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Matlab Simulink Implementation of Optimal Control Strategy for a Solar Photovoltaic Power System

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Abstract: In this paper, the Maximum Power Point Techniques to track the Maximum Power is investigated. PV power generation systems have one big problem that the amount of electric power generated by PV module is always changing with weather conditions. The weather and load changes cause a nonlinear I-V and P-V characteristics of a solar array which depends on the solar radiation and array temperature. In this paper, proposed an improved InC algorithm for tracking a MPP on the V-I characteristic of the solar PV panel. The simulation obtained results validated the effectiveness of the proposal under various atmospheric conditions using Matlab Simulink software.

Keywords: PV, MPPT, Irradiation.

I. Introduction

As solar power increases in popularity, the need for this power to become more efficient is evident. It is very important with photovoltaic generation to operate the system at high power efficiency by ensuring that, the system is always working at the peak power point regardless of changes in load and weather conditions. As the solar panel outputs power, its maximum generated power changes with the solar radiation and temperature and the electrical characteristic of the load may also vary. Moreover, the solar cell V-I characteristic is nonlinear and varies with irradiation and temperature. In general, there is a unique point on the V-I or V-P curve, called the Maximum Power Point (MPP), at which the entire PV system (array, converter, etc…) operates with maximum efficiency and produces its maximum output power. As the location of the MPP on the I-V curve varies in an unpredictable manner it cannot be defined beforehand due to changes of irradiation and PV panel temperature. Accordingly, the use of MPPT algorithm or calculating model is required to locate this point. There are several methods to track the MPP of the photovoltaic system that have been carefully studied, developed and published over the last decades. There are variations between these techniques in terms of, simplicity, sensor requirements, cost, range of efficiency, convergence speed and hardware implementation. Some MPPT algorithms outperform the others under the same operating conditions. This thesis proposes an improved InC algorithm for tracking a MPP on the V-I characteristic of the solar PV panel. Based on the ST and MPPT, the solar PV panel is always guaranteed to operate in an adaptive and optimal situation for all conditions.

II. Renewable Energy

Renewable energy (RE) derived from natural sources such as wind, solar, hydro and biomass has potential to meet diverse and growing energy requirements. Traditionally, Renewable Energy sources have been used for heating, cooking, steam production, moving ships and also for powering mills to grind grains. Examples of Conventional Power Sources are Coal, nuclear, oil, and natural gas and Renewable Power Sources are Wind, solar, biomass geothermal, and ocean etc. An alternative to the nuclear and fossil fuel power is renewable energy technologies (hydro, wind, solar, biomass, geothermal, and ocean). Among the other renewable power sources, wind and solar have recently experienced a rapid growth around the world. The solar to electricity conversion is shown in Figure 1:

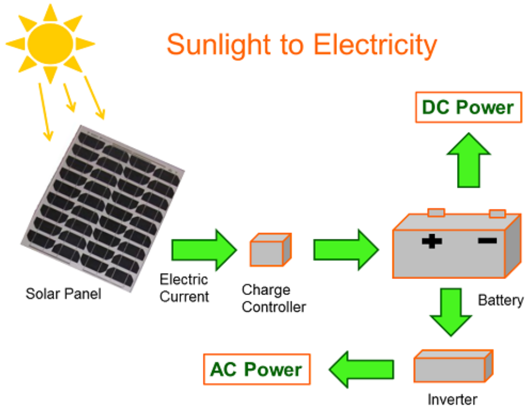

Figure 1: Solar to electricity conversion

Solar generated electricity has two main principles of operation; using the light from the sun to super-heat water and drive a steam turbine, or generating electricity directly via the photoelectric effect. The renewable compare well with the conventional in economy. Because of these benefits, many utilities and regulatory bodies are increasingly interested in acquiring hands on experience with renewable energy technologies in order to plan effectively for the future.

III. SOLAR PHOTOVOLTAIC

The integration of a large number of embedded PV generators will have far reaching consequences not only on the distribution networks but also on the national transmission and generation system. If the PV generators are built on the roof and sides of buildings, most of them will be located in urban areas and will be electrically close to loads. On the other hand, these PV generating units may be liable to common mode failures that might cause the sudden or rapid disconnection of a large proportion of operating PV capacity.Solar energy is the sunlight energy collected and used to provide electricity, heating, cooling homes, businesses or industry. It is a sustainable source in the sense that it does not provide greenhouse gas emissions and proves to be environmental friendly sources of energy. It is free and maintainable as the sun is here to stay. Photovoltaic is regarded as a phenomenon in which solar radiation is converted into electricity.

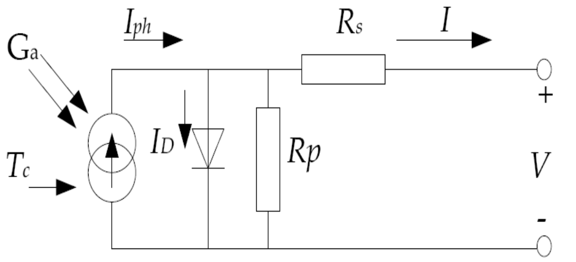

Figure 2: Equivalent circuit of solar cell with one diode

A PV cell is usually embodied by an electrical equivalent of one-diode, resistance series Rs and resistance parallel Rp as shown in Figure 2.

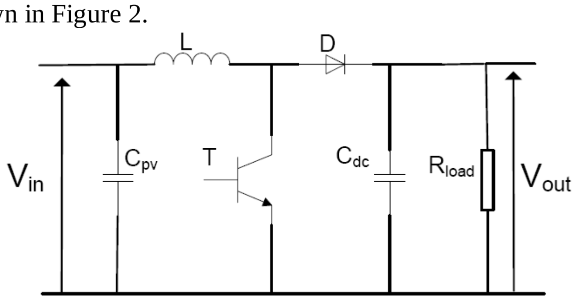

Figure.3: Boost converter

The datasheet which gives the electrical characteristics is calculated under standard test condition STC when the temperature T is 25°C and the irradiance G is 1000 W/m^2. Figure 3 shows the Boost converter. In continuous conduction mode (CCM), the switch is ON for period t to ton as shown Fig.3.10.

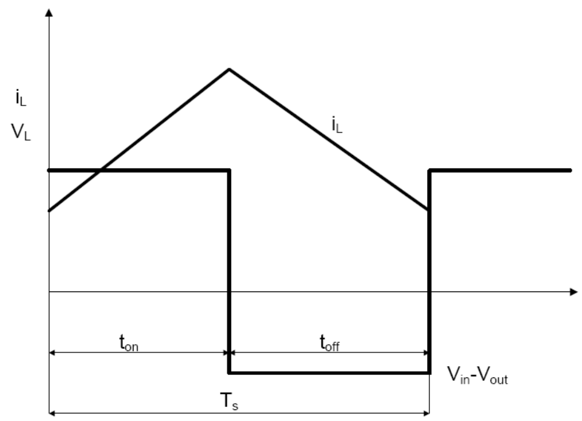

Figure 4: Continuous conduction mode

In this paper, two of the most prevalent MPPT algorithms, perturb and observe as well as incremental conductance, were used to control the converter and solar panel so that the panel operated at its MPP.

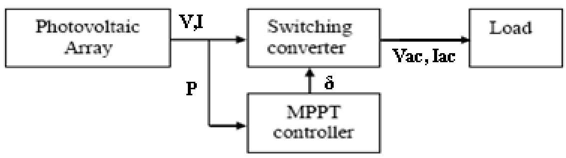

Figure 5: Basic MPPT system

Perturb and observe is probably the most commonly utilized MPPT method. The basic premise for P&O is to continually perturb or alter the power converter's operating point and then to observe or sense the ensuing effects. Utilizing the P&O algorithm has several benefits. For one, it is a reliable approach to MPPT, which means that it finds the MPP in almost all circumstances. The Incremental conductance method eliminates the drawbacks of the Perturb and Observe method. It uses the advantage that the derivate of the power with respect to the voltage at the maximum power point is zero. Furthermore the derivative at the left of the MPP is greater than zero and less than zero to the right of the MPP. The incremental conductance can determine that the MPPT has reached the MPP and stop perturbing the operating point.

IV. Simulation Result Analysis

This section presents detailed simulation results of the proposed solar photovoltaic using improved InC MPPT & will be compared with conventional MPPT. The simulated system is shown in Figure 6. Simulation studies are carried out in the MATLAB/SIMULINK environment.

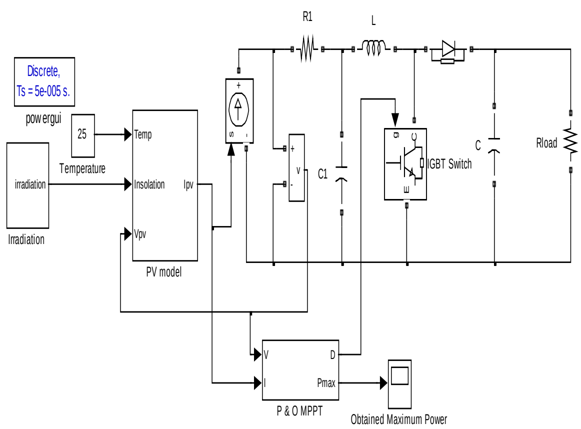

Figure 6: Matlab Simulink model for solar PV system

Table 1: Simulation parameters

S. No.	Description	Values
1.	Maximum power, P_{max}	22 W
2.	Short-circuit current, Is c	1.34 A
3.	Open-circuit voltage, Voc	21.99 V

Simulations are performed using MATLAB/SIMULINK software for tracking MPPs of the solar PV array whose specifications and parameters are in Table 1.

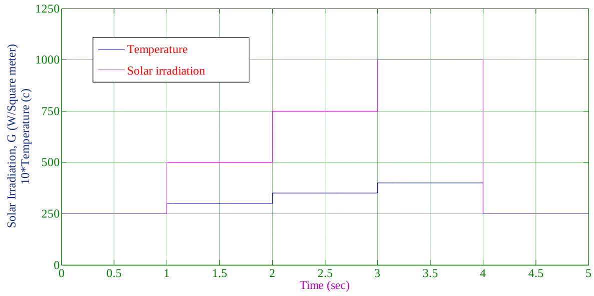

Figure 7: The variations of the solar irradiation and temperature

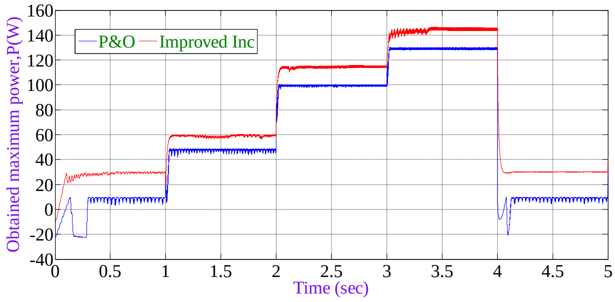

Figure 8: OMP with the P&O and improved InC algorithms under the variation of the solar irradiation

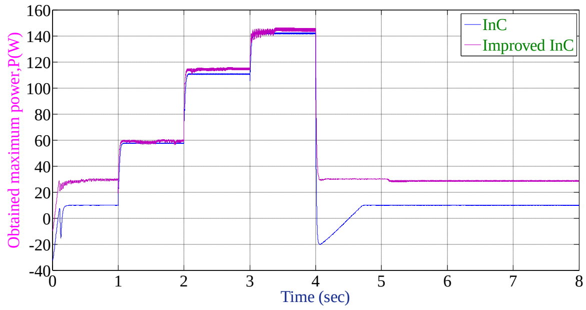

Figure 9: OMP with the InC and improved InC algorithms under the variation of the solar irradiation

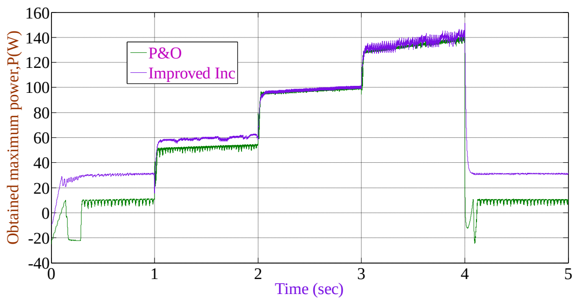

Figure 10: OMP with the P&O and improved InC algorithms under both the variations of the solar irradiation and temperature

The obtained output powers are shown as in Figure 7 & 8 using the P&O, InC and improved InC algorithms under the variation of both the temperature and solar irradiation. It can be realized that the simulation results of the cases using the improved InC algorithm are always better than the cases using the P&O and InC algorithms, Figure 8-9 and Figure 10–11. The better results are shown through the algorithm convergence and the MPPs' tracking ability, especially with the rapid variation of both the temperature and solar irradiation. This means that the drawbacks of the InC algorithm have been overcome using the proposed InC algorithm.

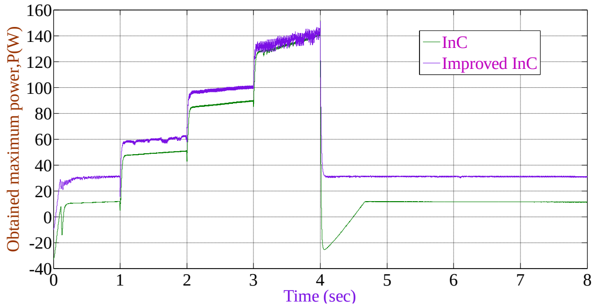

Figure 11: OMP with the InC and improved InC algorithms under both the variations of the solar irradiation and temperature.

V. Conclusion

In this paper, the proposed InC algorithm improves the conventional InC algorithm with an approximation which reduces the computational burden as well as the application of the CV algorithm to limit the search space and increase the convergence speed of the InC algorithm. This improvement overcomes the existing drawbacks of the InC algorithm.

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