Comparison of MPPT Algorithms for DC-DCConverters Based PV Systems

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***Abstract* –Maximum power point trackers (MPPT) 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. This work focuses on the pursuit of maximum power point tracking (MPPT) for photovoltaic generators. For this, we will use intelligent techniques: Neuro-Fuzzy control. The main objective of these controls is to extract, for loading conditions and atmospheric data, the maximum power of photovoltaic modules. The proposed controller relies upon an Adaptive Neuro Fuzzy Inference System (ANFIS) which is designed as a combination of the concepts of Sugeno fuzzy model and neural network.**
The controller employs the ANFIS of five layers with twenty five fuzzy rules. Simulations with practical parameters show that our proposed MPPT using ANFIS outperform the conventional MPPT controller terms of tracking speed and accuracy.

Keywords –SOLAR ENERGY, PV MODULE, MPPT, ANFIS, BOOST CHOPPER.

I. INTRODUCTION

Today, solar PV is a major source of renewable energy for electricity generation in countries where solar density is relatively high. Solar photovoltaic is a phenomenon where the solar radiant is converted directly into electricity by solar cell [1] and the process does not consume materials or issued.

The PV has a particular point of operation that can provide the maximum power load is usually called the maximum power point (MPP). The maximum power point is a non-linear where it varies according to the irradiating and the solar cell temperature [2].

To increase the efficiency of the PV system, the member will be followed and monitored by the control panel to operate PV MPP voltage point operation, optimizing the production of electricity. There are several methods that have been widely implemented to track the MPP [3.4]. The most common methods are Perturbed and observe (P & O), incremental conductance, Power based methods which are based on iterative algorithms to track continuously the MPP through the current [5] and voltage measurement of the PV module and Voltage feedback based methods which compare the PV operating voltage with a reference voltage in order to generate the PWM control signal of the DC–DC converter [6]. Furthermore, intelligent methods as artificial neural networks (NN), genetic algorithms and fuzzy logic (FL) have been also adopted to estimate the voltage and the current values of the load. And then to vary the duty cycle of the dc–dc converter so as to place the PVP system in its MPP [3.4]. In this article, the Neuro- fuzzy control is studied.

II. THE PROPOSED SYSTEM

The system analyzed in our paper. The whole system is composed of a PV generator, a power dc–dc adapter with the MPPT control and load resistive.

A. PV module

Kyocera KC200GT PV module is chosen for a MATLAB simulation model. The module is made of 54 poly-crystalline silicon solar cells in series and provides 200.143W of nominal maximum power.

B. DC–DC Boost converter

Boost converter steps up the input voltage magnitude to a required output voltage magnitude without the use of a transformer. The main components of a boost converter are an inductor, a diode and a high frequency switch. These in a co-ordinated manner supply power to the load at a voltage greater than the input voltage magnitude. The control strategy lies in the manipulation of the duty cycle of the switch which causes the voltage change [7] and [8].

$$\frac{V_0}{V_s} = \frac{1}{1-D} \quad (1)$$

Where V_O = output voltage, V_s = source voltage, D = duty cycle.

The critical values of the inductance and capacitance can be calculated using the following equations, [9]

$$L = \frac{1-D^{\,2}.D.R}{2.f} \quad (2)$$

$$C = \frac{D}{2.f.R} \quad (3)$$

Where L= Inductance, C=Capacitor, R= Resistor, f= Frequency and D = duty cycle.

Here, f = frequency 10 MHz. The inductance and capacitance are calculated as L = 120 uH, C = 100 uF.

III. MAXIMUM POWER POINT TRACKING CONTROLLER

When a PV module is directly coupled to a load, the PV module's operating point will be at the intersection of its I–V curve and the load line which is the I–V relationship of load.

In general, this operating point is seldom at the PV module's MPP, the optimal adaptation occurs only at one particular operating point, called Maximum Power Point (MPP).

MPPT (Maximum Power Point Tracking) controller is a functional body of the PV system and allows you to search the optimal operating point of the PV generator in weather. Whether analogue or digital control, the control principle is based on the automatic variation of the duty cycle D to the appropriate value so as to maximize the power output of the PV panel.

MPPT controller is an electronic system that plays a vital role in operating the PV modules in a manner that it produces its maximum power according to the situation [10].

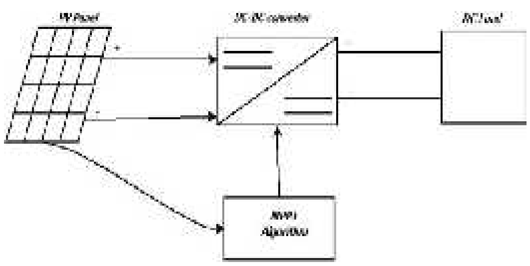

Fig.1 MPPT controller of PV system

The adaptation floor is usually implemented with a DC-DC converter and connected between the solar panel and a load as shown in Fig. 1 [10, 11]. An MPPT controller is usually implemented together with a boost converter and connected between the PV panel and load.

IV. MPPT CONTROLLER OF PV SYSTEMS USING ANFIS:

The Neuro- Fuzzy controller developed in this section has two input 'e' and 'from' and a single output 'D' represent respectively the error, the error variation, and control. The two input variables produce the control action 'D' to be applied to the chopper, to adjust the duty ratio of the latter so as to ensure the adaptation of the power supplied by the GPV. This controller allows automatic generation of fuzzy rules based on Sugeno inference model.

The equivalent neuronal structure proposed in matlab is shown in Figure 2.

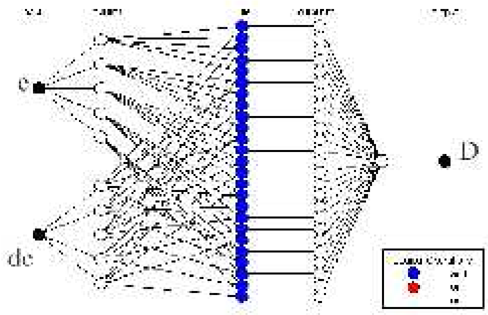

Fig.2 neuronal structure of the proposed model in Matlab.

V. MPPT CONTROLLER OF PV SYSTEMS USING FLC:

Fuzzy logic controllers have been introduced in the tracking of the MPP in PV systems [11, 13]. They have the advantage to be robust and relatively simple to design as they do not require the knowledge of the exact model. The proposed system in this thesis consists of two input variables:
Error (E) and change of error (CE), and one out variable: duty cycle (D). The variables E and CE are expressed as follows:

$$E(k) = \frac{P_{pv}(k) - P_{pv}(k-1)}{V_{pv}(k) - V_{pv}(k-1)} \qquad (4)$$

$$CE(k) = E(k) - E(k-1) \qquad (5)$$

Where P_{pv} (k) and V_{pv} (k) are the instant power and voltage of the photovoltaic module respectively.

The input E (k) shows if the load operation point at the instant k is located on the left or on the right of the maximum power point on the PV characteristic, while the input CE (k) expresses the moving direction of this point.

The defuzzification uses the center of gravity to compute the output of this FLC which is the duty cycle [15, 16]:

$$dD = \frac{\sum_{j=1}^{n} \mu(D_j) - D_j}{\sum_{j=1}^{n} \mu(D_j)} \qquad (6)$$

Duty cycle, the output of fuzzy logic control uses to control through PWM which generated pulse to control MOSFET switch in DC–DC converter.
The universe of discourse for input variable the E and CE is assigned according to its linguistic variable with five fuzzy sets which are designated by large negative, negative, zero , positive , and large positive. The output variable dD is assigned according to its linguistic variable with five fuzzy sets which are designated by large negative, negative, zero, positive, and large positive. The fuzzy rules are then generated, as shown in Table I.

TABLE I.
TABLE OF FUZZY RULES.

E \ CE	NM	NS	Z	PS	PM
NM	Z	Z	PM	PM	PM
NS	Z	Z	PS	PS	PS
Z	PS	Z	Z	Z	NS
PS	NS	NS	NS	Z	Z
PM	NM	NM	NM	Z	Z

However the output variable, which is the result of a deduction between the two input values, representing in our controller the cyclic ratio. In our regulation, we have used the Mamdani logic. Taking as an example of the control rules Table 1:
If E is PS and CE is Z then crisp dD is NS, its means that if the operating point is far away from the maximum power point (MPP) by the left side, and the variation of the slope of the curve is almost Zero; then decrease the duty cycle (dD).
The membership functions for the first input and output variables are shown in the figure. 3. This table is also known as fuzzy associative matrix. The fuzzy inference of FLC is based on the Mamdani method, which is associated with the max-min composition. Defuzzification is based on the centroid method which is used to compute the crisp output, dD.

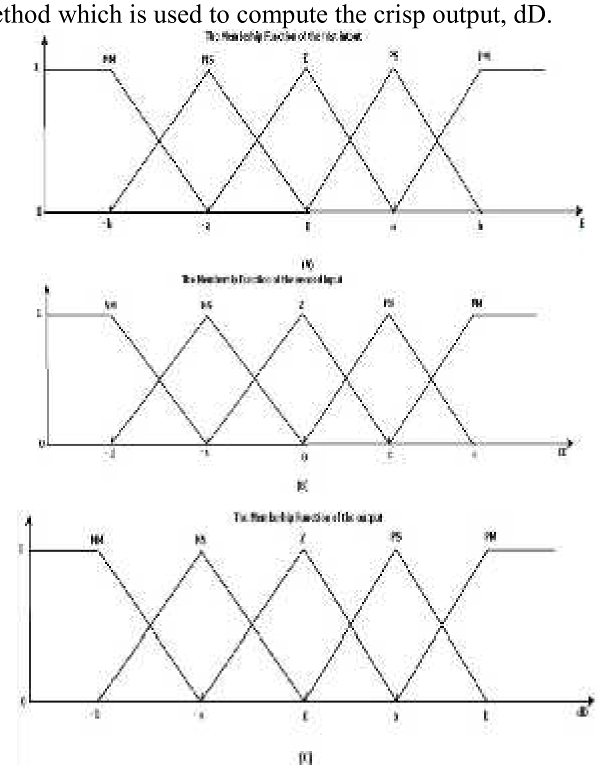

Fig. 3. Definitions and membership functions of (a) the 1st input variable (E), (b) the 2nd input variable (CE) and (c) the output variable (dD)

VI. SIMULATION MODEL OF MPPT CONTROLLER

The MPPT controller was modeled using the MATLAB/ Simulink software and the proposed ANFIS is embedded in MATLAB/Simulink using the S-function tool. From Fig. 4, the model consists of two external input parameter models, PV array subsystem block, controller subsystem block, the proposed boost converter circuit and resistive load. The input parameters are the Sun irradiation and temperature to feed the PV array subsystem block. The PV module parameters are obtained from the Kyocera KC200GT PV technical datasheet.

The controller block has 2 inputs, namely, the E and CE. The output of the block is the PWM signal used to trigger the MOSFET of the boostconverter

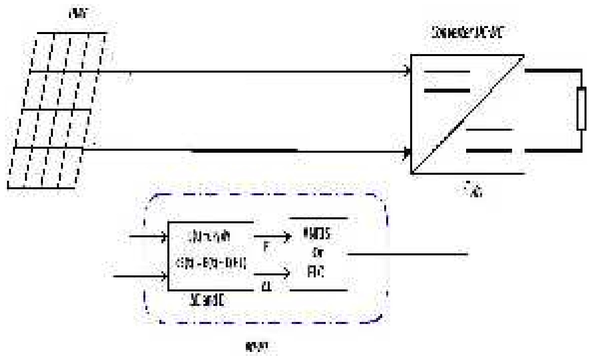

Fig 4.MPPT controller fuzzy with Boost chopper.

A. *Functioning in Constants Conditions*

In this case the temperature and sunshine are considered constant. We take the values of the standard conditions: temperature 25 ° C and sunshine to 1000W/m^2. The simulation results shown in the following Figure 5 and 6:

B. *Functioning under Variable Condition*

To highlight this technique we carried out simulations tests. We vary the illumination the 0W/m^2, 200W/m^2, 600W/m^2, 1000W/m^2 and a constant temperature of 25°C. The influence of illuminate is shown in figure 7, 8 and 9 following:

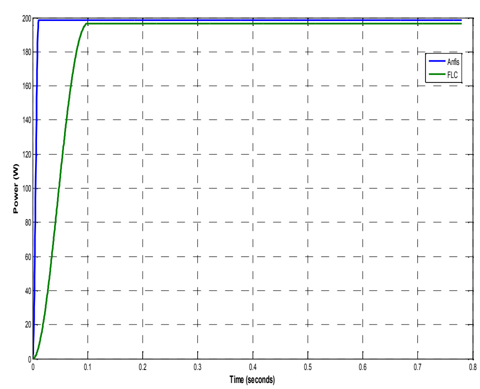

Fig. 5 Power modules for constant illumination

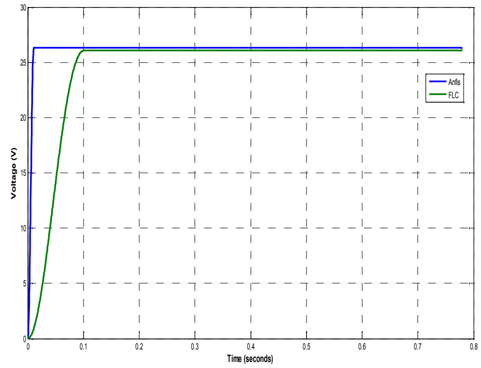

Fig. 6 Module voltages for constant illumination.

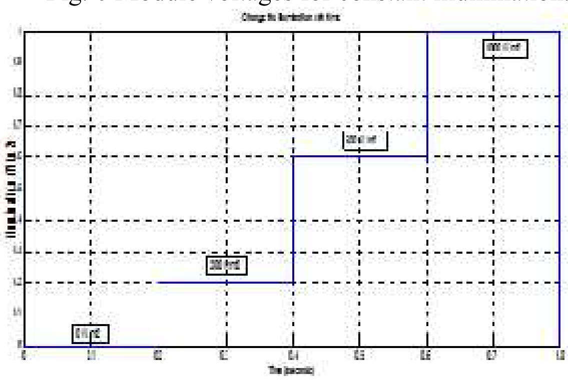

Fig. 7 Change the illumination with time.

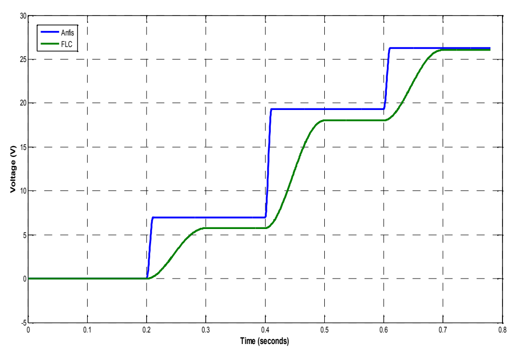

Fig. 8 Voltage variation of PV for a change of illumination

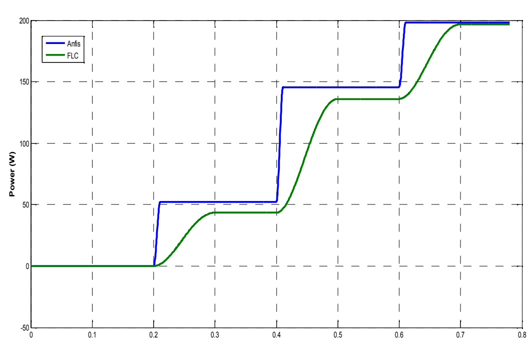

Fig. 9 Change in PV power for a change of illumination

VII. CONCLUSIONS

This paper proposes design of photovoltaic system, simple boost converter, FLC and ANFIS. One simple solar panel that has standard value of insolation and temperature has been included in the simulation circuit. From all the cases, the best controller for MPPT is ANFIS controller. This controller gives a better output value for buck and boost converter. Hence this controller will give different kind of curves for the entire converter.

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