PV System with Maximum Power Point Tracking: Modeling, Simulation and Experimental Results

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Abstract: This paper focuses on the five parameters modeling, consisting on a current controlled generator, single-diode, a shunt and series resistances. Also, a simulation, identification of the parameters for a photovoltaic system and the maximum power point tracking based on $\partial P/\partial V$ is presented. The identification of parameters and the performance of the equivalent circuit model for a solar module simulation are validated by data measured on the photovoltaic modules.

1 INTRODUCTION

The demand for energy, the shortage of fossil fuels and the need for carbon footprint reduction have resulted in a global awareness of the importance of energy savings and energy efficiency [1] and programs on the Demand-side Management have been developed in order to assist consumers on energy usage. Also, renewable energy sources coming from wind and solar energy sources are attractive to go into exploitation, considering not only large scale systems, but also micro and mini scale conversion systems [2], Disperse Generation (DG), that can be owned by consumer.

A photovoltaic (PV) system directly converts solar energy into electric energy. The main device of a PV panel is a solar cell. Cells may be grouped to form arrays and panels. A PV array may be either a panel or a set of panels connected in series or parallel to form large PV systems without or with tracking systems in order to achieve higher values of energy conversion during sunny days due to the diverse perpendicular positions to collect the sun´s irradiation.

Power electronic converters have been developed for integrating renewable energy sources with the electric grid. The use of power electronic converters, namely inverters, allows for operation of the PV system and enhanced power extraction. The inverter is needed for two reasons in a PV system. First, to adjusts the low DC voltage generated by the PV module to the voltage level in the electric grid. Second, the power delivered from the modules is very sensitive to the point of operation, and the inverter should therefore incorporate functionality for Tracking the Maximum Power Point (MPP) [3].

This abstract is organized as follows. Section 2 presents the modeling of the PV system with MPPT. Section 3 presents the simulation results. Finally, concluding remarks are given in Section 4.

2 MODELING

The equivalent circuit model used for the solar module simulation consists of a current controlled generator, a single-diode, a shunt and series resistances. The I-V characteristic associated with the model for the solar cell is formulated by an implicitly function is given by:

$$I = I_S - I_0 \left(e^{\frac{V + I R_S}{m V_T}} - 1 \right) - \frac{V + I R_S}{R_p} \tag{1}$$

The MPPT algorithm based on $\partial P/\partial V$ is given by:

$$\left(\frac{\partial P}{\partial V}\right)_{MPP} = \left(\frac{\partial VI}{\partial V}\right)_{MPP} = I_{MP} + V_{MP}\left(\frac{\partial I}{\partial V}\right)_{MPP} = 0 \tag{2}$$

The MPPT algorithm is shown in Figure 1.

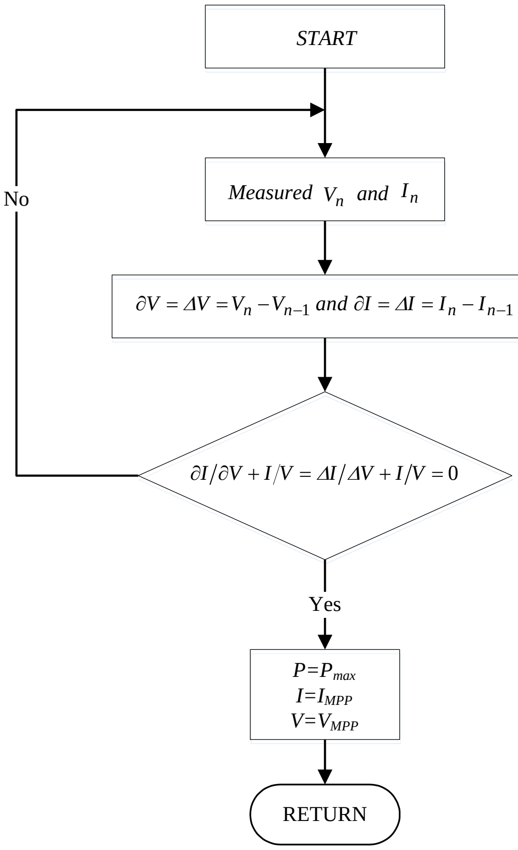

Figure 1: MPPT algorithm.

3 SIMULATION RESULTS

The model for the solar cell with single-diode, shunt and series resistances is implemented in Matlab/Simulink with Simscape library. The simulation results were compared with experimental observation carried out for a monocrystalline PV module technology. The Simulink structure for the PV system with MPPT in is shown in Figure 2.

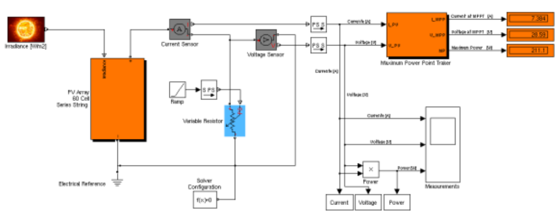

Figure 2: PV system with MPPT structure.

The I-V and P-V curves with MPP simulated and experimental are shown in Figure 3.

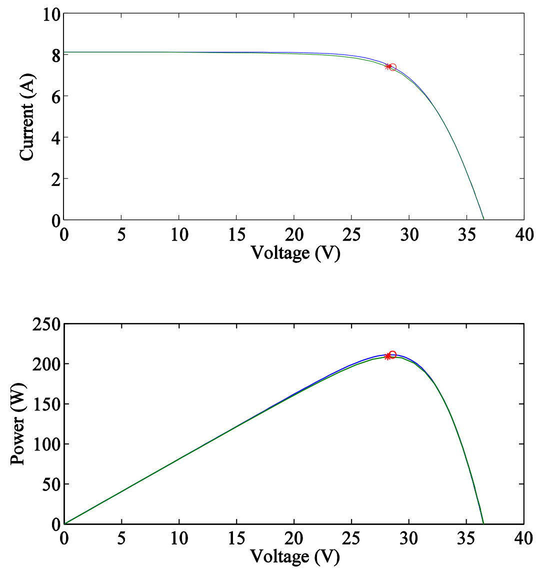

Figure 3: I-V and PV curves with MPP.

4 CONCLUSIONS

A solar cell model consisting of one current controlled generator, one single-diode, one shunt and series resistances is used in this paper in order to achieve an acceptable approximation of the I-V curves.

The simulation results proved the ability of the proposed algorithm to track the maximum power point under irradiance and temperature changes.

REFERENCES

[1] Seixas, M., Melicio, R., and Mendes, V.M.F. A simulation for acceptance of two-level converters in wind energy systems, *in Proc. of JIUE' 2013 - 3ª Jornadas de Informática da Universidade de Évora*, Évora, Portugal, February. 2013, p. 75-79.

[2] Blaabjerg, F., Chen, Z., and Kjaer, S.B., 2004. Power electronics as efficient interface in dispersed power generation Systems, *IEEE Trans. Power Electron*, Vol. 19, No. 5, p.1184-1194.

[3] Yang, Y., and Zhao F.P., 2011. Adaptive perturb and observe MPPT technique for grid- connected photovoltaic inverters, *Procedia Engineering*, Vol. 23, p. 468-473.