Hybrid power system for reducing energy storage requirements

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ABSTRACT

Present energy scenario is not only to satisfy demand but also maintaining higher power quality along with the rising concern about problems related to our environment, such as global warming. These are new challenges to the power grid and it is expected to perform better and be "Greener". The earliest power systems were Distributed Generation (DG) systems, which were intended to cater to the requirements of local areas. With the development of technology and increase in demand for energy resulted in the development of large Centralized Grids connecting up entire regions and countries.

At present, standalone solar photovoltaic, wind systems have been promoted around the globe on comparatively larger scale. These independent systems cannot provide continuous source of energy, as they are seasonal. Hence, energy storage systems will be required for each of these systems in order to satisfy the load demands. Usually storage system is expensive and the size has to be reduced to a minimum possible for the renewable energy system to be cost effective. Hybrid power system can be used to reduce energy storage requirements.

Key words- PV Array, Solar Energy, Power quality, Simulation Model

1. INTRODUCTION

The increase in industrialization leads to energy demand. Most of the energy demand is supplied by the fossil fuels. However, increase in air pollution, diminishing fossil fuels and their increasing cost have made it necessary to gaze towards renewable energy sources as a future energy solution. Among these Renewable Energy Sources (RES), solar power systems and wind power systems are the affable solution for electrification.

As the solar energy is available in nature and due to its inexhaustible availability, they become most promising renewable energy sources. Hence, Photo Voltaic (PV) system has been increasingly used in medium sized grid and the wind mill is widely used all around the world. The penetration of power electronic converters used for integration of RES at distribution level may create a hazard to network in terms of power quality problems such as harmonics. This harmonics may lead to malfunctioning of protective relays and other control unit. Hence the harmonics has to be reduced. The implementation of active filter results in an additional hardware cost. In order to overcome these problems, solutions are proposed in this research work.

1.1 ACTIVE POWER FILTERS (APF)

In order to overcome these shortages of passive filters, new technical alternatives are available to improve power quality. Among these, APF have proved to be a significant and lithe alternative for compensating harmonics in power systems. These filters do not resonate with the power system and they work independently with respect to the system impedance characteristics. They don't have any interference with other elements installed in the power system.

The active filter compensates the harmonic components produced by the non-linear load. Depending on the application to be solved, APF can be implemented as shunt type, series type or a combination of shunt and series active filters (shunt-series type). These filters can also be combined with passive filters to create hybrid power filters. Shunt Active Power Filter (SAPF) operate as a harmonic isolator and voltage regulator between the load and the utility system.

The SAPF is connected in parallel with the harmonic producing loads. They inject the harmonic currents absorbed by the loads. Thus the grid current will become sinusoidal. The series active filter injects a voltage component in series with the supply voltage and hence it is regarded as a controlled voltage source, it compensates swells and voltage sags on the load side. The series-shunt active filter is a combination of series active filter and shunt active filter. The shunt active filter is located at the load side to compensate the load harmonics whereas the series filter is located at the source side and act as a harmonic blocking filter. This topology is called as Unified Power quality Conditioner (UPqC). It allows simultaneously achieving sinusoidal source current and voltage. Hybrid power filters are a combination of active and passive filters. Although there are different types of APF, the SAPF is an attractive choice for harmonic problems. The basic function of the SAPF is to eliminate harmonics and compensate the reactive power requirements of the load besides power factor correction. The compensation characteristics of SAPF are shown in Figure 1.1.

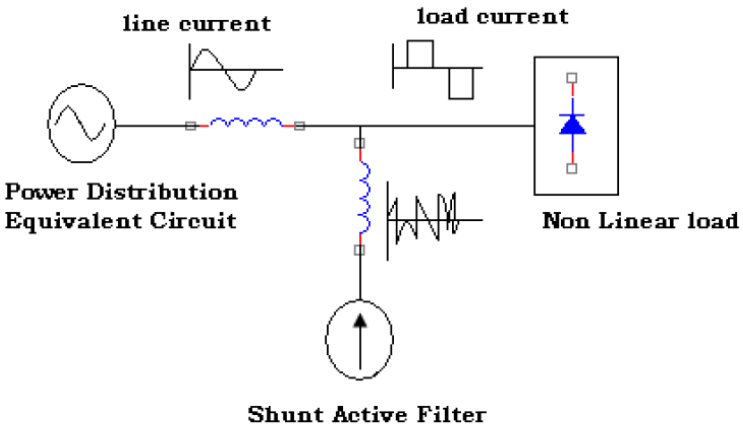

Figure 1.1: Compensation characteristics of SAPF

2. INTERCONNECT RENEWABLE ENERGY SOURCE

Grid coupled PV system is more reliable solution for increasing energy demand. Grid interconnection of photovoltaic power generation system has the advantage of more effective utilization of generated power. Grid interconnection of PV systems is accomplished through the inverter, which convert DC power generated from PV modules to AC power. Inverter technology is very important to have reliable and safety grid interconnection operation of PV system. Generally, current controlled voltage source inverters are used to interface the RES with Grid. This penetration of power electronic converters may create a hazard to network in terms of power quality problems such as harmonics. This harmonics may lead to malfunctioning of protective relays and other control unit. Hence the harmonics has to be reduced. Shunt active power filters have been recognized as most effective technique for harmonic compensation.

The Configurations of a photovoltaic interactive shunt active power filter system is shown in Figure 2.1. Solar energy is converted into electricity through PV array.

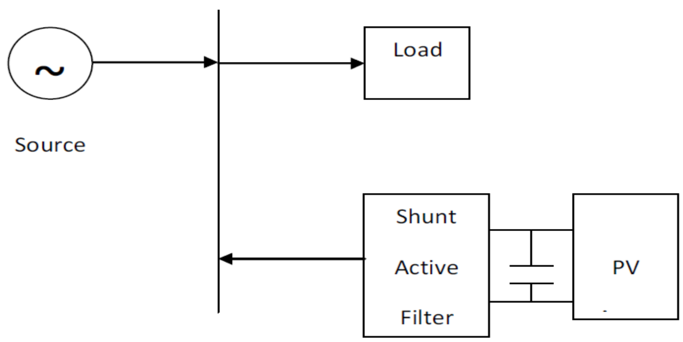

Figure 2.1: Configurations of a photovoltaic interactive shunt active power filter system

2.1 PHOTOVOLTAIC 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.

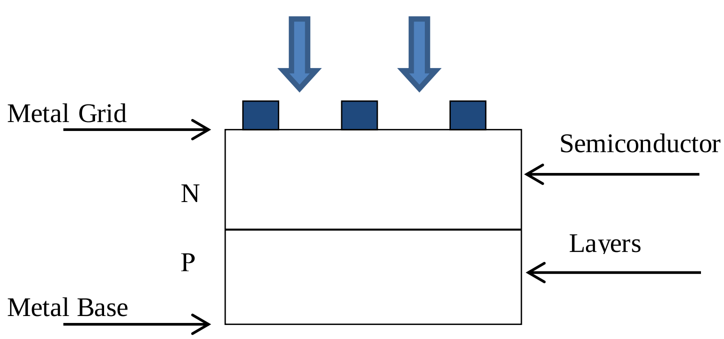

Figure 2.2: Structure of a PV cell

For accurate modeling of the solar panel, two diode circuits could have been used. But our scope of study is limited to single diode model. Following are the ideal characteristics of a solar array which show the variation of current and voltage with respect to voltage.

The current and power outputs of photovoltaic modules are approximately proportional to solar irradiation and the ambient temperature. At a given intensity, a module's output current and operating voltages are determined by the characteristics of the load. In order to determine the characteristics of the PV module, the Power vs. Voltage (P-V) and Current vs. Voltage (I-V) curves must be constructed. Three parameters, namely, Open Circuit voltage (Voc), Short circuit current (Isc), and Maximum Power Point (Vmp, Imp), given by the manufacturer of the PV module, are used for the prediction of the PV characteristics of solar PV module. The Typical P-V and I–V characteristics of a PV cell are shown in Figure 2.3. There is a unique Maximum Power Point (MPP) on the P–V curve, at which the PV cell generates the maximum power. This point is known as the maximum power point (Vmpp, Impp). The value of the maximum powers depends on the environmental factors, such as temperature and irradiation. The maximum power condition always occurs at the knee of the P-V characteristic curve.

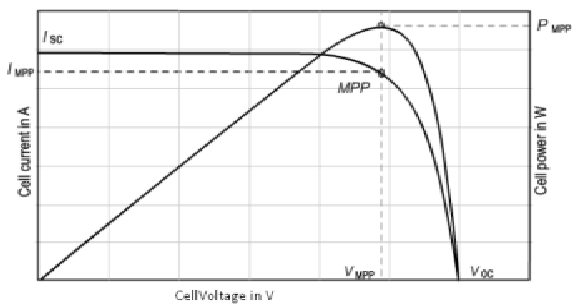

Figure 2.3: P-V, I-V curve of the PV cell at a given temperature and irradiation

3. DC-DC CONVERTER

A support converter (stride up converter) is a DC-to-DC power converter with a yield voltage more prominent than its data voltage. It is a class of exchanged mode control supply (SMPS) containing no less than two semiconductors (a diode and a transistor) and no less than one vitality stockpiling component, a capacitor, inductor, or the two in blend. Channels made of capacitors (now and then in mix with inductors) are regularly added to the yield of the converter to decrease yield voltage swell.

3.1 BOOST CONVERTER

A support converter (stride up converter) is a DC-to-DC power converter with a yield voltage more prominent than its info voltage. It is a class of exchanged mode control supply (SMPS) containing no less than two semiconductors (a diode and a transistor) and no less than one vitality stockpiling component, a capacitor, inductor, or the two in blend. Channels made of capacitors (now and then in mix with inductors) are regularly added to the yield of the converter to decrease yield voltage swell.

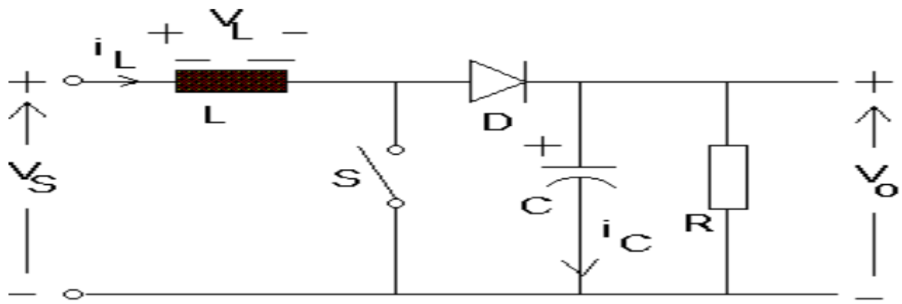

Figure 3.1: Boost Converter Circuit Diagram

When the switch is closed the inductor is charged through the battery and stocks the energy. In this mode, inductor current increases exponentially but for ease we assume that the charging and the discharging of the inductor are linear.

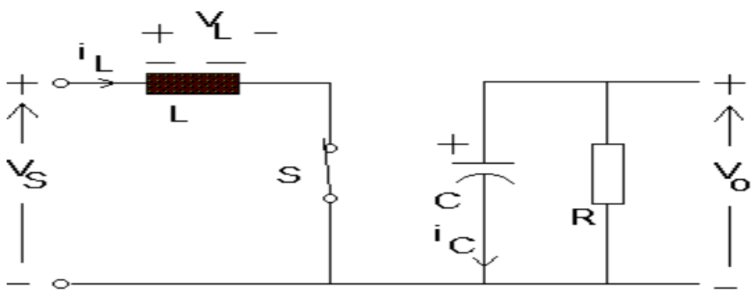

Figure 3.2: Close Loop Boost Converter Circuit Diagram

The diode blocks the flow of current and so the load current remains constant which is being supplied due to the discharging of the capacitor. The switch is open and so the diode becomes short circuited. The energy stored in the inductor gets discharged through opposite polarities which charge the capacitor. The load current remains constant throughout the operation.

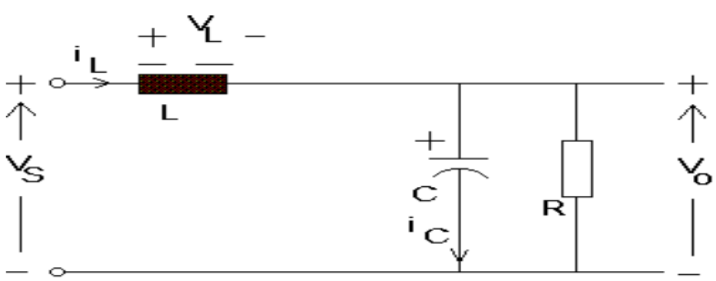

Figure 3.3: Open Loop Boost Converter Circuit Diagram

4. RESULTS

4.1 SIMULINK MODEL OF HYBRID WIND-SOLAR ENERGY SYSTEM

The proposed system presents power-power strategies of a grid-connected hybrid generation system with versatile power transfer. 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. Also, this configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. The turbine rotor speed is the main determinant of mechanical output from wind energy and Solar cell operating voltage in the case of output power from solar energy. Permanent Magnet Synchronous Generator is coupled with wind turbine for attaining wind energy conversion system.

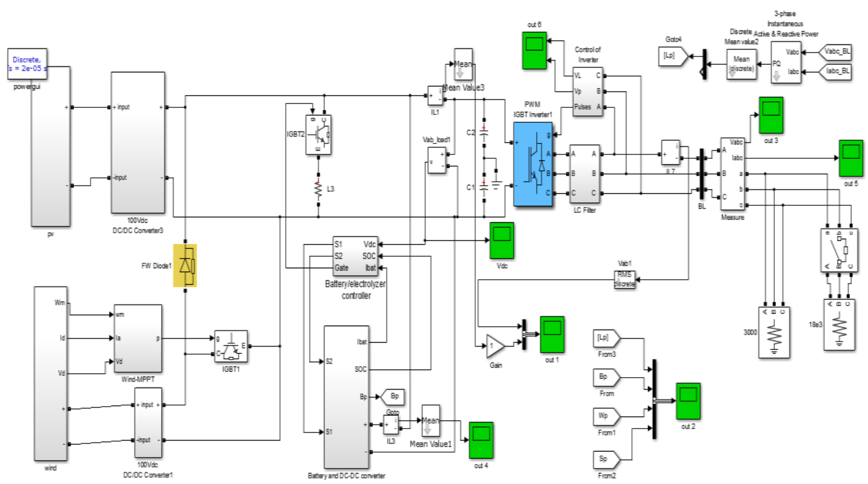

Figure 4.1: MATLAB Simulink Model of Hybrid Wind-Solar Energy System using MPPT Algorithm

The hybrid wind-solar energy system using MPPT algorithm is simulated using Simulink MATLAB software. A 10-kW Wind-solar hybrid system was considered. The load demand to fulfill is 10 KW throughout the time scale expect at 4 to 5 sec when it increase to 16 KW. The maximum voltage of PV array is observed at around 144 V for 1000 solar irradiation input S (W/m2).

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. The simulation results are presented to illustrate the operating principle, feasibility and reliability of this proposed system.

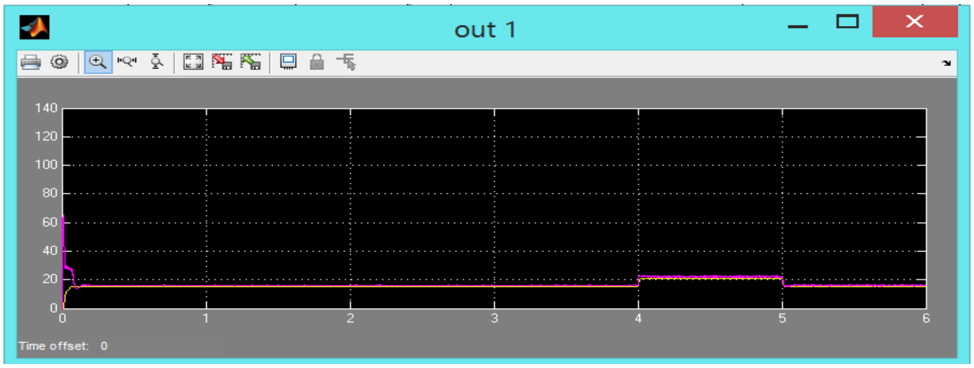

Figure 4.2: Gain of wind and solar energy hybrid system

Gain of wind and solar energy hybrid system is shown in figure 4.2. It is clearly that the gain is constant according to the gives constant energy of wind and solar energy hybrid system. Energy of wind and solar energy hybrid system is increase than gain is also increase. Figure 4.3 shows the simulation result for output voltage across load terminals. From this result we observed that the increase voltage with respect to change in either the wind or solar plants. The output voltage is increase according to the maximum power point tracking system. The maximum output voltage of 250 V in 0.04 load line.

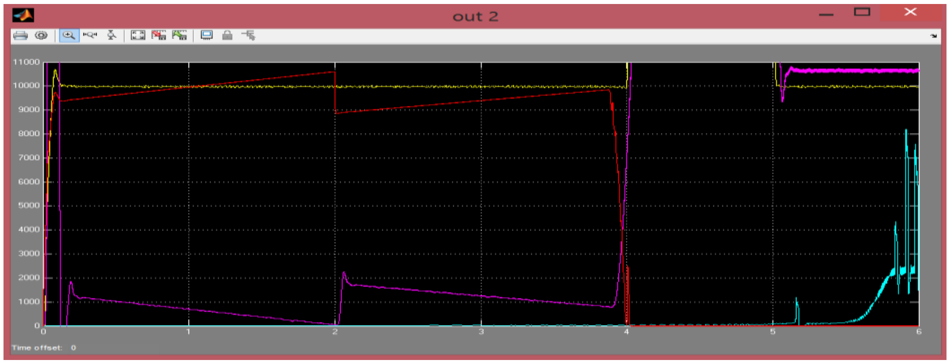

Figure 4.3: Power of wind hybrid system

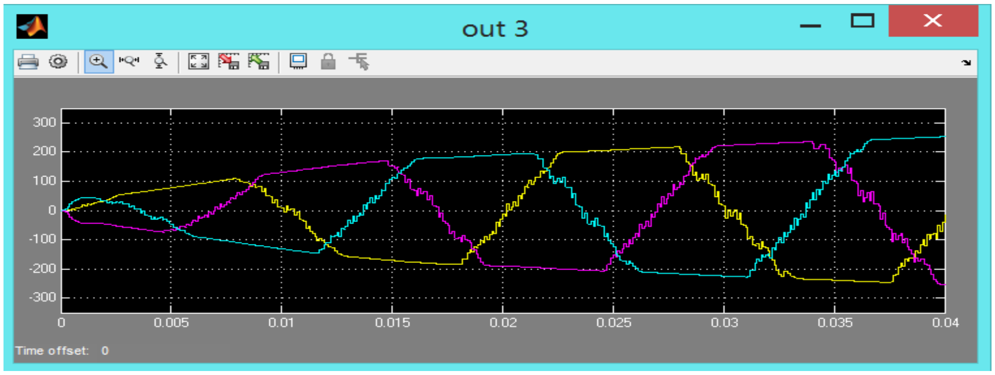

Figure 4.4: Output Voltage of wind and solar energy hybrid system

Figure 4.5 show the simulation result of output current through the load. If the load is changed or suddenly extra load applied to the system then changes occur in the load current. In this thesis we suddenly applied the load during the time 0 sec to 0.04 sec, then in this period the current rises.

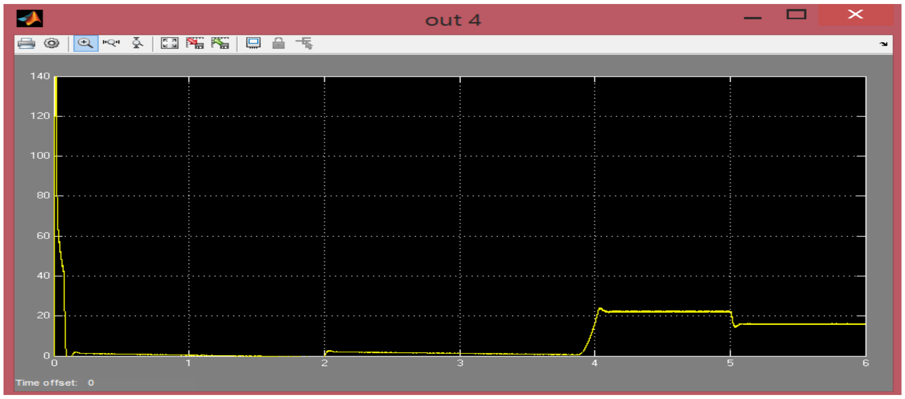

Figure 4.5: Mean Power of wind and solar energy hybrid system

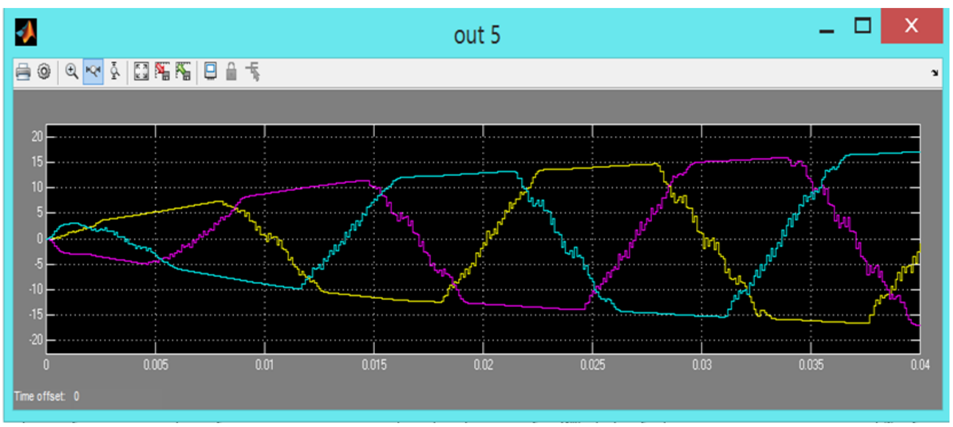

Figure 4.6: Output Current of wind and solar energy hybrid system

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