

Fuzzy Logic Concept Based MPPT Technique for Standalone PV System

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Abstract

This paper presents a new 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 because they do not 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 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

Due to population growth, global energy demand has recently grown considerably [1]. Furthermore, due to carbon dioxide emissions from fossil fuels, global warming is rising. Therefore, these complex challenges must be resolved. Several studies have recommended the use of renewable energy sources in the coming years to resolve the problem of lack of energy and to minimize the effects of fossil carbon emissions [2, 3]. Solar energy has many advantages over conventional energy sources, because of its, clean, sustainable and safe energy. However, the photovoltaic resource is considered to be of low efficiency, due to the dependence the power of PV panel on several factors such as the intensity of radiation and the temperature, i.e. weather conditions, resulting in energy loss and lower efficiency [4]. The MPPT technique is used to extract the maximum power of PV panels. In the literature, several techniques are used to extract this power [5]. In this paper, in order to improve energy conversion performance of standalone PV system, an intelligent control technique using fuzzy logic concept is used as an MPPT technique. Where the aim of this work is to investigate on the standalone photovoltaic system in order to improve its performance in point of view response time and avoid excessive shattering.

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 extract the maximum of PVG.

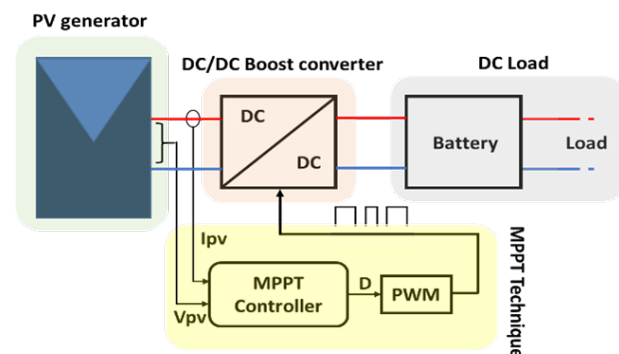


Figure 1: PV standalone system

3. 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".

In Figure 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.

4. 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.

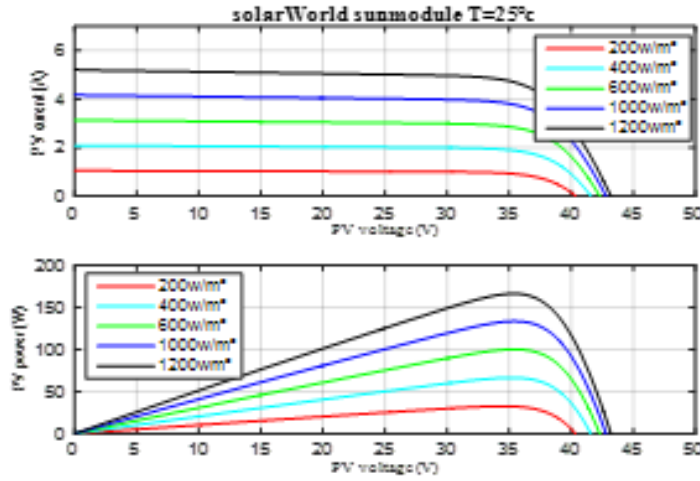


Figure 2: I-V & P-V characteristics of PV generator

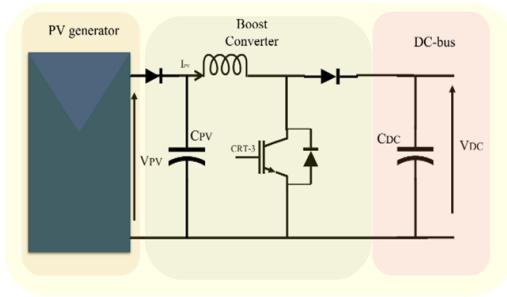


Figure 3: DC/DC boost converter

5. 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)).

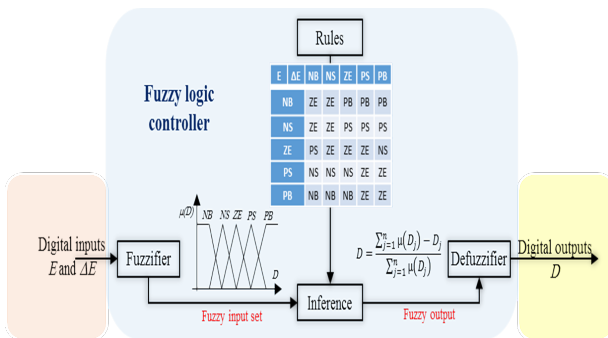


Figure 4: Fuzzy logic controller

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

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

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

6. 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 (600 W/m², 1000 W/m², 1200 W/m²) as illustrated in the following figure.

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.

7. Comparison Results

In 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.

8. Discussion of Results

By the way of comparison, the simulation results of the PV generator output power between FLC based MPPT and conventional P&O MPPT under the same conditions of irradiance and temperature:

Figure 7 presents the rise time in output power, settling time, it can be observed that the P&O has the longest rise time but still close to the FLC performances. It's obviously that the system with P&O MPPT has a loss of energy and clearly seen how FL based MPPT controller reduced the response time of photovoltaic system.

The power obtained is between 168 W and 200 W, which corresponds to the values presented in the figure. However,

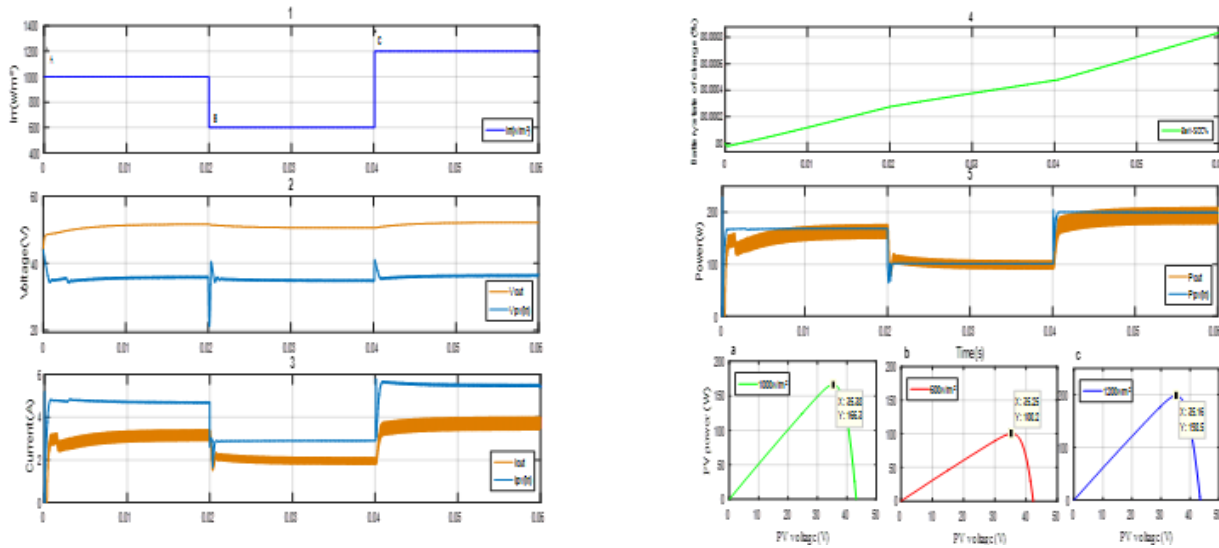


Figure 5: FLC obtained results: (1.Irradiation / 2.Vpv Voltage / 3.Ipv Current / 4.Battery State of charge / 5.Ppv Power)

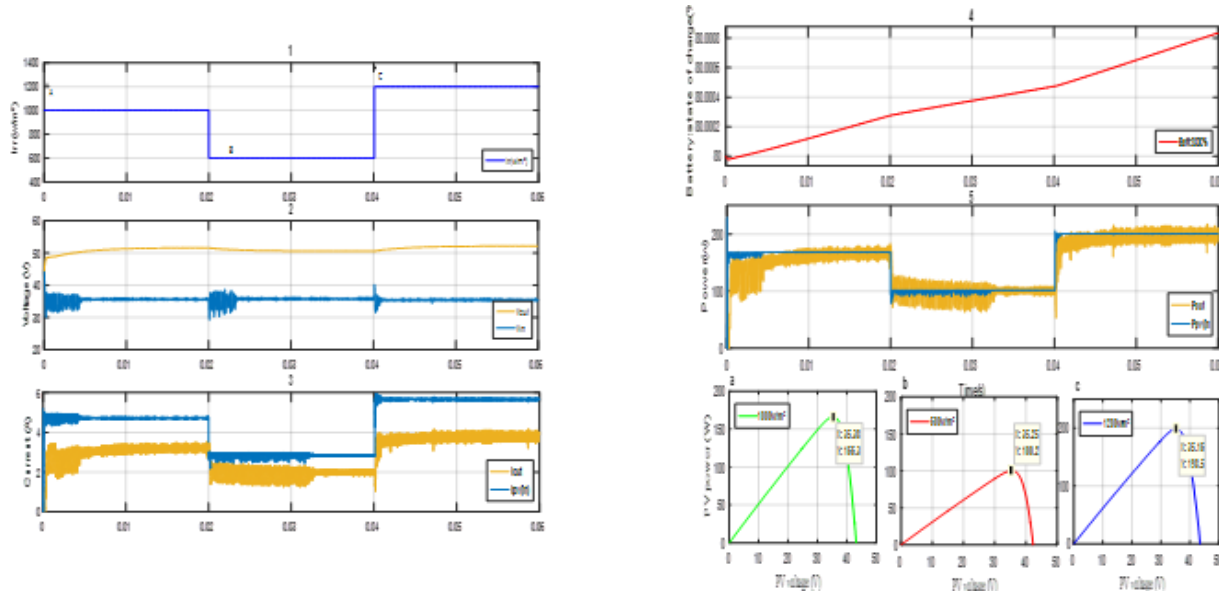


Figure 6: P&O obtained results: (1.Irradiation / 2.Vpv Voltage / 3.Ipv Current / 4.Battery State of charge / 5.Ppv Power)

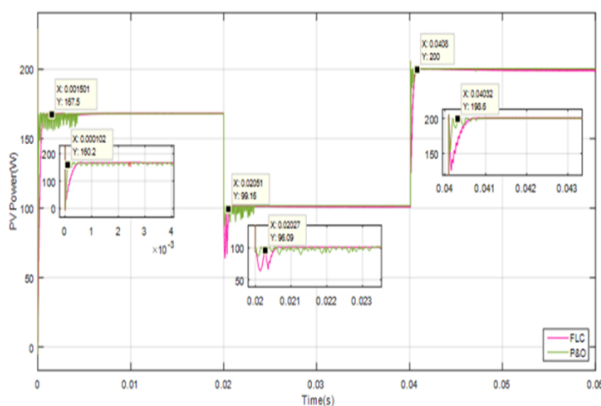


Figure 7: FLC and P&O comparison results

it should be noted that the worst case scenario of P&O controller by presented small oscillations, which is evidenced in times between $[0, 0.0004]$ and $[0.02, 0.023]$ and $[0.04, 0.041]$ when the irradiance changes from 1000 to 600 and from 600 to 1200 W/m^2 with a solar temperature of 25 °C.

So, it's clearly seen continues oscillation of operation point for the P&O conventional technique is a result of the continuous perturbation of the operating voltage in order to reach the MPP. Whereas this phenomenon of oscillation it doesn't observed in FL based MPPT technique, where signals of power, voltage, current, and duty ratio remain almost constant. This has as result a power losses reduction.

9. Conclusion

Several MPPT algorithms where 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 pa-

per. It can be seen as a comparative study between them, in order to determine the best method that can be used to generate the maximum power of PV generator.

The Fuzzy Logic Controller Increase output power, less fluctuation and fast Response time, against change in weather conductions. The Fuzzy controller is superior compared to P&O.

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