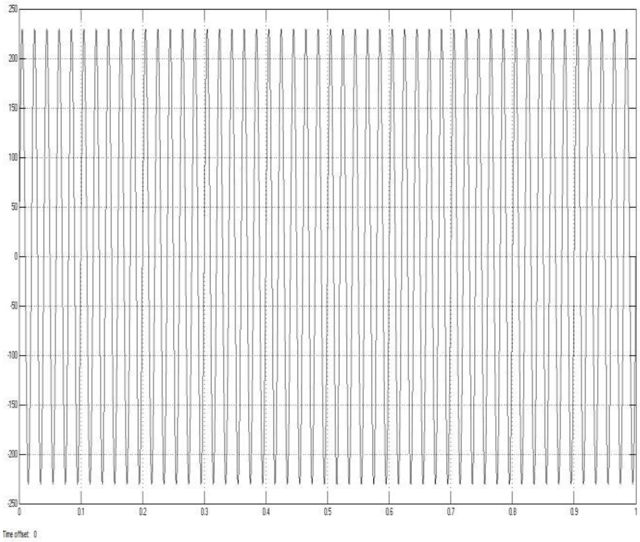

Figure 9. Regulated voltage

VI. CONCLUSION

The simulation results of solar panel, interleaved boost converter and closed loop system are presented. The maximum power point tracking algorithms namely perturb and observe algorithm used. All simulations are performed in Matlab/Simulink modeling and simulation platform. The output voltage obtained from a open loop system consists of voltage sag. The voltage sag is eliminated in the case of controlled closed loop system and the regulated output voltage is 230V.

REFERENCE:

[1] A. Bayod.R´ujula, "Future development of the electricity systems with distributed generation, energy," J. Energy, vol. 34, no. 3, pp. 377–383, 2009.

[2] N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics: Converters, Applications and Design, 2nd ed., New York: John Wiley & Sons, Inc., 1995, pp. 177-178.

[3] Doo-Yong Jung, Young-Hyok Ji, Sang-Hoon Park, Yong-Chae Jung, and Chung-Yuen Won (2011) „Interleaved Soft-Switching Boost Converter for Photovoltaic Power-Generation System‟, IEEE Transactions on Power Electronics, Vol. 26, No. 4, pp: 1137-1145.

[4] J. Surya Kumari1, Ch. Sai Babu, Nov 2011 "comparison of maximum power point tracking algorithms for photovoltaic system", International Journal of Advances in Engineering & Technology, ISSN: 2231-1963, Page 133-148.

[5] G. M. S. Azevedo, M. C. Cavalcanti, K. C. Oliveira, F. A. S. Neves, Z. D. Lins, 2008, "Evaluation of maximum power point tracking methods for grid connected photovoltaic systems," in *Proc.* IEEE PESC, pp. 1456-1462.

[6] Mei Shan Ngan and Chee Wei Tan, "A Study of Maximum Power Point Tracking Algorithms for Stand-Alone Photovoltaic Systems", IEEE Applied Power Electronics Colloquium (APEC), pp. 22-27, 2011.

[7] N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli, "Optimization of perturb and observe maximum power point tracking method," IEEE Trans. Power Electron., vol. 20, no. 4, pp. 963–973, Jul. 2005.

[8] O. Abutbul, A. Gherlitz, Y. Berkovich and A. Ioinovici, "Boost converter with high voltage gain using a switched capacitor circuit", Proceedings of the 2003 International Symposium on Circuits and Systems (ISCAS 2003), vol. 3, pp. 296-299, May2003.