Comparison of Tow Methods P&O and Fuzzy Logic Controller For MPPT in The Photovoltaic System.

Khelaifa Fethi
Department of Electrical Engineering
Laboratory of Electronics and New Technologies-LENT-
Larbi Ben M'hidi University Oum El Bouaghi, Algeria.
fethi.khelaifa@univ-oeb.dz / khaliafa1994@gmail.com

Lamamra Kheireddine
Department of Electrical Engineering
Laboratory of Electronics and New Technologies-LENT-
Larbi Ben M'hidi University Oum El Bouaghi, Algeria.
Lamamra.Kheireddine@univ-oeb.dz / l_kheir@yahoo.fr . IEEE Member.

Toumi Djaafar
Faculty of Science and Technology
Echahid Hamma Lakhdar University
El Oued, Algeria.
toumidjaafar@gmail.com

***Abstract*— An important consideration in the use of the PV system is to operate the system near the maximum power point to increase the output efficiency of the PV panel. Maximum power point tracking (MPPT) techniques are used in PV applications to extract the maximum power that the PV panel can produce, which depends on different atmospheric conditions, namely solar insolation and temperature. In this paper, a new maximum power point tracker using fuzzy set theory is proposed to improve the energy conversion efficiency. A fuzzy algorithm based on linguistic rules describing the operator control strategy is applied to the boost converter control so that the maximum power point tracker linguistic variables implemented in the fuzzy logic controller were appropriately selected to modulate the DC-DC converter. The fuzzy logic controller offers advanced features such as fast response, good oscillation performance the results obtained are compared with the P&O technology.**

Keywords— PV system, Maximum power point tracking (MPPT), fuzzy logic. P&O.

I. *INTRODUCTION*

Photovoltaic energy source is one of the most popular energy sources that many researchers are working on because it is clean, pollution-free and endless and can meet our demand without disturbing the environment. To decrease the use of conventional energy, the PV source must be integrated into the grid through step-up converters. [1]

As the efficiency of the PV source is very less an important consideration in the use of PV system is to operate the system near the maximum power point in order to increase the output efficiency of the PV panel, [2] as the maximum power point depends on the temperature and irradiance which are non-linear in nature, a maximum power point tracking control system is used, which can maximize the output energy of the PV system and work effectively on the non-linear variations of the parameters such as temperature and irradiance. [3]

There are many MPPT algorithms such as perturbation and observation (P&O), incremental conductance, fractional short-circuit current, fractional open circuit-voltage, neural networks and fuzzy logic. Each has its own advantages and disadvantages. [4] This paper focuses on the comparison of fuzzy logic controller and perturbations and observations (P&O) for tracking the maximum power point which is influenced by the non-linear characteristics of the photovoltaic panel depends on variable environmental conditions such as temperature and solar energy radiation. [5]

The major problem with the existing solar power MPPT harvesting technologies is that, the efficiency of the solar power system is still very low and the PV system does not operate at its best efficiency corresponds to the nonlinear variations, [6] thus the fuzzy logic controller is designed and compared with P&O Technique for MPPT controller operation for efficient operation under nonlinear parameter variations. One of the most difficult parts is the design of the fuzzy logic rules to track the maximum power point and control the DC - DC converter.

II. *CHARACTERISTICS OF THE PHOTOVOLTAIC SYSTEM*

A. Mathematical model of the photovoltaic cell:

A photocell consists of a semiconductor material that absorbs light energy and converts it directly into an electric current. She based on the physical phenomenon called the "photoelectric effect", which consists of creating an electric impulse when the surface of this cell is exposed to light [7]. Figure 1 shows a simplified electrical diagram of a solar cell [8].

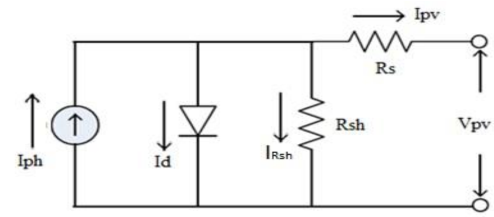


Figure.1. Solar cell diode model.

Kirchhoff's laws allow the writing of the following relationships:

$$I_p=I_d+I_{RP}+I_{RS} \quad (1)$$

The current in the diode is given by the following expression:

$$I_d=I_0\ [\exp\ (q\ (V+Rs)/mKT)-1] \quad (2)$$

The current flowing through the parallel resistance is given by:

$$I_{Rp}=V+I.R_s/R_p \quad (3)$$

From the equations above the expression of the total current is established:

$$I = I_{pv} - I_0 \left[\exp\left(q*V+I*R_S / N_S*n*K*T\right)-1\right] - \left(V+I*R_S/R_P\right)$$

(4)

Where:

I: is the current of the PV solar module.

Ipv: Photocurrent [A].

V: voltage at the terminals of the PV module [V].

I0: saturation current of the diode [A].

q: electron charge which is 1.602 * 10 ^ (-19) Coulomb.

Rs: series resistance of PV solar module (Ω).

Rp: parallel resistance of the PV module (Ω).

K: Boltzmann constant (J / K).

T: junction temperature [K].

Ns: number of cells in series and; n is the ideality factor of the diode.

The Matlab / Simulink model of the PV module is given in Fig.2.

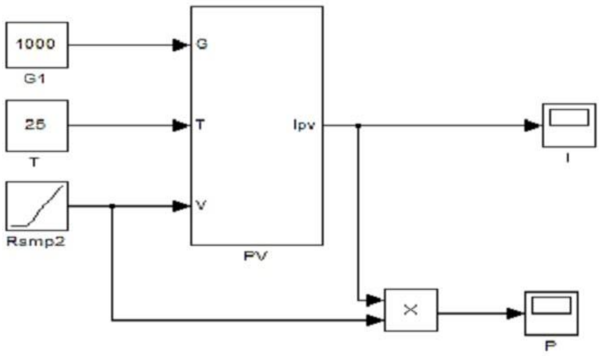


Figure.2. Presentation of the PV module in Matlab/Simulink.

B. the P&O Algorithm:

In this algorithm, a small error is introduced into the system due to the power of the module changes. [9] If the power change is positive the disturbance continues in that direction After the MPP point the power at the next instant decreases, then the disturbance reverses At the steady state, the algorithm oscillates around the peak point.

C. the Fuzzy Logic Controller:

The fuzzy system is composed of a knowledge-based rule system; the main part of FLC is the knowledge base composed of the If-Then rules. [10]

Fuzzy Logic is implemented to get the MPP operating voltage point faster with less overshoot and it can minimize the voltage fluctuation after the MPP recognition. [11] The control objective is to track the maximum power will therefore lead to efficient operation of the PV panel.

To design the FLC, the variables that represent the dynamic performance of the system should be chosen as input for the controller. The basic block diagram implemented in the fuzzy logic controller is shown in Figure.3.

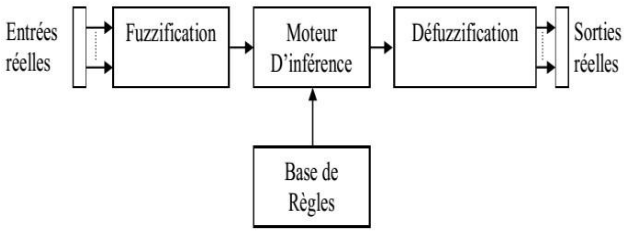


Figure.3. General diagram of a fuzzy command.

Fuzzy control is based on three main steps are:

a. Fuzzification

In the fuzzification step, the numerical input variables are calculated or converted into linguistic variables based on a subset called membership function. To translate the value of voltage change and power change, the fuzzy input "power change" and "voltage change" is designed with seven fuzzy variables called PB (Positive Big), PM (Positive Medium), NS (Negative Small), PS (Positive Small), ZE (Zero), NM (Negative Medium), and NB (Negative Large).The voltage change and power change are the input variables in the proposed system and the output of the fuzzy logic controller is the duty cycle change. [12].

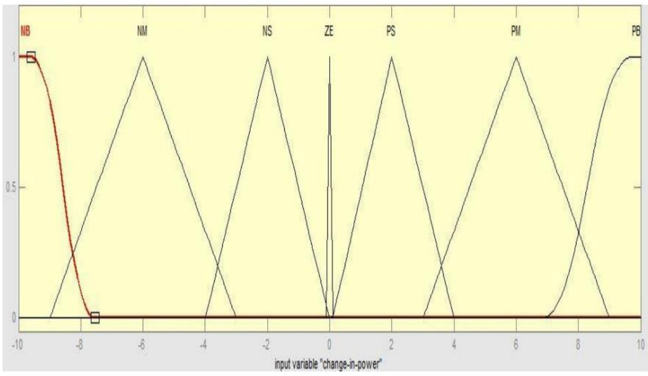


Figure.4.FLC voltage change input.

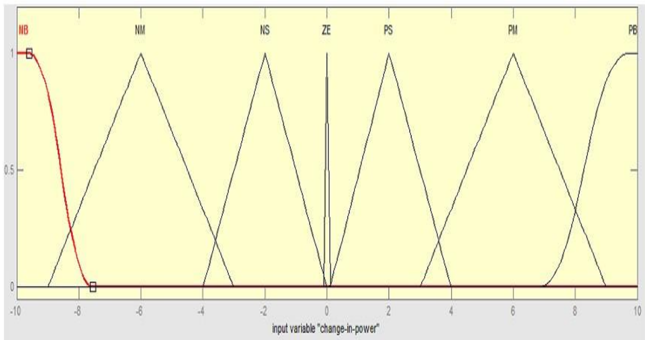


Figure.5.Input to the FLC as power change.

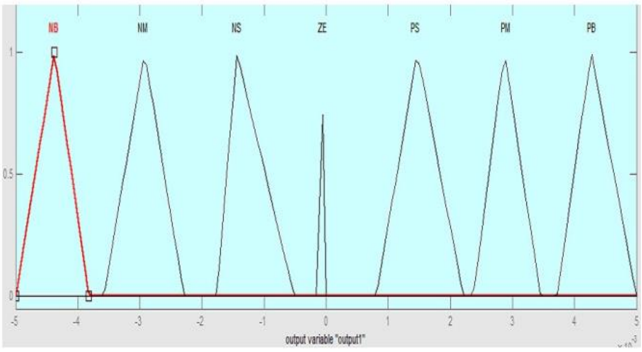


Figure.6.Output of the FLC as a change of cyclic ratio.

b. Inference system

The fuzzy rule algorithm collects a set of fuzzy control rules in a specific order, these rules are used to control a system to meet the desired performance requirements and they are designed based on the expert knowledge of the system under control. [13] The fuzzy inference of FLC is based on the Mamdanis method, which is associated with max-min composition.

c. defuzzification

The input for the defuzzification process is a fuzzy set and the output is a single number to be applied to the system, for the final desired output according to the system, a non-fuzzy value of control output is required, so a defuzzification step is mandatory.[14] The defuzzification method presenting in the proposed scheme.

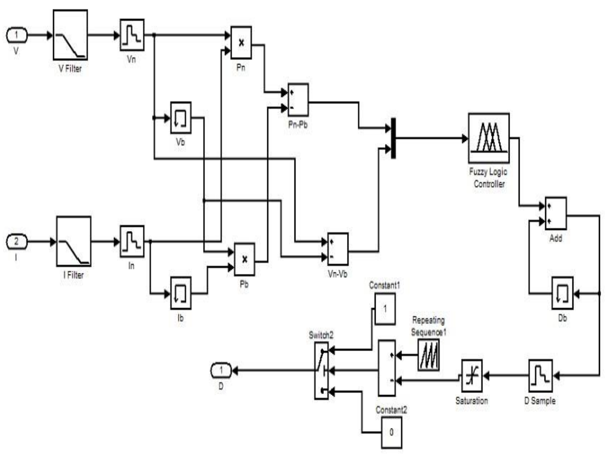
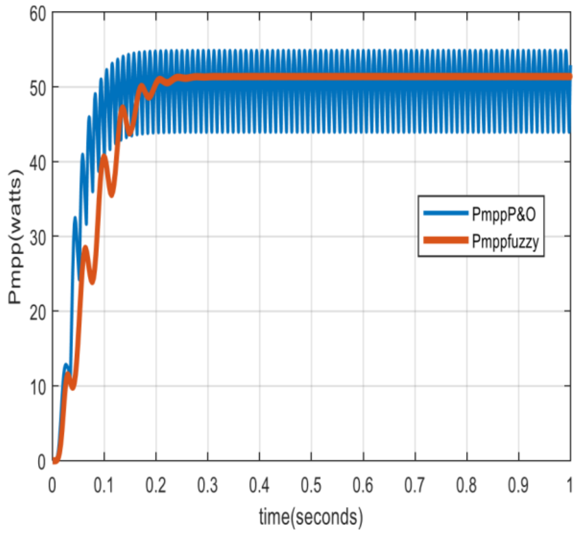


Figure.7.Model of the fuzzy logic controller.

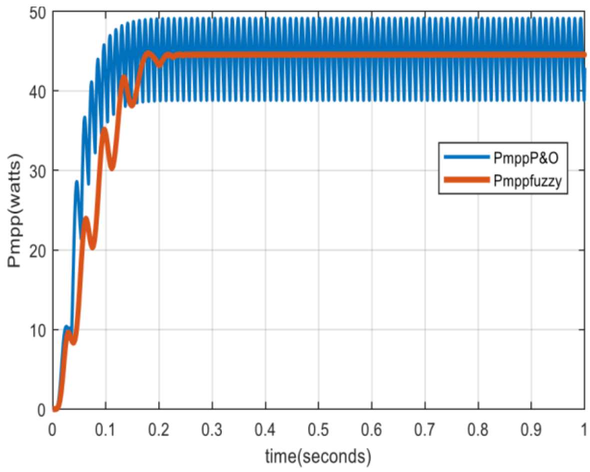
III. RESULTS AND DISCUSSIONS

The power output of PV module and inverter with two different MPPT techniques is obtained in MATLB / Simulink at 400 W/m^2 irradiance and 250 C° temperature. The simulation results show the implementation of fuzzy logic and P&O technique on tracking the maximum power point (Pm) is given in figure 8 (a), (b).

We note that the maximum power produced is accurate, stable and effective compared to the fuzzy logic technique compared to the P&O technique.



(a)

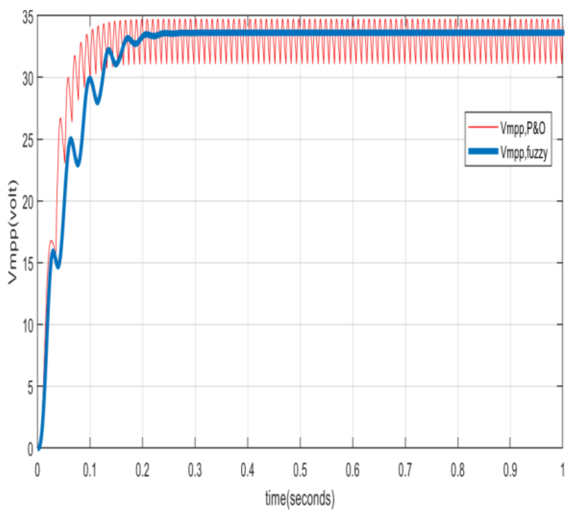


(b)

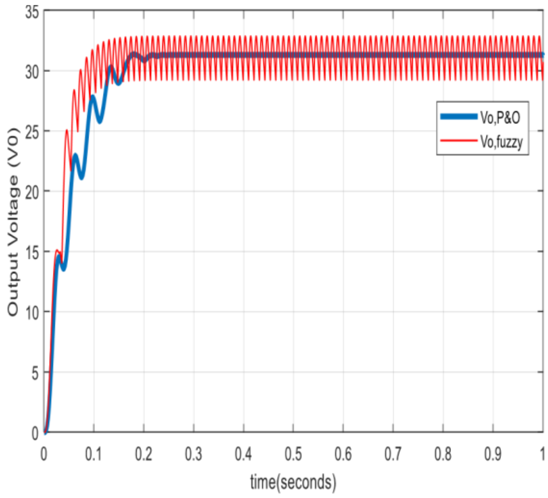
Figure.8.Maximum power (Pmpp) and power output (Po) of the proposed PV array.

The voltage variations in Vmpp and Vo for these converters are shown in the corresponding figure 9 (a) and (b).

We note that fuzzy logic controller gives us more stable results compared to the P&O technique.



(a)



(b)

Figure.9.Output voltage (Vmpp) and output voltage (Vo) of the photovoltaic generator PV.

IV. Conclusion

In this paper, the V-I and P-V characteristics of the PV module are obtained using MATLAB / Simulink at a temperature of 250 ° C and an irradiance of 400 W/m2. The analysis of fuzzy logic controller and P&O based MPPT is done and the simulation results are presented. From the simulation results, the Fuzzy based MPPT tracks the power continuously with less fluctuations and also has less overshoot with fast tracking time compared to the P&O MPPT algorithm.

References

[1] Dunia, James, and Bakari MM Mwinyiwiwa. "Performance Comparison between ĆUK and SEPIC Converters for Maximum Power Point Tracking Using Incremental Conductance Technique in Solar Power Applications." world academy of science, engineering and technology International Journal of Electrical, Computer, Electronics and Communication Engineering Vol:7 No:12, 2013.

[2] A. Azouzoute, A.A. Merrouni, S. Touili, Overview of the integration of CSP as an alternative energy source in the MENA region, Energy Strategy Rev 29 (2020) 100493.

[3] Khelaifa .F, L. Kheireddine, S.Youcef "Modeling of partial shading in photovoltaic systems by MLP artificial neural networks ";The International Conference on Sustainable, Renewable Energy Systems and Applications (ICSRESA'19), December 4 – 5, 2019.

[4] A.H. Elsheikh, V.P. Katekar, O.L. Muskens, S.S. Deshmukh, M.A. Elaziz, S.M. Dabour, Utilization of LSTM neural network for water production forecasting of a stepped solar still with a corrugated absorber plate, Process Safety and Environmental Protection, 148 (2021) 273-282.

[5] Habbati Bellia, Ramdani Youcef and Moulay Fatima. "A detailed modeling of photovoltaic module using MATLAB." NRIAG Journal of Astronomy and Geophysics vol. 3, no. 1, 2014, pp.53-61.

[6] J. Ahmed and Z. Salam, "An Enhanced Adaptive P&O MPPT for Fast and Efficient Tracking Under Varying Environmental Conditions," *IEEE Trans. Sustain. Energy*, vol. 9, no. 3, pp. 1487–1496, 2018.

[7] M. Angel Cid Pastor, ''Conception et réalisation de modules photovoltaïques électroniques''. Thèse de doctorat, Institut National des Sciences Appliquées de Toulouse, septembre 2006.

[8] Hunan-Liang Tsai, Ci-Siang Tu and Yi-Jie Su, Member, IAENG "Development of Generalized Photovoltaic Model Using MATLAB/SIMULINK" Proceedings of the world congress on Engineering and Computer Science, October 22-24, 2008, San Francisco, USA.

[9] J. Prasanth Ram and N. Rajasekar, "A Novel Flower Pollination Based Global Maximum Power Point Method for Solar Maximum Power Point Tracking," *IEEE Trans. Power Electron.*, vol. 32, no. 11, pp. 8486–8499, 2017.

[10] Raedani, Ronn, and Moin Hanif. "Design, testing and comparison of P&O, IC and VSSIR MPPT techniques." In Renewable Energy Research and Application (ICRERA), 2014 International Conference on, pp. 322-330. IEEE, 2014.

[11] M.Zein Alabedin, E.F. El-Saadany, M.M.A. Salama, "Maximum Power Point Tracking for Photovoltaic System Using Fuzzy Logic and Artificial Neural Networks".

[12] M.A.S. Masoum, M.Sarvi, "A new fuzzy-based maximum power point tracker for photovoltaic applications", Iranian Journal of Electrical & Electronic Engineering, Vol.1, January 2005.

[13] N.Ammasai Gounden, Sabitha Ann Peter, Himaja Nallandula and S.Krithiga. "Fuzzy logic controller with MPPT using linecommuted inverter for three-phase grid-connected photovoltaic systems", Renewable Energy (ELSEVIER Journal), vol.34, pp. 909-915, July 2008.

[14] Y. Chaibi, A. Allouhi, M. Malvoni, M. Salhi, and R. Saadani, "Solar irradiance and temperature influence on the photovoltaic cell equivalent-circuit models," *Sol. Energy*, vol. 188, pp. 1102–1110, 2019.