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Fuzzy logic concept based MPPT technique for standalone PV system

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Abstract

This paper presents a study of an Intelligent Maximum Power Point Tracking (IMPPT) system for the Standalone PV system. The proposed MPPT technique is based on a fuzzy control concept (FLC). FLC is easy to design due it doesn't require precise system knowledge and work well with the nonlinear systems; the obtained results were compared with the famous MPPT method (P&O). According to the obtained simulation results, the proposed method gave good results compared to the P&O technique, these results are shown by the low oscillation and rapid response of the proposed method, which provides the maximum transmission of power to the load.

Keywords: Photovoltaic system, maximum power point tracking (MPPT), fuzzy logic, perturb and observe.

1. Introduction

Global energy demand has recently increased significantly due to human population growth [1]. Furthermore, global warming is rising as a result of carbon dioxide emitted by fossil fuels. So, these challenging issues must be carried out. Many studies have proposed the potential of renewable energy sources in the upcoming years to resolve the problem of energy scarcity and to reduce the consequences of fossil carbon emissions [2-4]. solar energy is clean, sustainable, and safe, it has several advantages over traditional energy sources.

The photovoltaic resource, on the other hand, is thought to be inefficient since the power of PV panels is dependent on numerous parameters such as the intensity of sunlight and the temperature, i.e., weather conditions, which lead to an energy loss and reduced efficiency [5-6]

The MPPT technique is employed to provide the maximum power from the PV panels. Several strategies are used in the literature to extract this power [7-8].
In this paper, an intelligent control technique based on the fuzzy logic concept is employed as an MPPT technique to increase the energy conversion performance of a standalone PV system. The scope of this work is to investigate the stand-alone photovoltaic systems to enhance their performance in terms of response time and avoid excessive shattering [8-10].

2. Description of standalone PV system

The studied system is a standalone PV system, the letter composed PV generator as a main source. The power of this source is estimated 170W in the STC conditions, also the PV connected to the battery bank through a DC/DC boost converter, the whole of system controlled by MPPT technique (P&O or FLC) in order to attempt the maximum of PVG.

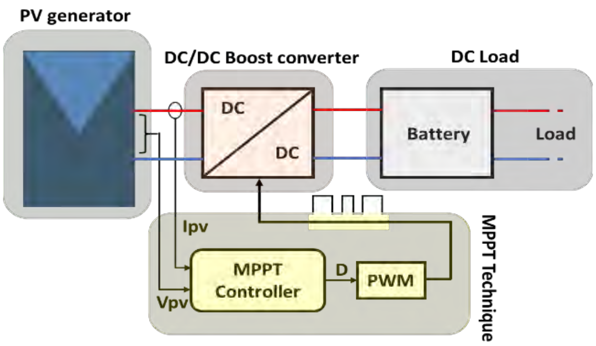

Figure 1. PV standalone system

2.1 PV generator

The chosen type in this work is the Poly-crystalline silicon cell, the solar panel that was chosen in this design is the “Solar World module SW 85 W R5A.

Table 1. Parameters of the PV panel.

Parameters of PV	Values and units
Pmax	84.1 W
Cells per Module	60
Vpv at Pmax	17.9 V
Ipv at Pmax	4.7 A
Vo (open circuit voltage)	22 V
Is (short circuit current)	5.2 A

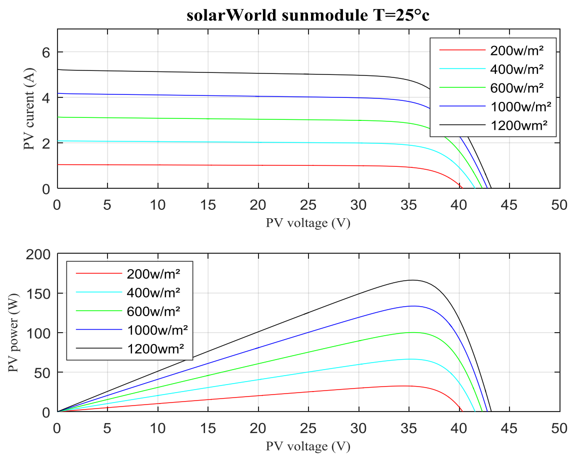

Figure 2. I-V & P-V characteristics of PV generator

In figure (Fig.2) presents 2 series-connected panels, one can be observed how the I-V and P-V curves are affected by changes in irradiation from 200 W/m2 until 1200 W/m2, from these curves we can see when the Irradiation increase, the power of PV generator increase.

2.2 DC-DC boost converter

The role of the DC/DC boost converter (in the context of the PV) on the one hand is to make an adaptation between the source (PV-G) and the load (in the boost sens) to have a maximum power transfer to the load.

Figure 3 present the schematic circuit of the used DC/DC boost converter

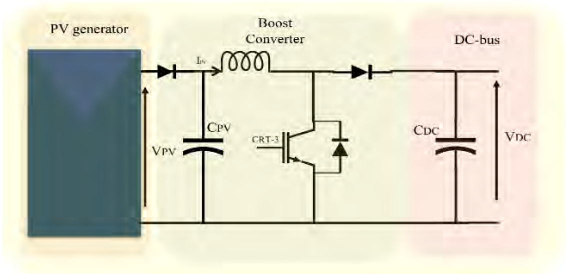

Figure 3. DC/DC boost converter

2.3 MPPT technique based fuzzy logic controller

The proposed FL controller, used to track the MPP, has two inputs and one output as illustrated in Figure (4), The inputs are the error E (equation (1)) and the error variation ΔE (equation (2)) and the output represents the duty cycle D (equation (3)).

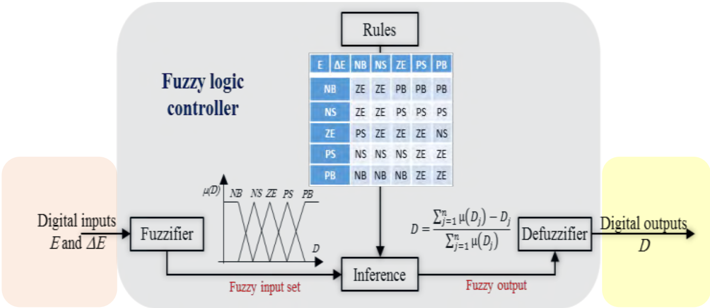

Figure 4. Fuzzy logic controller

$$E\,(k) = \frac{P_{pv}(k) - P_{pv}(k-1)}{V_{pv}(k) - V_{pv}(k-1)} \quad (1)$$

$$\Delta E(k) = E(k) - E(k-1) \quad (2)$$

$$D = \frac{\sum_{j=1}^{n} \mu(D_j) - D_j}{\sum_{j=1}^{n} \mu(D_j)} \quad (3)$$

3. Simulation and results

This section is dedicated to presenting the obtained results of using Fuzzy Logic Controller as a Maximum Power Point Tracker. We have tested the operation of the studied system under a fixed temperature at 25 ° C and variable Irradiance (600W \ m2, 1000W \ m2, 1200W \ m2,) as illustrated in the following figure.

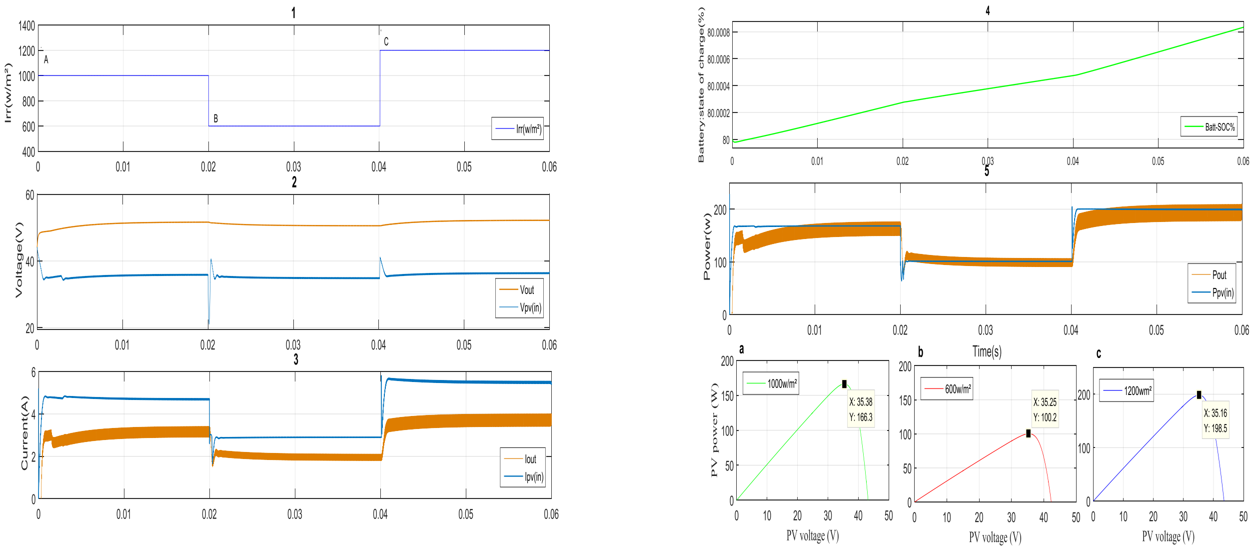

Figure 5. FLC obtained results: (1. Irradiation / 2. Vpv Voltage / 3. Ipv Current /4. Battery State of charge /5. Ppv Power)

The obtained results, Figure (5), show that the control based on fuzzy logic responds correctly to the characteristics of the PV generator. The electrical power generated by the PV panels are always maintained at its maximum power, whatever the atmospheric conditions.

3.1 Comparison results

order to show the effectiveness of fuzzy logic controller, another simulation has been done of MPPT technique based on P&O algorithm, then we try to compare the obtained results with those obtained by FLC.

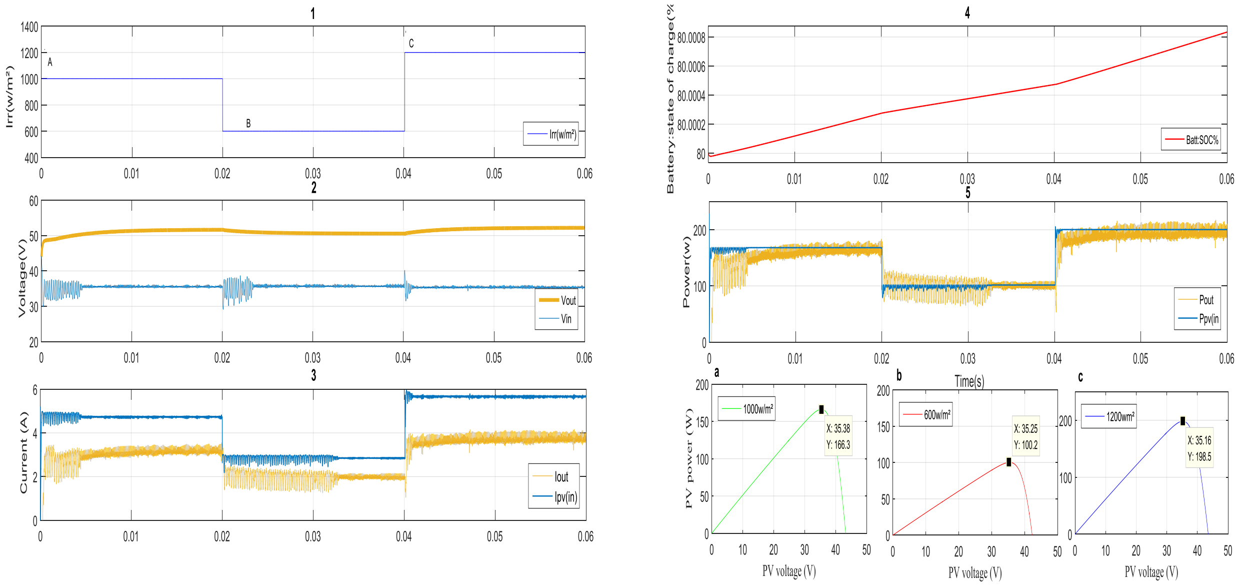

Figure 6. P&O obtained results: (1. Irradiation / 2. Vpv Voltage / 3. Ipv Current/4.Battery State of charge /5. Ppv Power)

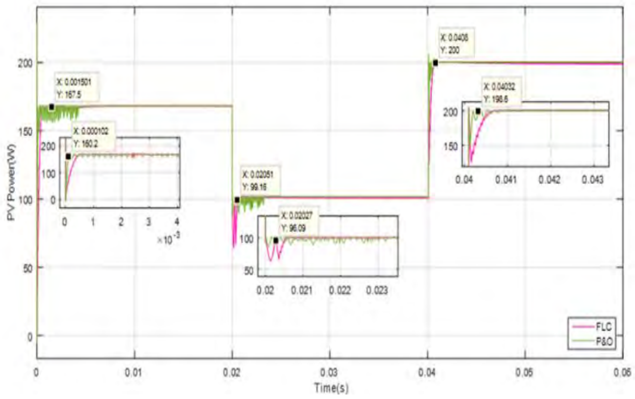

Figure 7. FLC and P&O comparison results

3.2 Discussion results

The simulation results of the PV generator output power comparing FLC MPPT and P&O MPPT within the same conditions of irradiation and temperature are as follows:

Figure (7) shows the rise time in output power and settling time. It can be seen that the P&O has the longest rise time but is still close to the FLC performances. There is no doubt that the P&O MPPT system has an energy loss. It can be observed how the FL-based MPPT controller improved the photovoltaic system's response time.

The obtained power is between 168 and 200 watts, which corresponds to the values shown in the figure. However, it should be noted that the P&O controller's worst-case scenario showed minor oscillations, as illustrated by times between [0 0.0004] and [0.02 0.023] and [0.04 0.041]. when the irradiance changes from 1000 to 600 W/m2 and then from 600 to 1200 W/m2 at a solar temperature of 25 C°

So, for the P&O technique, the continual oscillation of the operation point is a result of the continuous perturbation of the operating voltage to achieve the MPP. In contrast, oscillation is not observed in FL-based MPPT techniques, where power, voltage, current, and duty ratio signals are practically constant. As a result, power losses have been decreased.

4. Conclusion

Several MPPT algorithms were studied in relation to this work, however two of the most commercially implemented ones, and for their simplicity and effectiveness reasons, P&O, and FLC were selected for further analysis in this paper. It can be seen as a comparative study between them, in order to determine the best method that can be applied to generate the maximized power from the PV generator.

The Fuzzy logic controller enhances output power, reduces fluctuation and fast response time, against changing in weather conditions. The Fuzzy controller is superior to the P&O technique.

5. References

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