Modeling and Simulation of Microgrid Connected Renewable Energy Resources with MPPT Controller and by Using SVPWM Technique

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Abstract- **Technology evolution, environmental concerns associated with central electric power plants and deregulation of the electric utility industry are providing the opportunity for renewable energy resources to become very important in order to satisfy the on – site customer expanding power demand. In this paper, the operation of a typical microgrid is studied, which is the combination of DC grid and AC grid. The models of four dispersed generation units (photovoltaic system, wind turbine, Fuel Cell and Micro Turbine Power generation) are presented here. Usually, a combination of MPPT controller and boost-type dc–dc converter is added to each units to the renewable energy step up, the output of each source is converted into DC and connected to common DC grid. This paper deals with modeling and simulation of microgrid connected with renewable energy resources. The inverter circuit is controlled by Space vector Pulse Width Modulation Technique.**

Keywords-microgrid,wind turbine, photovoltaic system, micro turbine, fuel cell, MPPT,SVPWM

INTRODUCTION:

1.1. Renewable energy resources:

Microgrids comprise low voltage distribution systems with distributed energy resources, such as photovoltaic power systems and wind turbines, together with fuel cell and micro turbine. These systems are interconnected to the medium voltage distribution network, but they can be also operated isolated from the main grid. From the customer point of view, microgrids provide both thermal and electricity needs and in addition enhance local reliability, reduce emissions, improve power quality by supporting voltage and reducing voltage dips and potentially lower costs of energy supply. From the utility point of view application of distributed energy sources can potentially reduce the demand for distribution and transmission facilities. Clearly, distributed generation located close to loads will reduce flows in transmission and distribution circuits with two important effects: loss ruction and ability to potentially substitute for network assets.

Furthermore, the presence of generation close to demand could increase service quality seen by end customers. Microgrids can provide network support in times of stress by relieving congestions and aiding restoration after faults. The development of microgrids can contribute to the reduction of emissions and the mitigation of climate changes. This is because available and currently developing technologies for distributed generation units are based on renewable sources and micro sources that are characterized by very low emissions.

1.2 Microgrid system components and modeling:

A single line diagram of the microgrid system studied in this paper is illustrated in Fig.1.1. The micro sources considered comprise a photovoltaic generator, a fixed speed wind turbine equipped with an induction generator, A fuel cell battery is used as energy storage unit and is simply represented as a DC voltage source with adequate capacity and micro turbine. all are equipped with a Maximum Power Point Tracker (MPPT) capable of meeting the real and reactive power commands within pre-specified limits.

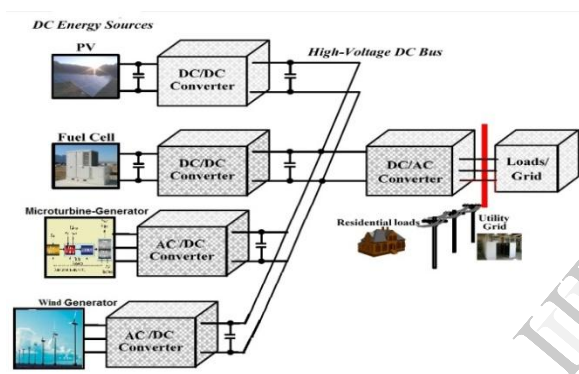

Fig.1.1 single line diagram of micro grid

1.3 Solar energy:

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.

1.4 Wind turbine system:

Wind energy conversion is the fastest-growing source of new electric generation in the world and it is expected to remain so for some time . Its long lifespan, emission-free operation and low cost have made it more attractive compared to the other sources. These turbines complement the use of other electric power sources by providing a least cost approach under certain conditions, in many situations.

A wind turbine is a device that converts kinetic energy from the wind into mechanical energy. If the mechanical energy is used to produce electricity, the device may be called a wind generator or wind charger. If the mechanical energy is used to drive machinery, such as for grinding grain or pumping water, the device is called a windmill or wind pump. The three bladed rotor is the most important and most visible part of the wind turbine. It is through the rotor that the energy of the wind is transformed into mechanical energy that turns the main shaft of the wind turbine. Simply stated, a wind turbine is the opposite of a fan. Wind turbines, like aircraft propeller blades, turn in the moving air and power an electric generator that supplies an electric current. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity. The smallest turbines are used for applications such as battery charging or auxiliary power on sailing boats; while large grid-connected arrays of turbines are becoming an increasingly large source of commercial electric power.

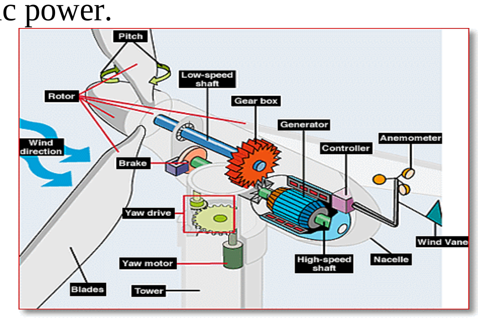

Fig 1.2 wind turbine system

1.5 Micro turbine:

There are essentially two types of micro turbine designs. One is a high-speed single-shaft design with the compressor and turbine mounted on the same shaft as the permanent magnet synchronous generator. The generator generates a very high frequency three phase signal ranging from 1500 to 4000 Hz. The high frequency voltage is first rectified and then inverted to a normal 50 or 60 Hz voltage.

1.6 Fuel cells:

These 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.

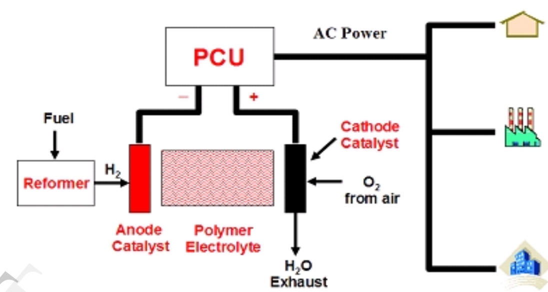

Fig.1.3 fuel cell system

1.7 Grid-connected operation:

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.

1.8 MPPT:

1.8.1 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.)

1.8.2 Algorithm of perturb observe method:

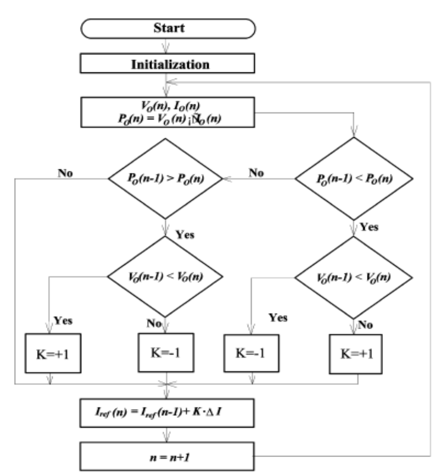

Fig 1.4: Flow chart of the MPPT algorithm with P&O method.

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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].

1.9 SVPWM technique:

The topology of a three-leg voltage source inverter is shown in Fig.2.7 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.

2.1 Matlab/simulink models:

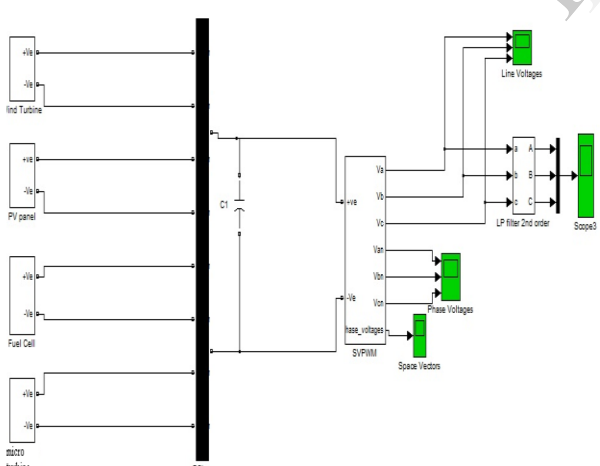

Fig.2.1.simulationCircuit of proposed system

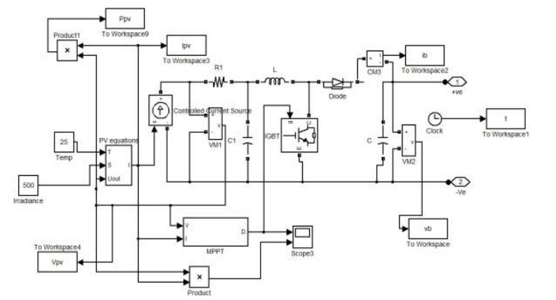

Fig 2.2 PV panel with boost converter

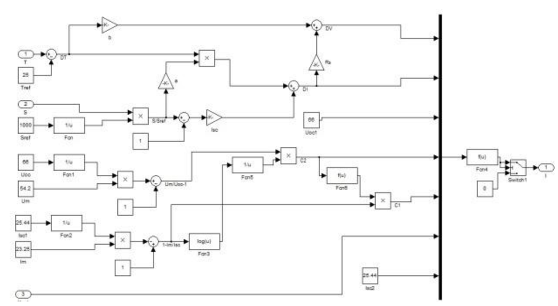

Fig 2.3 PV panel Internal Architecture

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 ($1.380*^{10-23}$ J/K).
k is the ideality Factor.

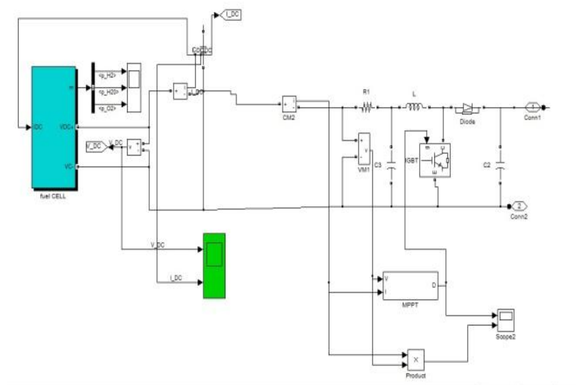

Fig 2.4 Simulation of Fuel Cell

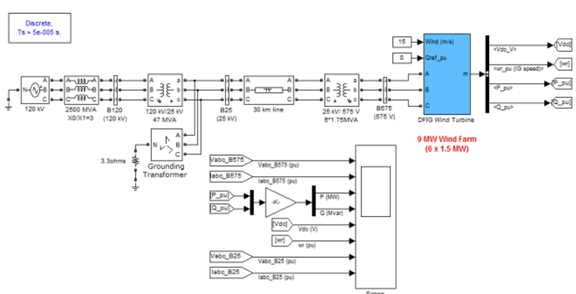

Fig 2.5 DFIG Internal Architecture (wind turbine)

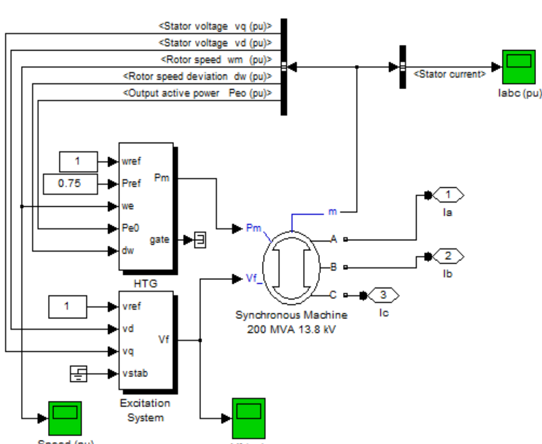

Fig .2.6 simulation of micro turbine

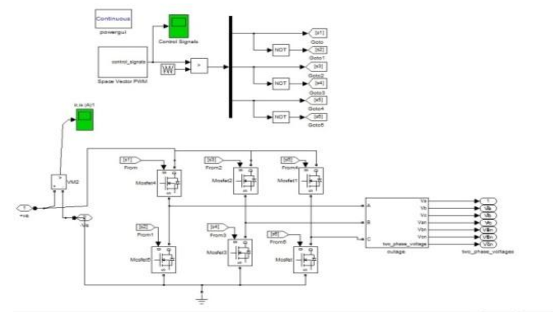

Fig 2.7 SVPWM technique

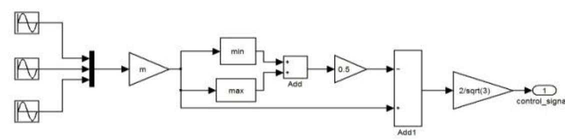

Fig 2.8 SVPWM internal Architecture

2.2 Simulation results:

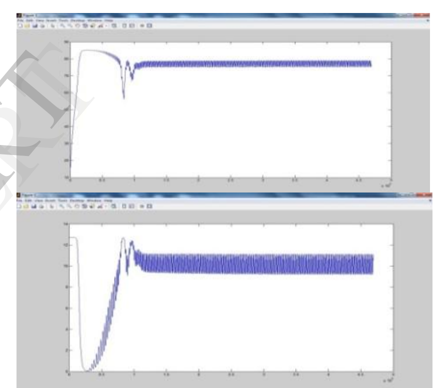

Fig 2.9 PV cell current and Voltage

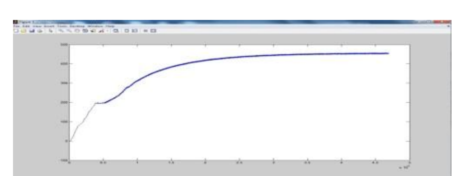

Fig 2.10 PV cell voltage after Boost converter

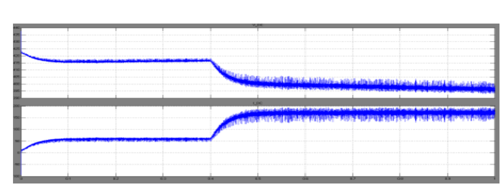

Fig 2.11 Fuel cell Output Voltage and Current

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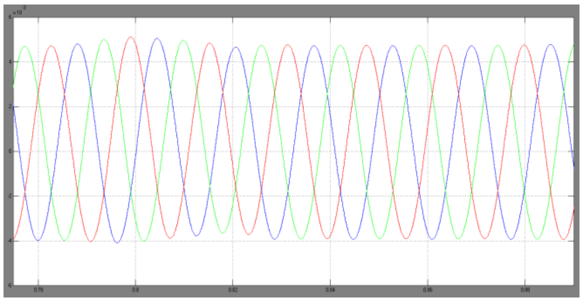

Fig 2.12 WIND and Micro turbine Voltage

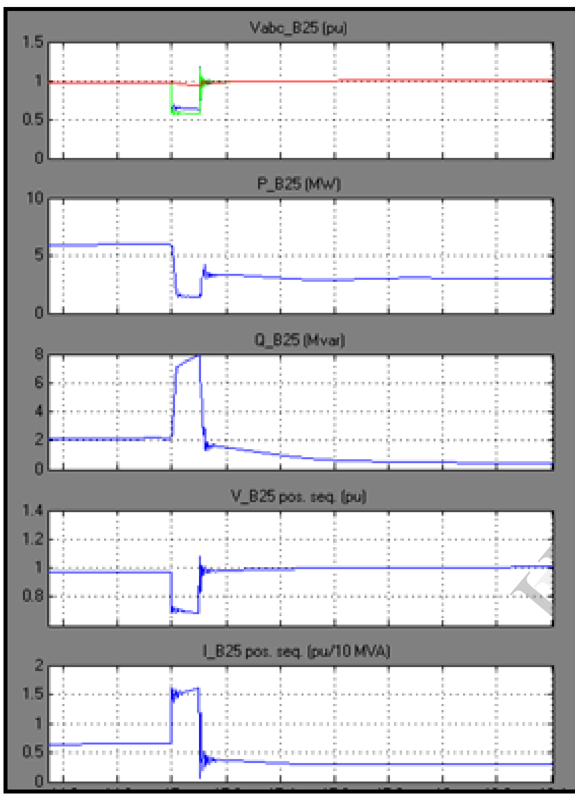

Fig .2.13 Wind Turbine Outputs

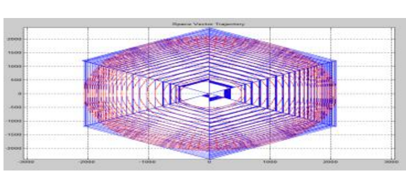

fig 2.14 SVPWM output

Fig 2.15 Line Voltages

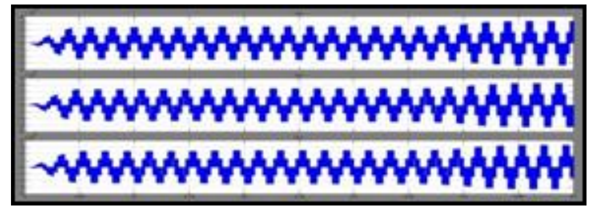

Fig 2.16 Phase Voltages

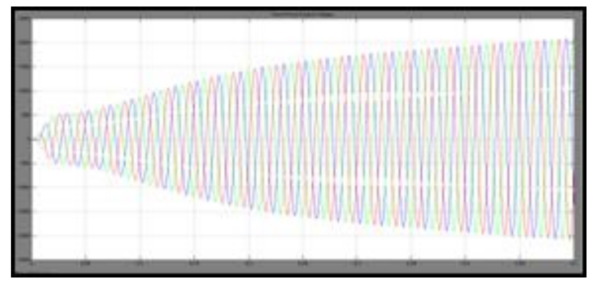

Fig 2.17 Three Phase Output Voltages

3. Conclusion:

This paper discuses above Photo voltaic panel,wind turbine, micro turbine 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 .

4.Future scope :

Although the hybrid grid can reduce the processes of dc/ac and ac/dc conversions in an individual ac or dc grid, there are many practical problems for implementing the hybrid grid based on the current ac dominated infrastructure. The total system efficiency depends on the reduction of conversion losses and the increase for an extra dc link. It is also difficult for companies to redesign their home and office products without the embedded ac/dc rectifiers although it is theoretically possible. Therefore, the hybrid grids may be implemented when some small customers want to install their own PV systems on the roofs and are willing to use LED lighting systems and EV charging systems with implementation of fuzzy and ANN.

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