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PSIM Simulation of Flyback Converter for P&O and IC MPPT Algorithms

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Abstract

The output power of PV panels varies continuously depending on some environmental factors such as temperature, shading and solar radiation level and load conditions. PV panels have a nonlinear characteristic since they have different output power at different operating points. Therefore, dc-dc converters are required between PV panels and load to obtain the maximum power from the panels. In this study, the simulation of the flyback converter for two most commonly used MPPT algorithms specifically Perturb and Observe (P&O) method and Incremental Conductance (IC) method are achieved in PSIM and performance of the control techniques are compared. The simulation results of P&O and IC MPPT algorithms are compared for different solar radiation conditions.

Key words

Flyback, Maximum powerpointtracking (MPPT), PerturbandObserve (P&O), IncrementalConductance (IC), PSIM

1. INTRODUCTION

Electric energy demand has been increasing recently due to the increasing population and industrialization. However, a great part of the electric energy has been met by fossil fuels such as oil and coal. Renewable energy sources have gained importance since the fossil fuels give harm to the environment and they will be exhausted in the near future. Among the renewable energy sources solar energy has been more attractive since it is clean, free and infinite [1, 2]. Among the renewable energy sources, the solar energy has gained popularity for energy demand recently and has been prompted. Therefore, the costs have reduced and studies in this field have increased. Although generating energy using PV panels has many advantageous, the efficiency of the panels is low depending on some environmental factors such as temperature, radiation level, shading, and dirt. Therefore, it becomes important to extract maximum power from PV panels by MPPT dc-dc converter [3].

In literature, many MPPT techniques are used to determine the maximum power point (MPP). Some of these MPPT techniques are fractional open circuit voltage, fractional short circuit current, perturb and observe, incremental conductance, lookup table method, neural network and fuzzy logic controller. Fractional open circuit voltage and short circuit current methods adopt approximation methods. However, these methods give low accuracy at MPP. On the other hand, a large database is needed for some MPPT techniques such as lookup table method, neural network and fuzzy logic. However, this increases the implementation complexity of the system. P&O and IC techniques are among the most used MPPT techniques. These methods are simple, high efficient, panel independent and provide high accuracy at MPP [4, 5].

In literature, some flyback converter applications with P&O MPPT method [6, 7], artificial neural network (ANN) P&O MPPT method [8] and IC MPPT method [9] have been studied. In the study, two most common used MPPT algorithms specifically P&O and IC methods are compared for flyback converter in PSIM.

2. FLYBACK CONVERTER

Figure 1 shows the PSIM simulation schematic of the flyback converter. The circuit consists of a power switch (S_1), transformer (1:n), magnetizing inductor of the transformer (L_m), rectifying circuit (D), output filter capacitor (C) and load resistance (R_o) [10]. PV panel (Perlight PLM-100P/12) with 100 W maximum power is modeled at PSIM for the simulated flyback converter. Six PV panels are connected in series and total 600 W power is obtained. The standard test conditions for the PV panel are as follows: 17.7 V maximum voltage and 5.65 A maximum current. The flyback converter parameters: L_m 0.3 mH, C 10 µF, R_o 400 Ω and transformer turns ratio 1:4. The switching frequency is determined as 50 kHz.

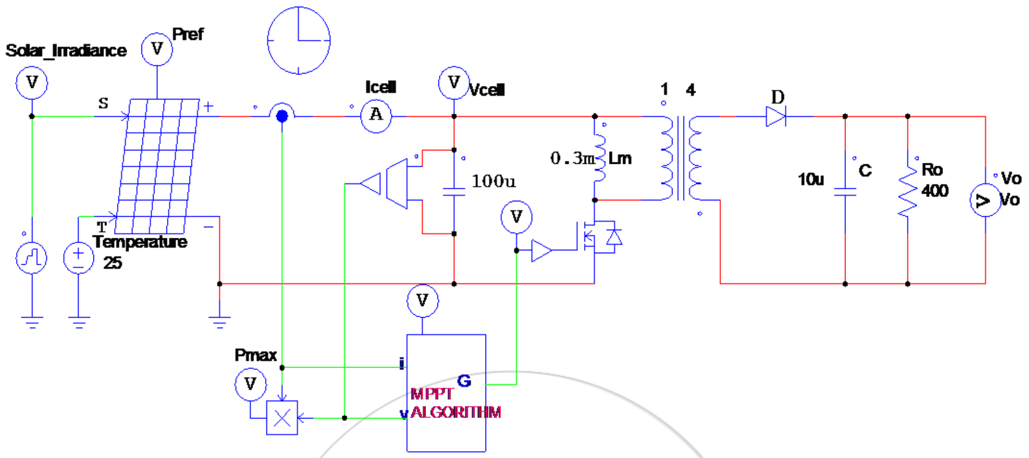

Figure 1.PSIM simulation schematic of the flyback converter

3. MPPT ALGORITHM METHODS

Load resistance must be equal to the optimal resistance in order to track the maximum power point. However, it is difficult to determine a fixed load corresponding this value. Therefore, a dc-dc converter is connected between PV panel and load to transfer maximum power from PV panel. The system is called as maximum power point tracking [11].

In literature, many MPPT techniques are used to determine maximum power point (MPP). P&O and IC methods are the most widely used MPPT techniques due to simplicity and low cost. However, in all MPPT techniques MPP is determined by changing the duty ratio (D) of the dc-dc converter [12].

3.1. P&O Method

P&O method is one of the most frequently used MPPT methods due to its simplicity, practicality and high efficiency. Moreover, the most important advantage of the method is that it is independent from some factors such as PV characteristic, temperature and radiation level in achieving MPP [13]. In P&O method, PV panel power is measured and compared with the previous one. If the power increases, perturbation direction is not changed. Otherwise, perturbation direction is reversed. Therefore, the operating point of the system moves towards MPP and oscillates around MPP under steady state conditions [14]. P&O simulation block diagram is shown in Figure 2.

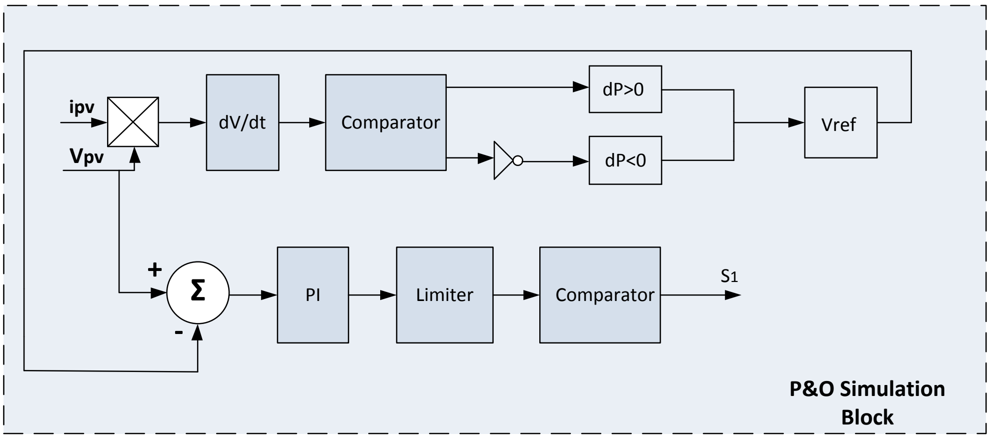

Figure 2. P&O simulation block

3.2. IC Method

Instantaneous voltage is adjusted according to MPP voltage in incremental conductance (IC) method. MPP voltage is dependent on incremental and instantaneous voltage of the PV panel. The principle of the method is that voltage-power characteristic curve of the PV panel is zero at MPP (dP/dV=0), greater than zero on the left of MPP (dP/dV>0), and smaller than zero on the right of MPP (dP/dV<0). Power-voltage characteristic showing the operating principle of IC method is given in Figure 3.

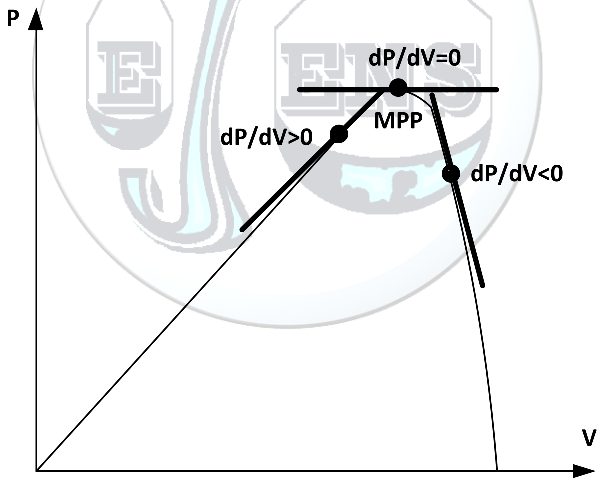

Figure 2. The operating curve of IC method

IC simulation block diagram is shown in Figure 4. The voltage and current values are used in IC block as input. The changes in voltage are converted into absolute value and the values are feedback to the positive input terminal of the comparator. If dV is not equal to zero, logic 1 will be the output. Otherwise, logic 0 will be the output. Therefore, it is determined whether dI is greater or lower than zero. In the third comparator it is determined whether dI/dV>-I/V or dI/dV<-I/V or not. Input logic combination activates Vn+K or Vn-K. So, the desired switching is provided by adding K to Vn or subtracting K from Vn [15, 16].

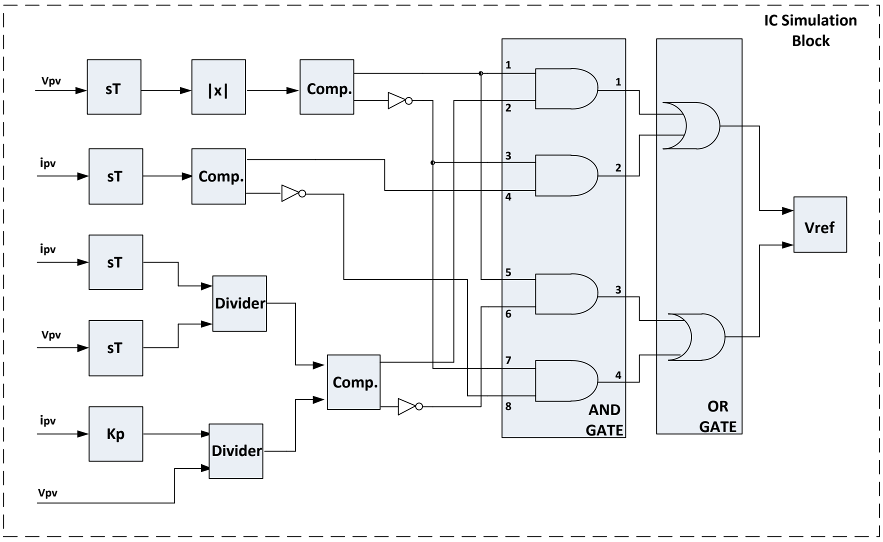

Figure 3. IC simulation block

4. SIMULATION RESULTS AND DISCUSSIONS

In the simulation, ramp and step inputs are applied to the input of solar radiation terminals to provide rapidly changing and slowly changing climate conditions. The simulation total time is 1 s. Solar radiation level is changed from 600 W/m^2 to 1000 W/m^2. The temperature terminal input remains constant at 25 °C in the simulation. Rapidly and slowly changing climate conditions are shown in Figure 5.

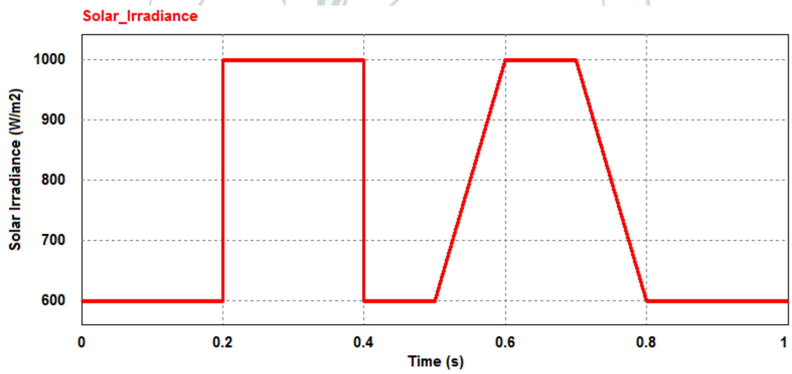

Figure 4. Rapidly and slowly changing radiation

The same standard environmental conditions are applied to compare the performance of P&O and IC MPPT algorithms. In Figure 6, P&O and IC MPPT algorithms tracking the maximum power point of PV panels are shown.

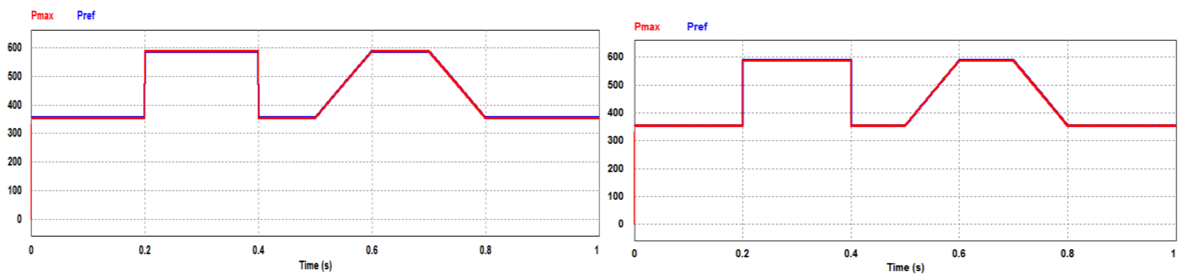

Figure 6. (a) P&O MPPT algorithm (b) IC MPPT algorithm

Figure 7 and 8 show the rapidly changing radiation effect on P&O and IC MPPT performance, respectively.

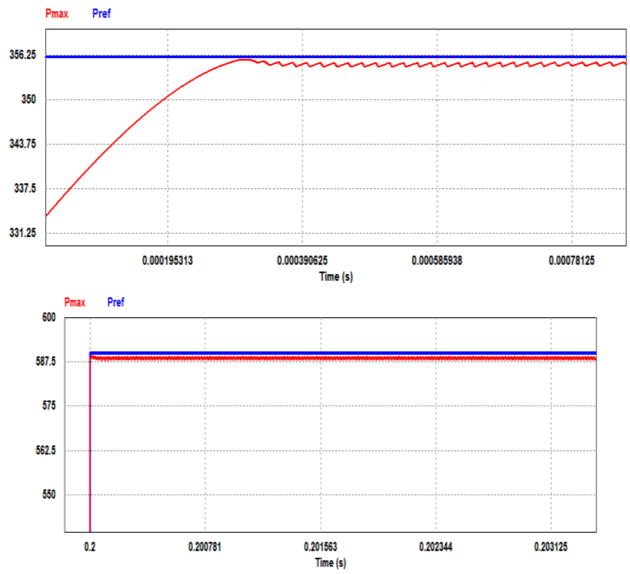

Figure 5. Zoomed window of P&O MPPT oscillations

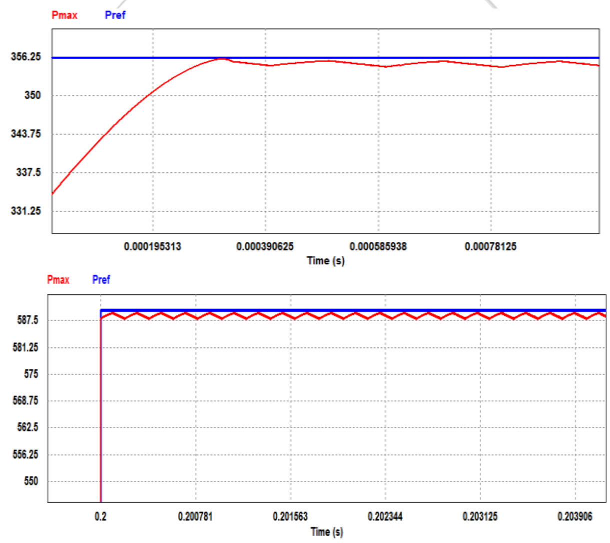

Figure 6. Zoomed window of IC MPPT oscillations

It can be concluded from the zoomed window Figure 7. showing the rapidly changing radiation that P&O oscillates around MPP resulting in some power losses. On the contrary, no such oscillations occur in IC algorithm. Moreover, P&O algorithm cannot find the new MPP quickly when radiation level changes rapidly. This is the main drawback of the P&O algorithm. IC algorithm finds the new MPP more accurately under rapidly changing radiation level. However, P&O MPPT is most commonly used due to its simplicity.

5. CONCLUSION

This paper presents the comparison of P&O and IC MPPT algorithms using PSIM simulation of the flyback converter under rapidly and slowly changing solar conditions by using PSIM. No significant differences are observed for P&O and IC MPPT algorithms when the climate changes slowly. However, IC algorithm finds the MPP quickly under rapidly changing climate conditions. Moreover, no additional oscillation occurs around MPP in IC algorithm. Therefore, it can be concluded that IC algorithm gives better results under rapidly changing climate conditions.

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