Le 4ème Séminaire International sur les Energies Nouvelles et Renouvelables
The 4th International Seminar on New and Renewable Energies
Unité de Recherche Appliquée en Energies Renouvelables, Ghardaïa – Algeria 24 - 25 Octobre 2016

Maximum power point tracking using fuzzy logic control

K.ROUMMANI[1], B.MAZARI[2], A. BEKRAOUI[1]

[1] Unité de Recherche en Energies Renouvelables en Milieu Saharien(URERMS), Centre de Développement des Energies Renouvelables, CDER, 0100, Adrar, Alegria
[2] Laboratory Development of Electric Drives LDEE. U.S.T. Oran, Algérie

rom_tmm@yahoo.fr

***Abstract*— In this paper an intelligent control method for the maximum power point tracking (MPPT) of a photovoltaic system under variable temperature and insolation conditions has been developed. This method uses a fuzzy logic controller applied to a DC-DC converter device. Maximum power point trackers (MPPTs) are used to track the peak output power of the solar photovoltaic source. The system is composed of a photovoltaic array, a boost converter. The complete system is simulated using MATLAB/SIMULINK.**

Keywords—**photovoltaic system; fzzy logic, maximum power point tracking,**

I. Introduction

Solar energy is an energy source par excellence, clean and promising; she acclimatized well with multiple systems.

Electricity production in solar systems is based on solar cells where photons are absorbed by a semiconductor converted directly into electrical energy [1].

In order to increase this efficiency, MPPT controllers are used. Such controllers are becoming an essential element in PV systems [2].

Different methods of peak power tracking schemes had been proposed in the past using different control strategies[3–6] some use conventional PID controllers [7] whereas others use rule based fuzzy logic tracking regulators [8], other methods based on Artificial Neural Networks[9] and etc. Among all of these techniques those based on Artificial Inelegance are very efficient nevertheless they are complicated.

The main purpose of this paper is to develop an fuzzy logic based maximum power point tracking controller that extracts maximum power from the solar panel via the chopper under variable radiation and weather conditions [10].

II. PV Model

Several models of photovoltaic cells exist in [3, 6, 7, 8]. In this paper, we chose the model as shown in Fig. 1.

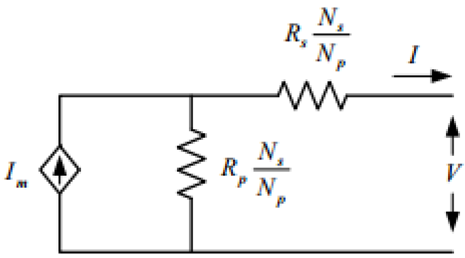

Fig.1 Circuit model of an array of Ns series modules and Np parallel modules [3].

I and V are the output current and voltage of the array and Imis the module current and can be obtained from the following equation:

$$I_m = I_{pv}N_p - I_o N_p\left[exp\left[\frac{V+R_s\left(\frac{N_s}{N_p}\right)I}{V_t a N_s}\right] - 1\right] \quad (1)$$

Where, as in the diode ideality constant, V_t is the thermal voltage of the array and can be obtained from the equation

$$V_t = \frac{N_{cs}KT}{q} \quad (2)$$

N_{cs} is the number of cells connected in series, q is the electron charge, k is Boltzmann's constant and T is the temperature of the P-N junction in Kelvin's. I_{pv} is the photovoltaic current and can be expressed by:

$$I_{pv} = (I_{pvn} + K_i \Delta T)\frac{G}{G_n} \quad (3)$$

And I_o is the reverse leakage current of the diode and can be calculated from:

$$I_o = \frac{I_{scn} + K_i \Delta T}{\exp\left(\frac{V_{ocn} + K_v \Delta T}{aV_t}\right) - 1} \quad (4)$$

Where: Ip_{vn} is the generated current at 25°C and 1000W/m^2 (nominal conditions), K_i, K_v the current and voltage temperature confidents respectively, G is the irradiance and G_n is the irradiance at nominal conditions, I_{scn} ,V_{ocn} are the short circuit current and open circuit voltage respectively at nominal conditions and ΔT is the difference between the actual and the nominal temperatures in Kelvin's.

Figure. 2 shows the MATLAB/SIMULINK PV model:

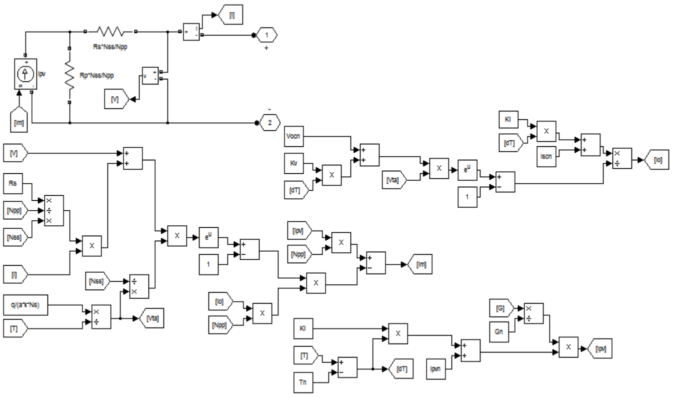

Fig. 2 PV model in Simulink.

III. MPPT USING FUZZY LOGIC CONTROL FLC

Recently fuzzy logic controllers have been introduced in the tracking of the MPP in PV systems [11]. MPPT using Fuzzy Logic Control gains several advantages of better performance, robust and simple design. In addition, this technique does not require the knowledge of the exact model of system [11, 12]. In most of the fuzzy-based MPPT algorithms, the optimum point is tracked after computing the slope of the power-current characteristic and the slope change. It is a non-linear control method, which attempts to apply the expert knowledge of an experienced user to the design of a fuzzy-based controller, generally, as shown in Fig.3 The fuzzy logic method generally consists of three stages [11, 13, 14]:

- The fuzzification : maps crisp values into input fuzzy sets;
- The rules: define by using a set of IF-THEN statements;
- Defuzzification : maps output fuzzy values into crisp values.

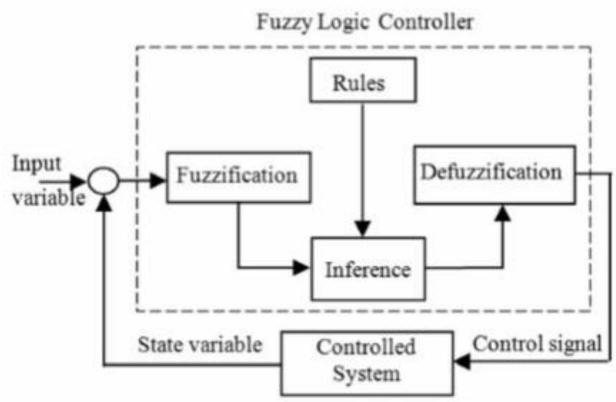

Fig.3 General diagram of a fuzzy controller [15].

The proposed system in this paper consist of two input variables: irradition (G) and the voltage (V), and one out variable: duty cycle (D), as shown in Fig. 4 [11].

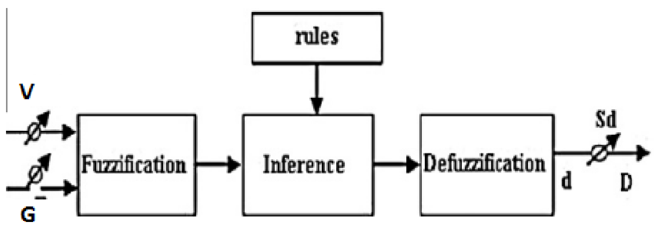

Fig.4 fuzzy controller diagram with inputs and output [11].

These variables are expressed in terms of linguistic variables or labels such as PB (Positive Big), PM (Positive Medium), PS (Positive Small), ZE (Zero), NS (Negative Small), NM (Negative Medium), NB (Negative Big) using the basic fuzzy subset. Each of these acronyms is described by a given mathematical membership function [16].

The structure of Fuzzy logic control network is shown in fig.5.

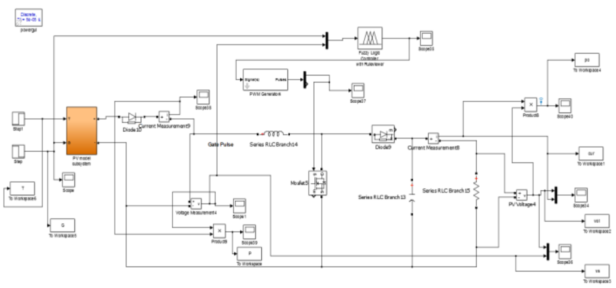

Fig.5 FLC controlled PV.

IV. SIMULATION RESULTS AND DISCUSSION

The complete system is to be simulated using the MATLAB/SIMULINK, and by varying the operating conditions (solar irradiance and temperature), The PV array is composed of (5x2) series and parallel modules respectively with a total output power of 1kW.

Table I Shows the simulation parameters for the proposed system.

TABLE I. SIMULATION PARAMETERS

Quantity	Value
Grid voltage	440V
Frequency	60 Hz
Switching frequency	1kHz
DC link capacitor C	1mF
DC link Voltage	400V
Converter inductance	0.0385 H
Converter Capacitor	0.04F
Sampling period	1µS

The Parameters of the PV model used in this paper are adjusted according to a real PV module (KC200GT) manufactured by KYOCERA.

TABLE II. KC200GT MODULE PARAMETERS

Quantity	Value
I max power	7.61A
V max power	26.3V
P max	200.143 W
I short circuit	8.21A
V open circuit	32.9V
I leakage	9.825×10^{-8} A
I photovoltaic	8.211A
Diode ideality constant (a)	1.3
Parallel resistance	415.406Ω
Series resistance	0.221Ω

By comparing the KC200GT datasheet I-V curves at different values of solar irradiance and temperature with the one's obtained by the MATLAB model, shown in Figures 6, 7, 8 and 9, It is very clear that the curves obtained by the model are almost identical to the one's found in the module data sheet which proves that the model is reliable.

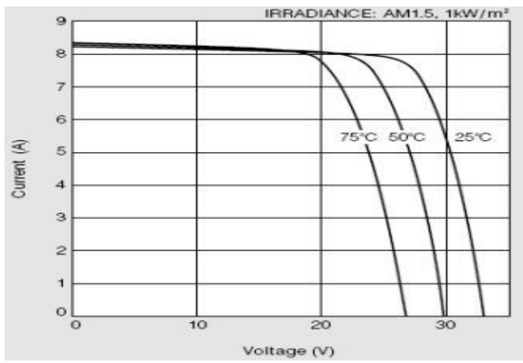

Fig. 6 V-I characteristics at constant irradiance 1000 W/m² and various temperatures found in KC200GT data sheet.

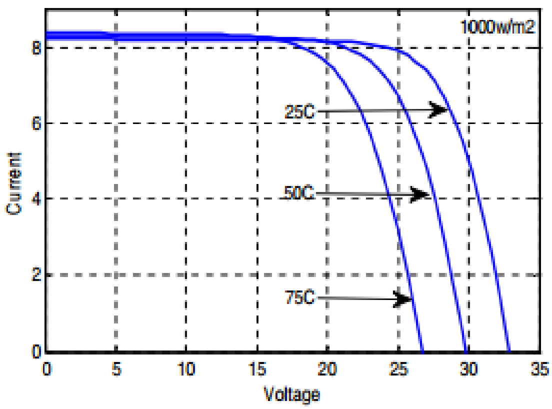

Fig. 7 V-I caharacteristics at constant irradiance 1000 W/m^2 and various temperatures obtained by MATLAB.

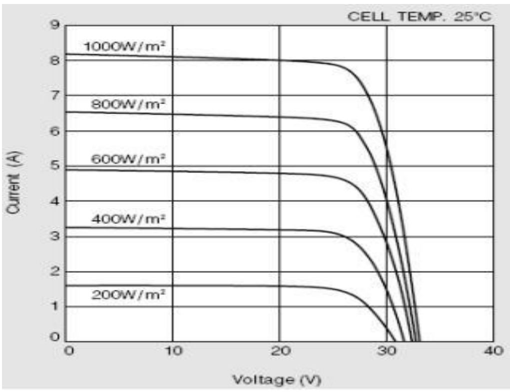

Fig.8 V-I characteristics at constant temperature 25°C and various irradiances found in KC200GT data sheet.

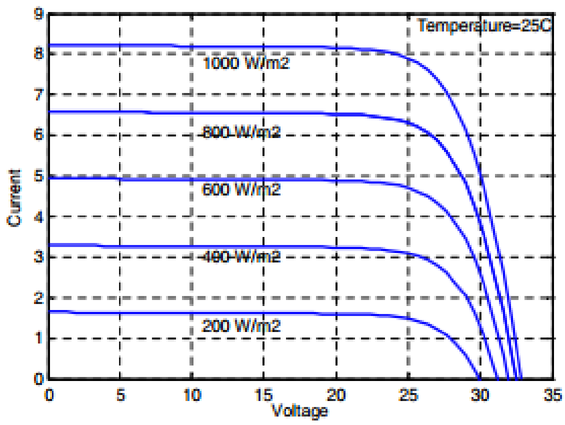

Fig.9 V-I characteristics at constant temperature 25°C and various irradiances obtained by MATLAB.

The system is operated with the proposed Fuzzy Logic control system to control the duty cycle of the Boost converter, Fig.9 shows the results in this case.

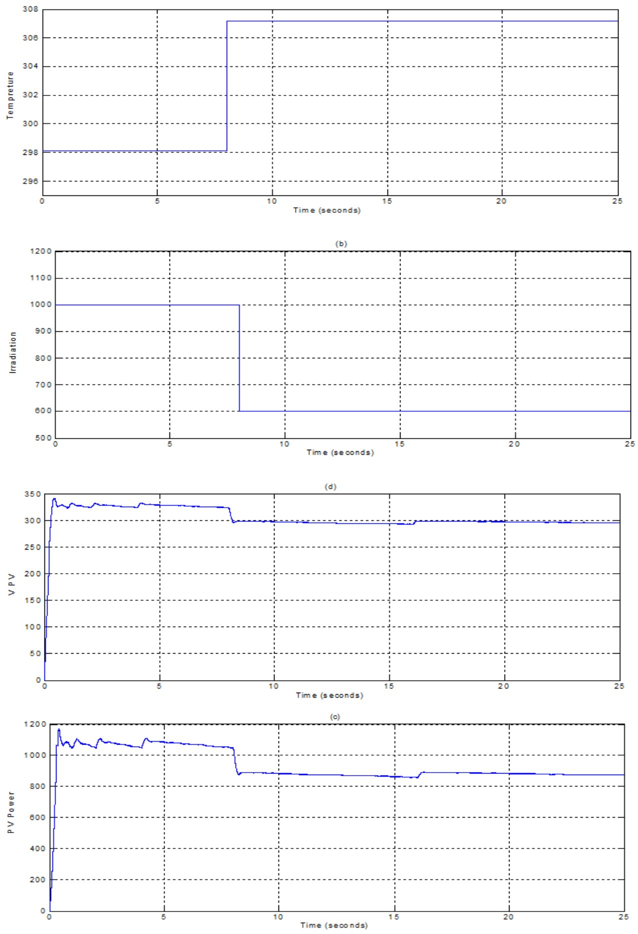

Fig.10 System with ANN MPPT (a) Temperature (b) Irradiance (c) PV output Power (d) PV terminal voltage.

V. CONCLUSION

This paper presents a complete controlled photovoltaic system. The peak power tracking capabilities of the proposed scheme based on Fuzzy Logic FLC based maximum power point tracking controller is demonstrated through simulated results. The simulated results show that the FLC based controller in its maximum power point tracking performance excels, showed faster response gave accurate results.

REFERENCES

[1] A.H. Bellia, Y. Ramdani, F. Moulay, K. Medles, Irradiance and Temperature Impact on Photovoltaic Power by Design of Experiments, Rev. Roum. Sci. Techn. – Électrotechn. et Énerg., 58, 3, p. 284–294, 2013.

[2] M. G. Villalva, J. R. Gazoli and E. Ruppert F. "Analysis and simulation of the P&O MPPT algorithm using alinearized array model". Power electronics conference, 2009, Brazil

[3] S.I. Sulaiman, T.K. Abdul Rahman, I.Musirin and S.Shaari. "Optimizing Three-layer Neural Network Model for Grid-Connected Photovoltaic output prediction". Conference on innovative technologies in intelligent systems and industrial applications.2009.

[4] Subiyanto, A.Mohamed and M.A.Hannan. "Maximum Power Point Tracking in Grid Connected PV System using A Novel Fuzzy Logic Controller". IEEE student conference on research and development, 2009.

[5] N. Dasgupta, Ashish Pandey, A.K. Mukherjee, Voltage-sensing based photovoltaic MPPT with improved tracking and drift avoidance capabilities, Solar Energy Material and Solar Cells 92 (12) (2008) 1552–1558.

[6] KenjiKobayashi,IchiroTakano,Yoshio Swada, Astudyofatwostage maximum power point tracking control of a photovoltaic system under partially shaded insolation condition, Solar Energy Material and Solar Cells 90 (18–19) (2006) 2975–2988

[7] A. Safri and S. Mekhilef. "Incremental conductance MPPT method for PV systems". Electrical and Computer Engineering (CCECE). 2011. Canada.

[8] M. Veerachary, T. Senjyu, K. Uezeto, Feed forward maximum power point tracking of PV systems using fuzzy controller, IEEE Transactions on Aerospace and Electronic System 38 (3) (2002) 969–981

[9] H. Diab, H. El-Helw, and H. Talaat, Intelligent Maximum Power Tracking and Inverter Hysteresis Current Control of Grid-connected PV Systems, International Conference on Advances in Power Conversion and Energy Technologies, APCET- 2012, IEEE, INDIA

[10] Trishan Esram and Patrick L. Chapman. "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques. " IEEE Transactions on energy conversion, Vol.22, NO. 2, 2007.

[11] Mohamed M. Algazar et al, "Maximum power point tracking using fuzzy logic control", Electrical Power and Energy Systems 39, pp. 21–28, 2012.

[12] Pongsakor Takun et al, "Maximum Power Point Tracking using Fuzzy Logic Control for Photovoltaic Systems", Manuscript received January 25, 2011. This work was supported by the faculty of engineering, King Mongkut's Institute of Technology Ladkrabang, Thailand.

[13] Roger Messenger, Ventre Jerry. Photovoltaic systems engineering. 2nd ed. CRC Press; 2003.

[14] Passino KM, Yurkovich S. Fuzzy control. Addison Wesley; 1998.

[15] A. Attou et al, "Comparison study of two tracking methods for photovoltaic system", Rev. Roum. Sci. Techn. – Électrotechn. et Énerg., 60, 2, p. 205–214, Bucarest, 2015.

[16] Ali M. Eltamaly, "Modeling of Fuzzy Logic Controller for Photovoltaic Maximum Power Point Tracker", Research & Reviews: A Journal of Trends in Electrical Engineering Volume 1, Issue 2, Pages 1-11, December 2011