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ANALYSIS OF A GRID CONNECTED PV-FC POWER MANAGEMENR SYSTEM

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ABSTRACT:
This paper shows the work done on the method to operate a grid connected hybrid system which is composed of a Photovoltaic (PV) array and a Proton exchange membrane fuel cell .With the proton exchange membrane the hybrid system output power becomes controllable. Here the system uses two operation modes, the unitpower control (UPC) mode and the feeder-flow control (FFC) mode. This papers discusses the coordination of two control modes, the coordination of the PV array and the proton exchange membrane fuel cell in hybrid system and the way in which the reference parameters are determined. The proposed operating strategy with a flexible operation mode change always operates the The PV array operates at maximum output power and the Proton Exchange membrane cell in its high efficiency performance band, using the proposed strategy which has a flexible operation mode thus improving the performance of system operation with enhance stability and reduction in number of operating mode change. The coordination of two control modes, the coordination of the PV array and the PEMFC in the hybrid system, and the determination of reference parameters are presented. The proposed operating strategy with a flexible operation mode change always operates the PV array at maximum output power and the PEMFC in its high efficiency performance band, thus improving the performance of system operation, enhancing system stability.

1. INTRODUCTION

With the world economic development and growing demand for energy, the conventional energy sources have become increasingly unable to meet the world demand for the energy. Thus, it is important to explore more and better means of alternative energy sources like sunlight, wind and biomass. Photovoltaic energy is a source of interesting energy; it is renewable, inexhaustible and non-polluting, and it is more and more intensively used as energy sources in various applications [1]. In regard to endless importance of solar energy, it is worth saying that solar energy is a unique perspective solution for energy crisis. Meanwhile, despite all these advantages of solar energy, they do not present desirable efficiency [2], [3]. The main renewable sources are biomass, geothermal, hydro, photovoltaic, and wind. Photovoltaic (PV) power is expected to have the fastest annual growth rate having already shown a top growth rate of more than 50% in 2006 and 2007 [4]. PV power systems have the advantage that their installation is static (i.e. no moving parts), simple and quickly compared to other renewable sources. Thus, they have a longer lifetime span, (typically more than 20 years) [5]. Moreover, due to their low operational cost and maintenance, they provide a significant solution for powering remote areas. The photovoltaic (PV) used to harness the solar energy tends to become an uncontrollable source because of the use of maximum power point tracking (MPPT) technique to continuously deliver the highest power to the load when variations in irradiation and temperature occur. The disadvantage of PV energy is that the PV output power depends on weather conditions and cell temperature, making it an uncontrollable source. Furthermore, it is not available during the night. In order to overcome these inherent drawbacks, alternative sources, such as PEMFC, should be installed in the hybrid system. By changing the FC output power, the hybrid source output becomes controllable. However, PEMFC, in its turn,

VOLUME-2 ISSUE-2
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works only at a high efficiency within a specific power range.

The hybrid system can either be connected to the main grid or work autonomously with respect to the grid connected mode or islanded mode, respectively. In the grid-connected mode, the hybrid source is connected to the main grid at the point of common coupling (PCC) to deliver power to the load. When load demand changes, the power supplied by the main grid and hybrid system must be properly changed. The power delivered from the main grid and PV array as well as PEMFC must be coordinated to meet load demand. The hybrid source has two control modes: 1) unit-power control (UPC) mode and feeder-flow control (FFC) mode. In the UPC mode, variations of load demand are compensated by the main grid because the hybrid source output is regulated to reference power. Therefore, the reference value of the hybrid source output must be determined. In the FFC mode, the feeder flow is regulated to a constant, the extra load demand is picked up by the hybrid source, and, hence, the feeder reference power must be known.The proposed operating strategy is to coordinate the two control modes and determine the reference values of the UPC mode and FFC mode so that all constraints are satisfied. This operating strategy will minimize the number of operating mode changes, improve performance of the system operation, and enhance system stability.

2. PROBLEM STATEMENTS

DES technologies have very different issues compared with traditional centralized power sources. For example, they are applied to the mains or the loads with voltage of 480 volts or less; and require power converters and different strategies of control and dispatch. All of these energy technologies provide a DC output which requires power electronic interfaces with the distribution power networks and its loads. In most cases the conversion is performed by using a voltage source inverter (VSI) with a possibility of pulse width modulation (PWM) that provides fast regulation for voltage magnitude. Power electronic interfaces introduce new control issues, but at the same time, new possibilities. For example, a system which consists of micro-generators and storage devices could be designed to operate in both an autonomous mode and connected to the power grid. One large class of problems is related to the fact that the power sources such as micro turbines and fuel cell have slow response and their inertia is much less. It must be remembered that the current power systems have storage in generators' inertia, and this may result in a slight reduction in system frequency. As these generators become more compact, the need to link them to lower network voltage is significantly increasing.

However, without any medium voltage networks adaptation, this fast expansion can affect the quality of supply as well as the public and equipment safety because distribution networks have not been designed to connect a significant amount of generation. Therefore, a new voltage control system to facilitate the connection of distributed generation resources to distribution networks should be developed. In many cases there are also major technical barriers to operating independently in a standalone AC system, or to connecting small generation systems to the electrical distribution network with lower voltage, and the recent research issues includes:

1. Control strategy to facilitate the connection of distributed generation resources to distribution networks.
2. Efficient battery control.
3. Inverter control based on only local information.
4. Synchronization with the utility mains.
5. Compensation of the reactive power and higher harmonic components.
6. Power Factor Correction.
7. System protection.
8. Load sharing.
9. Reliability of communication.
10. Requirements of the customer.

DES offers significant research and engineering challenges in solving these problems. Moreover, the electrical and economic relationships between customers and the distribution utility

VOLUME-2 ISSUE-2
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and among customers may take forms quite distinct from those we know today. For example, rather than devices being individually interconnected in parallel with the grid, they may be grouped with loads in a semi-autonomous neighborhood that could be termed a micro grid is a cluster of small sources, storage systems, and loads which presents itself to the grid as a legitimate single entity. Hence, future research work will focus on solving the above issues so that DES with more advantages compared with tradition large power plants can thrive in electric power industry.

3. MPPT CONTROL

Many MPPT algorithms have been proposed in the literature, such as incremental conductance (INC), constant voltage (CV), and perturbation and observation (P&O). The two algorithms often used to achieve maximum power point tracking are the P&O and INC methods. The INC method offers good performance under rapidly changing atmospheric conditions. However, four sensors are required to perform the computations. If the sensors require more conversion time, then the MPPT process will take longer to track the maximum power point. During tracking time, the PV output is less than its maximum power. This means that the longer the conversion time is, the larger amount of power loss will be. On the contrary, if the execution speed of the P&O method increases, then the system loss will decrease. Moreover, this method only requires two sensors, which results in a reduction of hardware requirements and cost. Therefore, the P&O method is used to control the MPPT process.

In order to achieve maximum power, two different applied control methods that are often chosen are voltage-feedback control and power-feedback control. Voltage-feedback control uses the solar-array terminal voltage to control and keep the array operating near its maximum power point by regulating the array's voltage and matching the voltage of the array to a desired voltage. The drawback of the voltage-feedback control is its neglect of the effect of irradiation and cell temperature. Therefore, the power-feedback control is used to achieve maximum power.

The P&O MPPT algorithm with a power-feedback control is shown in Fig. 1. As PV voltage and current are determined, the power is calculated. At the maximum power point, the derivative (dP/dV) is equal to zero. The maximum power point can be achieved by changing the reference voltage by the amount of □Vref. . In order to implement the MPPT algorithm, a buck-boost dc/dc converter is used as depicted in Fig. 2. The parameters L and C in the buck-boost converter must satisfy the following conditions:

VOLUME-2 ISSUE-2
ISSN : 2799-18

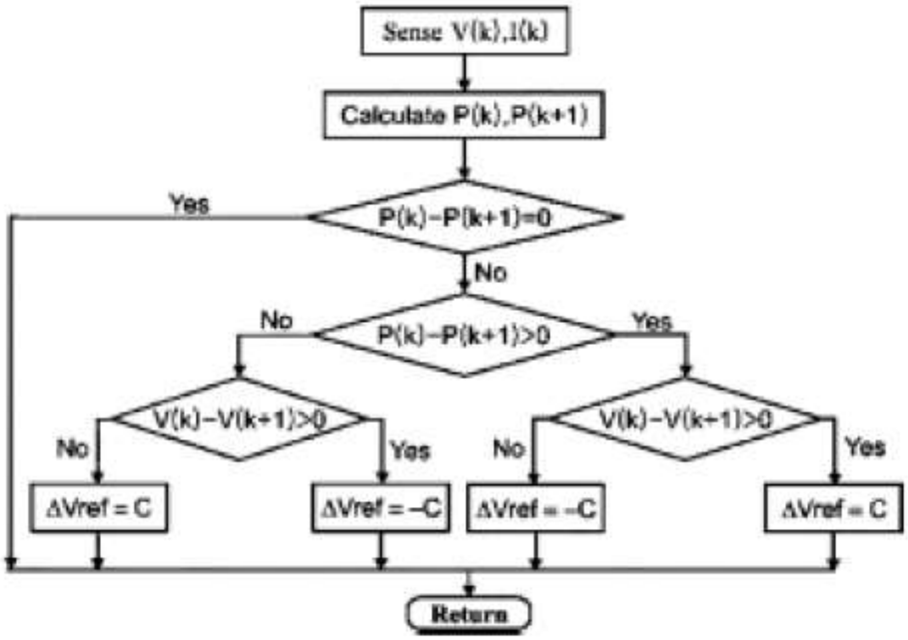
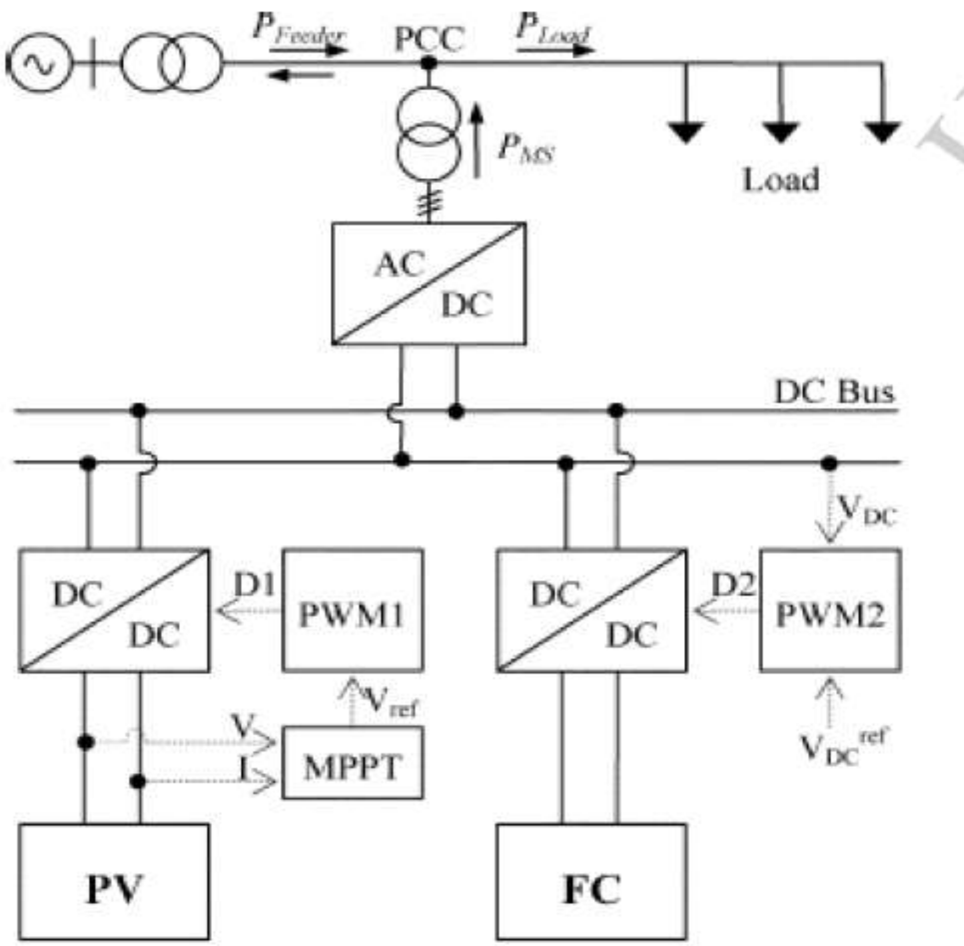


Fig. 1. P&O MPPT algorithm

VOLUME-2 ISSUE-2
ISSN : 2799-18



Fign 2 :Grid-connected PV-FC hybrid system

$$L > \frac{(1-D)^2 R}{2f} \quad ; \quad C > \frac{D}{Rf(\Delta V / V_{out})}.$$

The buck-boost converter consists of one switching device (GTO) that enables it to turn on and off depending on the applied gate signal D. The gate signal for the GTO can be obtained by comparing the sawtooth waveform with the control voltage. The change of the reference voltage □Vref obtained by MPPT algorithm becomes the input of the pulsewidth modulation (PWM). The PWM generates a gate signal to control the buck-boost converter and, thus, maximum power is tracked and delivered to the ac side via a dc/ac inverter.

4. CONTROL OF THE HYBRID SYSTEM

Unit power control, feeder flow control, and mixed control mode are the control modes used in microgrid. In the UPC mode, the DGs (the hybrid source in this system) regulate the voltage magnitude at the connection point and the power that source is injecting. In this mode if a load increases anywhere in the microgrid, the extra power comes from the grid, since the hybrid source regulates to a constant power. In the FFC mode, the DGs regulate the voltage magnitude at the connection point and the power

VOLUME-2 ISSUE-2
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that is flowing in the feeder at connection point Pfeeder . With this control mode, extra load demands are picked up by the DGs, which maintain a constant load from the utility viewpoint. In this paper, a coordination of the UPC mode and the FFC mode was investigated to determine when each of the two control modes was applied and to determine a reference value for each mode. With both the sources having their constraints the reference power must be set at an appropriate value so that the constraints of these sources are satisfied.

CONCLUSION

In this paper we have been able to present an available method to operate a hybrid grid-connected system which is composed of a PV array and PEMFC with hysteresis and witout hysteresis. The operating strategy of the system is based on the UPC mode and FFC mode. The purpose for going for this particular strategy is to determine the control
mode, to minimize the number of mode changes, to operate PV at the maximum power point, and to operate the FC
output in its high-efficiency performance band. In brief, the proposed algorithm presents a simplified and flexible method to operate a hybrid source in a gridconnected microgrid which can improve the performance of the system's operation and thus allows the system to work more stably while maximizing the PV output power.

Future work may involve considering the operation of the battery into account to enhance operation performance of the system. Work may also be carried to study the application of the operating algorithm to a microgrid with multiple feeders and DGs will also be studied in detail.

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