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Modeling and Simulation of Microgrid Connected Renewable Energy Resources with Svpwm Technique

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Abstract
The increasing tension on the global energy supply has resulted in greater interest in renewable energy resources. This presents a significant opportunity for distributed power generation (DG) systems using renewable energy resources, including wind turbines, photovoltaic (PV) generators, small hydro systems, and fuel cells .However, these DG units produce a wide range of voltages due to the fluctuation of energy resources and impose stringent requirements for the inverter topologies and controls.
Usually, a boost-type dc–dc converter is added in the DG units to step up the dc voltage. This kind of topology, although simple may not be able to provide enough dc voltage gain when the input is very low, even with an extreme duty cycle. Also, large duty cycle operation may result in serious reverse-recovery problems and increase the ratings of switching devices. Furthermore, the added converter may deteriorate system efficiency and increase system size, weight, and cost. This paper deals with modeling and simulation of microgrid connected with renewable energy resources like Photo Voltaic panel and fuel cell. The inverter circuit is controlled by Space vector Pulse Width Modulation Technique.
Key Words: DG, PV, SVPWM

I. INTRODUCTION

1.1. Distributed Generation

The centralized and regulated electric utilities have always been the major source of electric power production and supply. However, the increase in demand for electric power has led to the development of distributed generation (DG) which can complement the central power by providing additional capacity to the users. These are small generating units which can be located at the consumer end or anywhere within the distribution system. DG can be beneficial to the consumers as well as the utility. Consumers are interested in DG due to the various benefits associated with it: cost saving during peak demand charges, higher power quality and increased energy efficiency. The utilities can also benefit as it generally eliminates the cost needed for laying new transmission/ distribution lines.

Distributed generation employs alternate resources such as micro-turbines, solar photovoltaic systems, fuel cells and wind energy systems. This thesis lays emphasis on the fuel cell technology and its integration with the utility grid.

The World Energy Forum has predicted that fossilbased oil, coal and gas reserves will be exhausted in less than another 10 decades. Fossil fuels account for over 79% of the primary energy consumed in the world, and 57.7% of that amount is used in the transport sector and are diminishing rapidly. The exhaustion of natural resources and the accelerated demand of conventional energy have forced planners and policy makers to look for alternate sources. Renewable energy is energy derived from resources that are regenerative, and do not deplete over time. Concern about the development of applications of, and the teaching about, renewable energies have increased markedly in recent years.

The sun is regarded as a good source of energy for its consistency and cleanliness, unlike other kinds of Energy such as coal, oil, and derivations of oil that pollute the atmosphere and the environment. Most scientists, because of the abundance of sunshine capable of satisfying our energy needs in the years ahead, emphasize the importance of solar energy.

Solar energy is obviously environmentally advantageous relative to any other renewable energy source, and the linchpin of any serious sustainable development program. It does not deplete natural resources, does not cause CO2 or other gaseous emission into air or generates liquid or solid waste products. Concerning sustainable development, the main direct or indirectly derived advantages of solar energy are the following; no emissions of greenhouse (mainly CO2, NOx) or toxic gasses (SO2, particulates), reclamation of degraded land, reduction of transmission lines from electricity grids, increase of regional/national energy independence, diversification and security of energy supply, acceleration of rural electrification in developing countries.

Moreover, solar energy is a vital that can make environment friendly energy more flexible, cost effective and commercially widespread. Photovoltaic source are widely used today in many applications such as battery charging, water heating system, satellite power system, and others. Recently, researchers have strongly promoted the use of solar energy as a viable source of energy. Solar energy possesses characteristics that make it highly attractive as a primary energy source that can be integrated into local and regional power supplies since it represents a sustainable environmentally friendly source of energy that can reduce the occupants' energy bills.

Solar radiation is available at any location on the surface of the earth. The energy intensity of the sun to the world, the atmosphere on the kW per square meter is about 1.35.

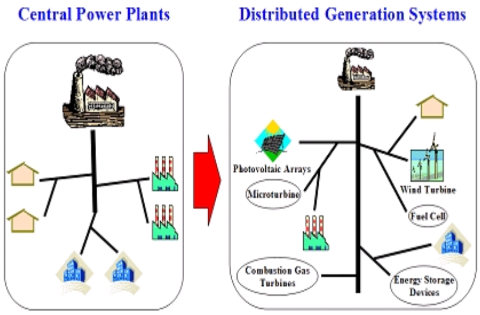

Figure 1.1: A large central power plant and distributed generation systems

Recently, the use of distributed generation systems under the 500 kW level is rapidly increasing due to technology improvements in small generators, power electronics, and energy storage devices. Efficient clean fossil-fuels technologies such as micro-turbines, fuel cells, and environmental-friendly renewable energy technologies such as biomass, solar/photovoltaic arrays, small wind turbines and hydro turbines, are growingly used for new distributed generation systems. These DGS are applied to a standalone , a grid-interconnected, a standby, peak shavings , a cogeneration etc. and have a lot of benefits such as environmental friendly and modular electric generation, increased reliability/stability, high power quality, load management, fuel flexibility, uninterruptible service, cost savings, on-site generation, expandability, etc.

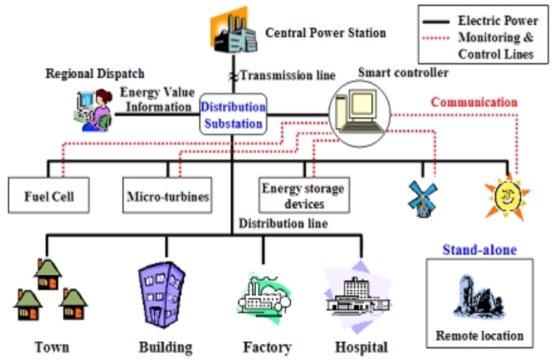

Figure 1.2: Operating system for DGS

1.22. Fuel cells are also well used for distributed generation applications, and can essentially be described as batteries which never become discharged as long as hydrogen and oxygen are continuously provided. The hydrogen can be supplied directly, or indirectly produced by reformer from fuels such as natural gas, alcohols, or gasoline. Each unit ranges in size from 1-250 kW or larger MW size. Even if they offer high efficiency and low emissions, today's costs are high. Phosphoric acid fuel cell is commercially available in the range of the 200 kW, while solid oxide and molten carbonate fuel cells are in a pre-commercial stage of development. The possibility of using gasoline as a fuel for cells has resulted in a major development effort by the automotive companies. The recent research work about the fuel cells is focused towards the polymer electrolyte membrane (PEM) fuel cells. Fuel cells in sizes greater than 200 kW, hold promise beyond 2005, but residential size fuel cells are unlikely to have any significant market impact any time soon.

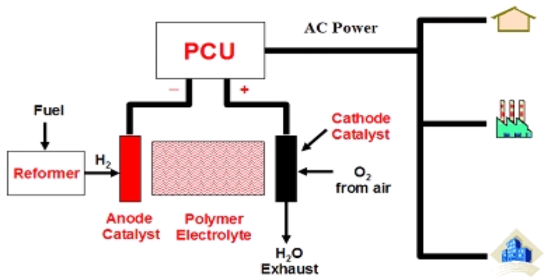

Figure 1.3 Block diagram of fuel cell system

SVPWM

The topology of a three-leg voltage source inverter is shown in Fig.1.4 Because of the constraint that the input lines must never be shorted and the output current must always be continuous a voltage source inverter can assume only eight distinct topologies. Six out of these eight topologies produce a nonzero output voltage and are known as non-zero switching states and the remaining two topologies produce zero output voltage and are known as zero switching states.

DG INTERFACING POWER ELECTRONICS

Generally, micro-sources are dc or non-utility-grade ac, whose voltage/current has to be converted to utility-grade ac with the desired magnitude, frequency, and phase angle through the interfacing power converters. Furthermore, unlike conventional rotating machines based DG, the power electronics interfaced DG usually need an energy storage system to handle the grid transient or load demand change, especially when the microgrid is operating in islanding mode. With today's increased penetration of DG, the power electronic interfaces are subject to the requirements related to the energy source characteristics, the energy storage system, the distribution system configuration, power quality, etc. [2]. Fig. 2 shows a diagram of a power electronics interfaced DG system, where the energy source is interfaced to the local loads and utility system through a voltage source inverter (VSI). Note that for different microgrid voltage levels and system configurations, different interfacing converter topologies can be employed with the associated PWM technique implemented. An energy storage system is usually connected to the dc link of the interfacing inverter to enable the DG unit to produce controllable output power. The energy storage system can be in the form of batteries, supercapacitors, flywheels, superconductors, etc,

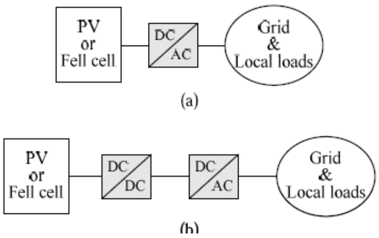

Fig 1.5 PV & FUEL cell Connected GRID

which is also interfaced to the system through a power converter for energy charging/discharging. A more detailed power electronics system in a PV or a fuel cell system (where the output of both energy sources is dc) is shown in Fig. 4. In this system, a unidirectional dc-dc boost converter is employed to boost the dc output from the energy source to a level that is optimized for the inverter.

The MPPT for a PV system or optimal efficiency operation for a fuel cell system is normally realized at this boost converter stage The bidirectional dc-dc converter in Fig. 3 functions by charging and discharging the battery to enable controllable output power generation in the grid-connected mode and load demand matching in the islanding operation.The interfacing converters can have single-stage, doublestage or multiple-stage configurations. The dc-ac conversion for a PV or fuel cell system with a single-stage dc-ac converter or double-stage converter system using a dc-dc converter followed by a dc-ac converter. Normally the single-stage topology needs an overrated inverter and high dc output voltage from the PV panel or fuel cell stack, and features high efficiency while suffering from limited power capacity, compro

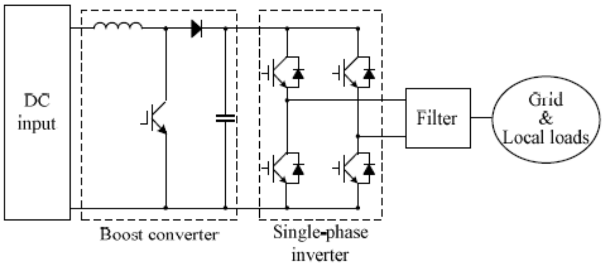

Fig. 6. A two-stage dc-ac conversion system with a boost dc-dc converter and a buck dc-ac inverter.

the multilevel converters based interfaces are becoming more attractive. One reason is that PV systems can easily provide different dc voltage levels with the modular structure of PV arrays. On the other hand, the trend of larger wind turbine systems also makes the use of high power multilevel converters a natural choice because of the better harmonic performance and low switching losses. Some popular multilevel converters used in DG systems are neutral point clamped (NPC) converters, cascaded H-bridge converter, etc. Finally, note that some other interfacing converter topologies such as ac-ac matrix converter, soft-switching converters etc, have also been seen in DG.

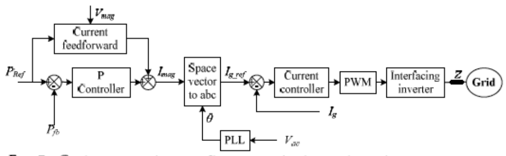

Fig. 7. Grid-connected power flow control scheme through output **current** regulation (with unity power factor).

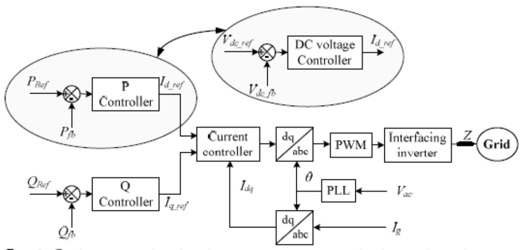

Fig. 8. Grid-connected real and reactive power control scheme through output **current** regulation.

II. GRID-CONNECTED OPERATION AND DG POWER FLOWCONTROL

The control of a microgrid involves many challenging issues. In order to operate a microgrid properly in different operation modes and during operation mode transitions, good power management strategies including real and reactive power control, frequency and voltage regulation, synchronization, load demand matching, etc., should be developed. This section discusses the power flow control for a microgrid in the grid-connected operation mode.

The islanding operation and related issues will be addressed in Section V. In the grid-connected operation mode, the main function of a DG unit is to control the output real and reactive power,where the real power reference can be given from the microgrid energy management controller or can be determined with MPPT. On the other hand, the reactive power reference can be zero for unity power factor injection or commanded according to grid reactive power or voltage requirement The real and reactive power generated by a DG can be controlled through current or voltage regulation, thus the DG output power control schemes can be generally categorized as current- based and voltage-based power flow control.

A Power Flow Control through Current Regulation

Fig. 7 shows the power control scheme (with unity power factor) through current regulation. As illustrated, the reference current magnitude is obtained from the real power control loop, where the real power reference can be produced from the MPPT (like in a wind or PV system), the maximum system efficiency control (like in a fuel cell system) or from the command value of the energy manager.

III. MPPT

3.1 PRINCIPLE OF MPPT

Maximum power point tracker (or MPPT) is a high efficiency DC to DC converter that presents an optimal electrical load to a solar panel or array and produces a voltage suitable for the load.

PV cells have a single operating point where the values of the current (I) and Voltage (V) of the cell result in a maximum power output. These values correspond to a particular load resistance, which is equal to V/I as specified by Ohm's Law. A PV cell has an exponential relationship between current and voltage, and the maximum power point (MPP) occurs at the knee of the curve, where the resistance is equal to the negative of the differential resistance (V/I = -dV/dI). Maximum power point trackers utilize some type of control circuit or logic to search for this point and thus to allow the converter circuit to extract the maximum power available from a cell.

Traditional solar inverters perform MPPT for an entire array as a whole. In such systems the same current, dictated by the inverter, flows though all panels in the string. But because different panels have different IV curves, i.e. different MPPs (due to manufacturing tolerance, partial shading, etc.) this architecture means some panels will be performing below their MPP, resulting in the loss of energy.

Some companies (see power optimizer) are now placing peak power point converters into individual panels, allowing each to operate at peak efficiency despite uneven shading, soiling or electrical mismatch.

At night, an off-grid PV power system uses batteries to supply its loads. Although the battery pack voltage when fully charged may be close to the PV array's peak power point, this is unlikely to be true at sunrise when the battery is partially discharged. Charging may begin at a voltage considerably below the array peak power point, and a MPPT can resolve this mismatch.

When the batteries in an off-grid system are full and PV production exceeds local loads, a MPPT can no longer operate the array at its peak power point as the excess power has nowhere to go. The MPPT must then shift the array operating point away from the peak power point until production exactly matches demand. (An alternative approach commonly used in spacecraft is to divert surplus PV power into a resistive load, allowing the array to operate continuously at its peak power point.)

In a grid-tied photovoltaic system, the grid is essentially a battery with near infinite capacity. The grid can always absorb surplus PV power, and it can cover shortfalls in PV production (e.g., at night). Batteries are thus needed only for protection from grid outages. The MPPT in a grid tied PV system will always operate the array at its peak power point unless the grid fails when the batteries are full and there are insufficient local loads. It would then have to back the array away from its peak power point as in the off-grid case (which it has temporarily become).

3.2 ALGORITHM OF PERTURB OBSERVE METHOD

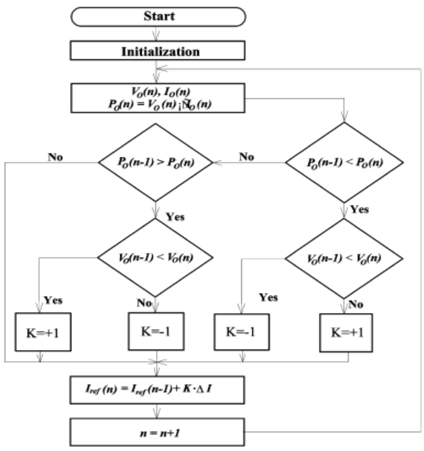

Fig 3.1: Flow chart of the MPPT algorithm with P&O method.

By comparing the recent values of power and voltage with previous ones, the P&O method shown in the flow chart can determine the value of reference current to adjust the output power toward the maximum point [4].

Matlab Circuits

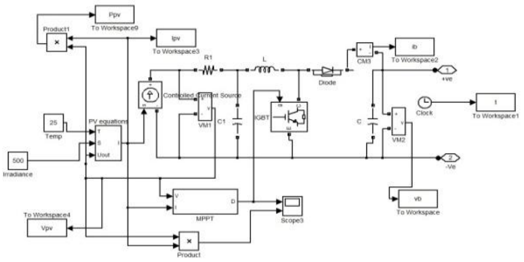

Fig 4.1 PV panel with boost converter

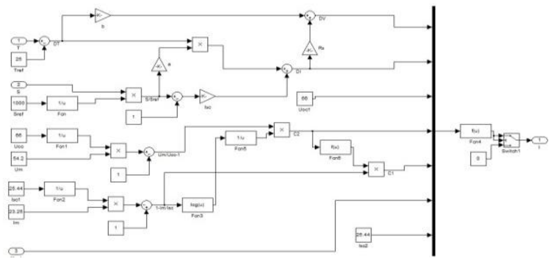

Fig 4.2 PV panel Internal Architecture Photo Voltaic Equations

$$I_d = I_s \left[e^{\frac{qV}{2kT}} - 1 \right],$$

$$I = I_{ph} - I_s \left[e^{\frac{qV}{2kT}} - 1 \right].$$

I and V are the output current and voltage of the cell. Iph is the generated photocurrent and Is is the reverse saturation current of the diode. Furthermore characteristics are influenced by the temperature T and by the constant for the elementary charge q (1.602*10-19 C) and Boltzmann's constant k (1.380*$^{10\text{-}23}$ J/K).
k is the ideality Factor.

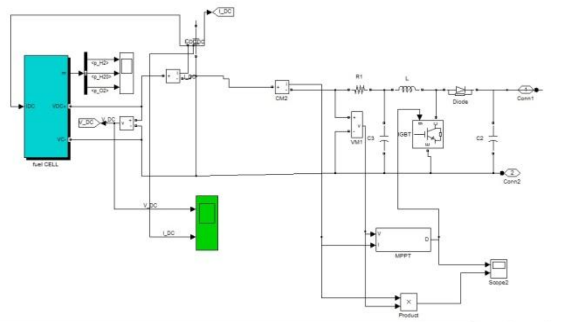

Fig 3.3 Fuel Cell

SVPWM TECHNIQUE

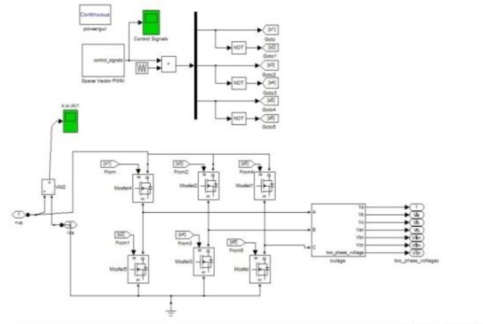

Fig 4.4 SVPWM technique

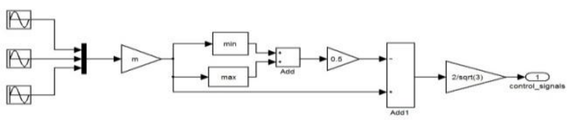

Fig 4.5 SVPWM internal Architecture

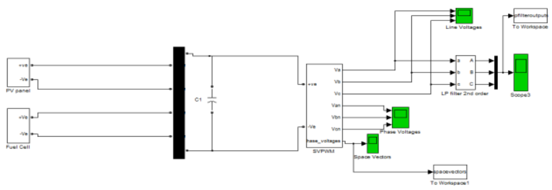

Fig 4.6 FUEL & PV cell with SVPWM OUTPUTS:

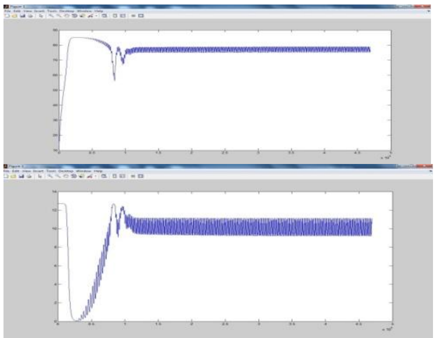

Fig 5.1 PV cell current and Voltage

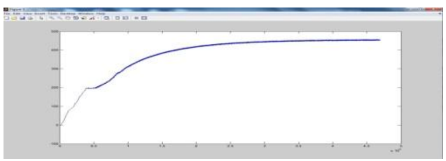

Fig 5.2 PV cell voltage after Boost converter

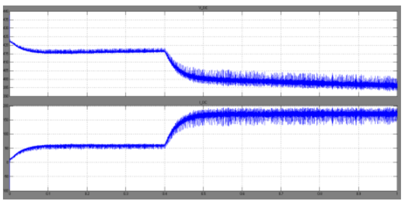

Fig 5.3 Fuel cell Output Voltage and Current

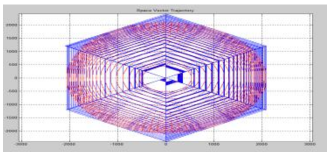

Fig 5.4 SVPWM OUTPUT

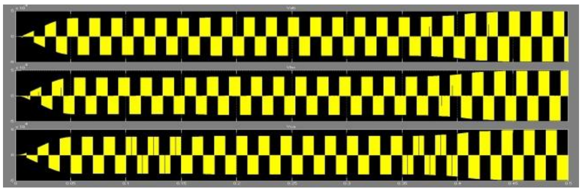

Fig 5.5 Line Voltages

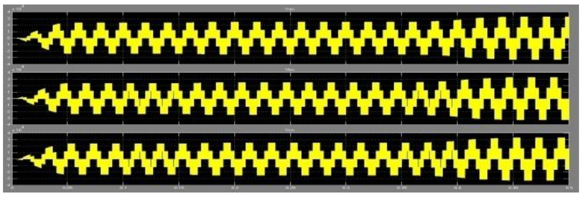

Fig 5.6 Phase Voltages

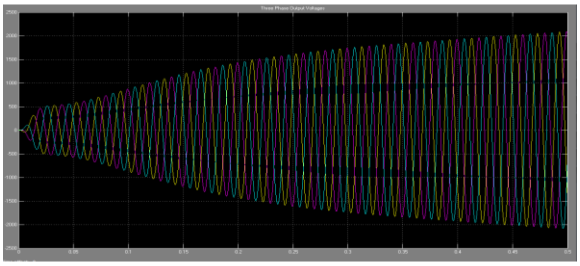

Fig 5.7 Three Phase Output Voltages

IV. Conclusion and future Scope

This paper discuses above Photo voltaic panel and Fuel cell with Mppt perturb and observe method using SVPWM technique. when compared to remaining existing pwm techniques this method proved to be more efficient in terms of voltage and the model is designed with low complexity .

This model can be extended by using Other renewable energy resources like Wind mill and micro grid and the control system can also be improved by implementing non linear controllers such as Fuzzy or Neural Networks .

References

[1] Engler A., “Applicability of Droops in Low Voltage Grids”, International Journal of Distributed Energy Sources, Vol.1, number 1, pp 3-15, September 2004.

[2] F. D. Kanellos, N. D. Hatziargyriou, "The effect of variable speed wind turbines on the operation of weak distribution networks," IEEE Trans.Energy Conversion, vol. 17, pp.543-548, Dec. 2002.

[3] Chee-Mun Ong, Dynamic Simulation of Electric Machinery Using Matlab®/Simulink, Prentice Hall PTR, New Jersey, 1998.

[4] S. A. Papathanassiou, M. P. Papadopoulos, "Dynamic behavior of variable speed wind turbines under stochastic wind, " IEEE Trans.Energy Conversion, vol. 14, pp. 1617-1623, Dec. 1999.

[5] R. A. Messenger, J. Ventre, Photovoltaic Systems Engineering (2nd ed.),CRC Press, New York, 2004.

[6] O. Wasynczuk, N. A. Anwah, "Modeling and dynamic performance of a self-commutated photovoltaic inverter system, " IEEE Trans. Energy Conversion, vol. 4, pp. 322-328, Sep. 1989.

[7] G. Vachtsevanos, K. Kalaitzakis, "A hybrid photovoltaic simulator for utility interactive studies," IEEE Trans. Energy Conversion, vol. EC-2, pp. 227-231, June 1987.

[8] A.D. Hansen, P. Sørensen, L. H. Hansen and H. Bindner, "Models for a Stand-Alone PV System," Risø National Laboratory, Roskidle, Tech. Rep. Risø-R-1219 (EN)/SEC-R-12, Dec. 2000.

[9] K. H. Hussein, I. Muta, T. Hoshino, M. Osakada, "Maximum photovoltaic power tracking: an algorithm for rapidly changing atmospheric conditions, " IEE Proc.-Gener. Transm. Distrib., vol. 142, pp.59-64, Jan. 1995.