MPPT algorithm for solar wind system using standard perturbs and observe method

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ABSTRACT

A hybrid renewable energy system that combines the generation of power through solar and wind system is installed to meet the load demand of a particular location which has adequate solar insolation and wind velocity. This hybrid system allows maximum utilization of freely available renewable energy sources like wind and photovoltaic energies. For this, an adaptive MPPT algorithm along with standard perturbs and observes method will be used for the system. The inverter converts the DC output from non-conventional energy into useful AC power for the connected load. This hybrid system operates under normal conditions which include normal room temperature in the case of solar energy and normal wind speed at plain area in the case of wind energy. This system has lower operating cost and finds applications in remote area power generation, constant speed and variable speed energy conversion systems and rural electrification. MATLAB/ SIMULINK software is used to model the PV panel, wind turbine, DC-DC converters, MPPT controller and proposed hybrid system.

Key words- MPPT Algorithm, DC-DC Converter, Power Quality, Simulation Model

1. INTRODUCTION

The growth of world energy demand all over the world and the environmental concerns lead to an increase of the renewable energy production over the last decade. Energy sources such as solar, wind or hydro became more and more popular because they produce no emissions and are inexhaustible. The increased efforts in the semiconductor material technology resulted in the appearance of commercial PV cells and consequently made the PVs an important alternative energy source. As the PV system is growing extensively, the impact of PV modules on power grid can't be ignored. They cause problems such as harmonics and provoked stability of the power system. Hence in order to maintain power quality, it is essential to act in accordance with the technique requirements of the PV system, such as harmonic current regulation. Especially when a large scale PV module is connected to the grid, the effects on the grid may be quite severe. Similarly, in modern wind power plants a huge number of power electronic apparatus is installed. These power electronic devices have significant effect on the harmonic emissions. Thus the increasing use of static power converters like rectifiers and switched mode

power supplies causes injection of harmonic currents into the distribution system. Current harmonics produce voltage distortions, current distortions and unsatisfactory operation of power systems.

1.1 PASSIVE FILTERS

Passive filters have been commonly used to limit the flow of harmonic currents in distribution systems. Inductor and the capacitor are considered as a resistance and are tuned to control the harmonics. Shunt passive filters compensate harmonics as well as reactive power. Notch filter bye pass the high frequency harmonics to ground. Single tuned filters suppress only the harmonics of selected frequency. As these filters are adjusted according to the impedance of the point where it is connected, they cannot be adjusted according to the load immediately. Hence their cutoff frequency changes unexpectedly after any change in the load impedance and produces a resonance with other elements installed in the system.

Also, these filters commences problems such as

- Involving bulky equipment, this results in aging problems.
- The size of the filter depends on the harmonic specter and the grid impedance.
- Any modifications in the grid must be accompanied with modifications in the filter.
- The construction of filter requires a concise knowledge of the configuration of the electric grid.
- The resonance caused by these filters affects the stability of the power system.

2. MPPT ALGORITHM

2.1 PERTURB AND OBSERVE

In this method the controller adjusts the voltage from the array and measures power. If the power increases, further adjustments in that direction are tried until power no longer increases. This is called the perturb and observe method and is most common. It is also referred as a hill climbing method, because it depends on the rise of the power against voltage below the maximum power point. Perturb and observe is the most commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in high efficiency.

2.2 INCREMENTAL CONDUCTANCE

In the incremental conductance method, the controller measures incremental changes in PV array by measuring both current and voltage in order to forecast the effect of a voltage change. This method involves more computation, but can track changing conditions more quickly than the perturb and observe method (P&O). The incremental conductance method computes the maximum power point by comparison of the incremental conductance ($I\Delta$ / $V\Delta$) to the array conductance (I / V). When these two are the same (I / $V = I\Delta$ / $V\Delta$), the output voltage is the MPP voltage. The controller maintains this voltage until the irradiation changes and the process is repeated.

2.3 CONSTANT VOLTAGE METHOD

The Constant Voltage (CV) algorithm is the simplest MPPT control method. The operating point of the PV

array is kept near the MPP by regulating the array voltage and matching it to a fixed reference voltage VMPP of the characteristic PV module. The temperature and insulation variations on the array are of no consequence on the VMPP and that the constant reference voltage is an approximation of the real MPP. Consequently, the operating point is never exactly at the MPP and different data have to be adopted for different geographical regions. The CV method needs the measurement of the voltage of PV array to set up the duty-cycle of DC/DC boost converter. It is important to observe that when the PV panel is in low insulation conditions, the CV technique is, more effective than either the P&O method or the IC method.
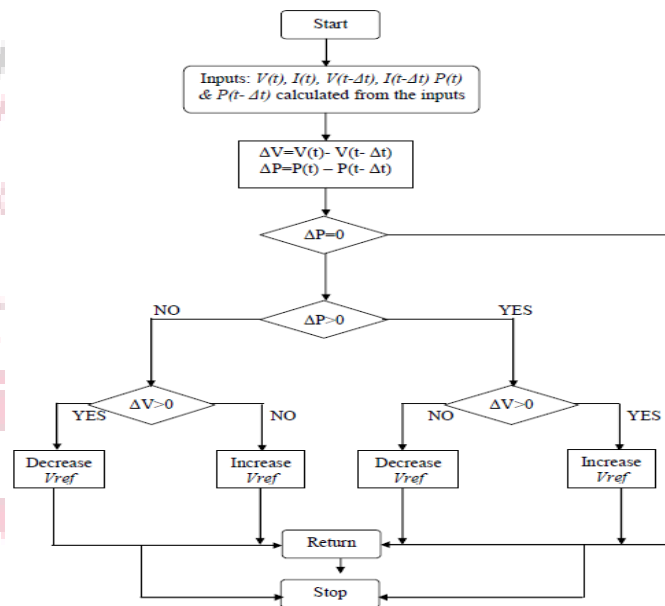

Figure 2.1: Algorithm of perturbation and observation

3.   EVOLUTION OF PWM STRATEGIES

The most popular and widely used PWM technique, SPWM involves the simple direct comparison of a sinusoidal modulating signal with a triangular carrier to produce the PWM switching edges. The instantaneous comparison of these two signals determines the PWM switching instants by a process of natural sampling and the technique is called as Natural Sampled PWM (NSPWM). The performance enhancement in NSPWM has a wide scope through carrier and reference modifications. These are the attempts to use different functions for reference (other than sine) and carrier (other than triangular) towards improving the performance.

The digital implementation requires solving non-linear transcendental equations for emulating the switching instant when carrier and reference functions become equal and can be solved using only numerical techniques. An earnest effort to represent a sine wave in the digital platform has been to view it in the form of a staircase; the number of steps and the frequency ratio are selected for a desired output voltage quality. Instead of staircase reference, trapezoidal wave has also been used as the modulating signal for the microcomputer based PWM. These strategies are grouped under a category called as Regular Sampled PWM (RSPWM). Although the early triangle intersection implementations mostly involved analog hardware circuits, the advent of low cost digital

electronics rendered the analog solutions obsolete. Most present triangle intersection implementations involve high resolution digital PWM counters and comparators.

A host of PWM methods are researched and motivated to achieve the above objectives. The PWM techniques namely, Selective Harmonic Elimination PWM (SHEPWM), Space Vector PWM (SVPWM), Discontinuous PWM (DPWM), Third Harmonic Injection PWM (THIPWM) etc. are triumph in achieving their objectives. These methods can be either grouped under NSPWM or RSPWM. The following section describes different PWM strategies developed in the past decades to achieve specific objectives.

3.1 TRAPEZOIDAL PWM

The trapezoidal PWM strategy offers several advantages compared to SPWM in terms of easy and fast real-time waveform generation and higher fundamental output voltage. The trapezoidal wave can be obtained from a triangular wave by limiting its magnitude as shown in Figure 3.1.
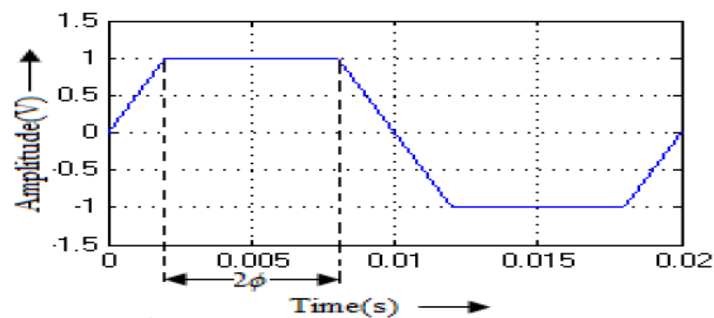

Figure 3.1: Reference waveform of trapezoidal PWM

4. RESULTS

4.1 SIMULATION MODEL FOR PV ARRAY

Again the power produced by a single module is not sufficient to meet the power demands for most of the practical purposes. PV arrays can use inverters to convert the dc output into ac and use it for motors, lighting and other loads. The modules are connected in series for more voltage rating and then in parallel to meet the current specifications.
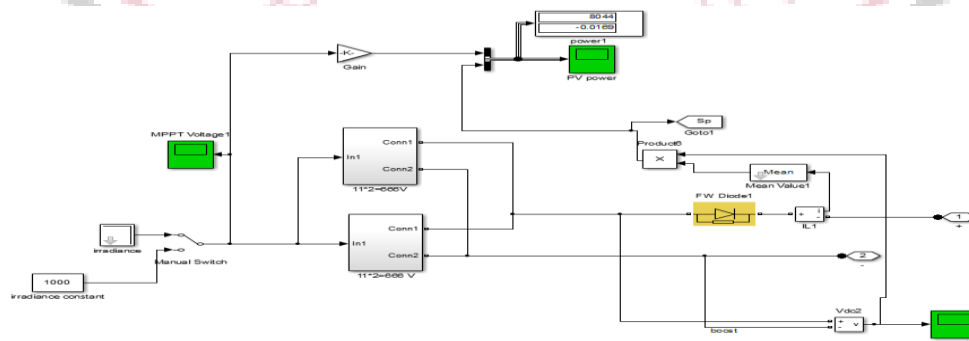
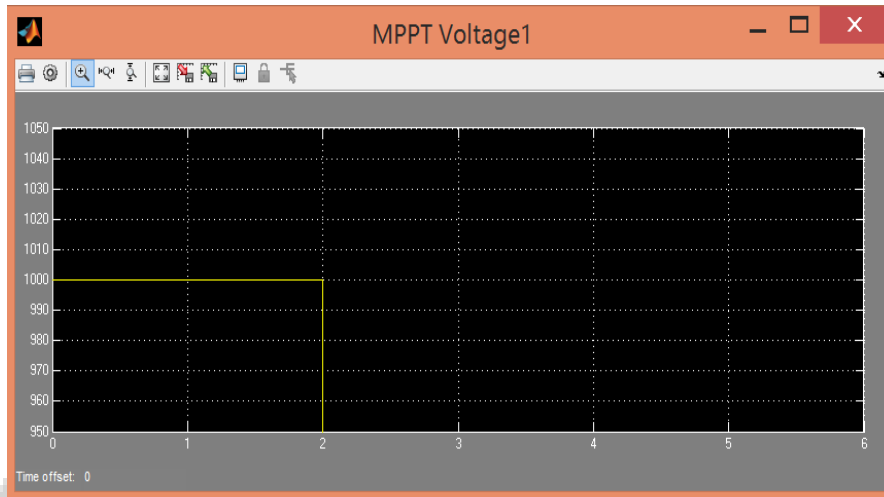

Figure 4.1: Simulation Model for PV Array
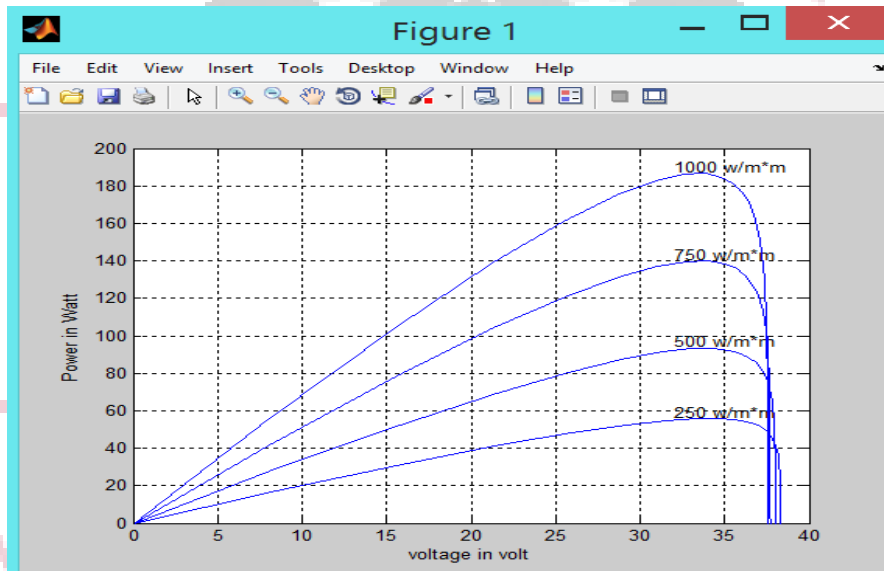
Figure 4.2: Output Voltage of PV System

Figure 4.3: Output Voltage of MPPT System

The output waveform of the PV array with 1000 irradiation is shown in figure 4.2. The maximum power of the PV array is 80.44 W. Different types of solar irradiation input gives different types of power is shown in figure 4.3. To determine power, the range of light intensity to perform MPPT needs to be set first. The range of light intensity investigated for this work ranges from 250 to 1000W/m2. The maximum power can only be obtained when the input resistance of the boost converter is equal to the internal resistance of the PV panel.

REFERENCES

[1] K. Sujatha, R. Nagaraj, M. M. Ismail, "Real time supervisory control for hybrid power system", International Conference on Green Computing Communication and Conservation of Energy (ICGCE), pp. 415-418, 2013.

[2] A. M. Osman, Haruni Michael, Negnevitsky Md, Enamul Haque, A. Gargoom, "A Novel Operation and Control Strategy for a Standalone Hybrid Renewable Power System", IEEE Transactions on sustainable energy, vol. 4, no. 2, pp. 402-413, April 2013.

[3] A. M. Osman, Haruni Michael, Negnevitsky Md, Enamul Haque, A. Gargoom, "A Novel Operation and Control Strategy for a Standalone Hybrid Renewable Power System", IEEE Transactions on sustainable energy, vol. 4, no. 2, pp. 402-413, April 2013.

[4] C. Liwen, W. Jiadan, D. Qingtang, "Simulation research of a novel wind and solar hybrid power system", Power Engineering and Automation Conference, pp. 1-4, 2012.

[5] T. Jacob, S. Arun, "Maximum Power Point Tracking of hybrid PV and wind energy systems using a new converter topology", International Conference on Green Technologies (ICGT), pp. 280-287, 2012.

[6] S. Rehman, MD. M. Alam, J. P. Meyer, L. M. Al-Hadhrami, "Feasibility Study of a Wind PV Diesel Hybrid Power System for a Village", Elsevier Renewable Energy, vol. 38, pp. 258, February 2012.

[7] T. Salmi, M. Bouzguenda, A. Gastl, Ahmed Masmoudi, "MATLAB/Simulink Based Modelling of Solar Photovoltaic Cell", International Journal of Renewable Energy Research, vol. 2, no. 2, 2012.

[8] B. Sungwoo, A. Kwasinski, "Dynamic Modeling and Operation Strategy for Microgrid With Wind and Photovoltaic Resources", IEEE Transaction on smart grid, vol. 3, no. 4, pp. 1867-1876, December 2012.

[9] M. A. Abdullah, A. H. M. Yatim, C. Wei Tan, "A study of maximum power point tracking algorithms for wind energy system", IEEE First Conf. on Clean Energy and Tech. CET, pp. 321-326, 2011.

[10] Y. Xia, K. H. Ahmed, B. W. Williams, "A new maximum power point tracking technique for permanent magnet synchronous generator based wind energy conversion system", IEEE Trans. on power electronics, vol. 26, pp. 3609-3620, 2011.

[11] F. Ding, P. Li, B. Huang, F. Gao, C. Ding, W. Chengshan, "Modeling and Simulation of Grid-connected Hybrid Photovoltaic/Battery Distributed Generation System", China International Conference on Electricity Distribution, pp. 1-10, Sept 2010.

[12] F. Liu, S. Duan, F. Liu, B. Liu, Y. Kang, "A Variable Step Size INC MPPT Method for PV Systems", IEEE Transaction on industrial Electronics, vol. 55, no. 7, pp. 2622-2628, July 2008.

[13] W. Xiao, N. Ozog, W.G. Dunford, "Topology Study of Photovoltaic Interface for Maximum Power Point Tracking", IEEE Transactions on industrial electronics, vol. 54, no. 3, pp. 1696-1704, June 2007.