Analysis of PV-Fuel Cell System with Super Capacitor Support

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ABSTRACT: ***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.***

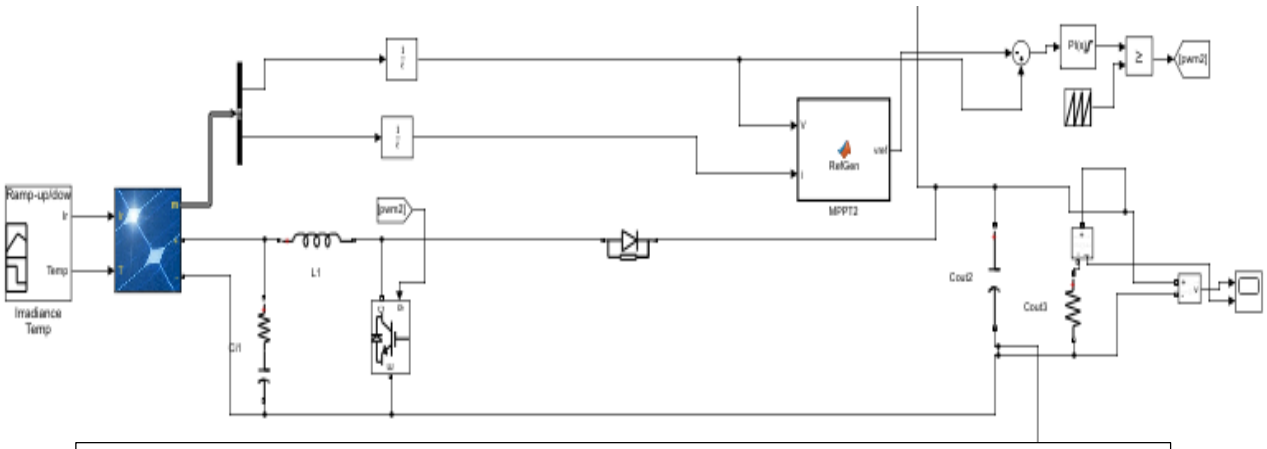

Figure 1: Simulink Model of the system

Key Words: Solar PV system, Fuel Cell, Hybrid system

1. INTRODUCTION

The unique source of almost all the energy used on earth is the sun. Photovoltaic cells (PV) are combined to form Solar Panels. Photo means light and voltaic is related to the production of electricity. Photovoltaic technology supports in creation of electricity using light. A positive charged layer and a negative charged layer made of semiconductors constitute a PV cell. When the semiconductor receives the rays from sunlight, the electric

field across the junction between these two layers causes electricity to flow. Higher the intensity of light, stronger the flow of electricity will be. PV panels are available in various forms for use. The PV tiles which replaced the normal tiles are easy to install. The light that hits the panels is converted into clean electricity. This is a silent operation because there are no moving parts. The electricity generated by the panels comes in the form of a direct current. The amount of energy available from the sun differs depending on one‘s location. Table 1 shows that Tamil Nadu stands first in solar power generation in India.

2. Fuell Cell System

Generally battery and capacitor are based systems are primarily used to store energy inorder to meet the demand of the load and fault conditions. Also the available battery is cheap and it is placed along with the capacitor. But the disadvantage are of this system is that battery cannot be charged indefinitely and it has a shorter life span and for every battery unit per volume ratio, capacitors are required, making the system expensive. In this research, a fuel cell system is introduced with an ultra-capacitor. The Fuel cell system is more attractive in the present era of engineering field because of its efficient power distribution capability as a result of electrochemical reaction. The power generated from hydrogen or the fuels is highly efficient and has a low emission rate. The above system is familiar to load conditions which include acceleration, breaking periods and distortion periods.

Table 1.1 Growth of Solar Power in India

State	MW as of March 2015	MW as of March 2016	MW as of Jan 2017
Tamil Nadu	142.58	1061.82	1590.97
Rajasthan	942.10	1269.93	1317.64
Gujarat	1000.05	1119.17	1159.76

3. SUPER CAPACITOR (SC)

“Supercapacitors function as per secondary batteries in terms of storing and delivering energy. However, the charge storage methods itself is very diverse compared to batteries. As opposed to batteries, which produce electric charge through chemical processes, supercapacitors store energy in the form of static charge. Since the energy is stored in the same from that it is used, supercapacitors offer faster charging and discharging rates compared to batteries of similar volume. The energy densities of supercapacitors are however comparatively less than that of batteries by a factor of 10 to 20”, modeled by Surewaard and Tiller [12, 13].

The proposed system presents power-control 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. This research is focusses on the performance of Fuel Cell fed various Interleaved converter topology for focusing on suitable conversion scheme for proposed Proton Exchange Membrane Fuel Cell (PEMFC). This research also aims to improve fast time extraction and less voltage spikes across both input and load side, regulating current spikes or control across fuel cell side and load terminals. This research also aims to increase the voltage gain of DC-DC converter used for PV cell, fuel cell and super capacitor applications.

4. MODELLING OF HYBRID SYSTEM

PV power is confined to the day, night time load demand must be met by traditional means. This creates a symbiotic relationship between installed generation, generation scheduling. For all these environmental problems required a hybrid system to develop which contains a PV, fuel cell

and supercapacitor for the battery energy storage system. General representation of this work is shown in Fig. 2.

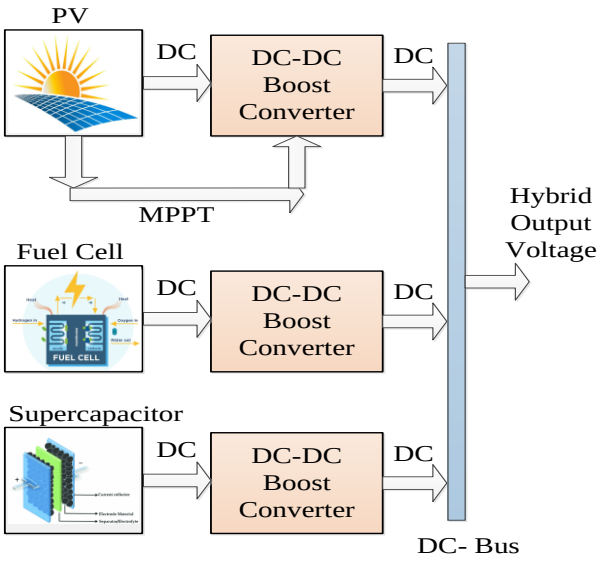

Figure 2: General representation of Hybrid System

5. PROBLEM FORMULATION

The hybrid system includes wind and PV system. Wind energy is a form of kinetic energy associated with the atmospheric air. The wind energy system includes wind turbine, generator, and an AC/DC converter. The wind energy along with WT and PMSG converts the rotating mechanical energy into electrical energy. The maximum promising power from the wind is extracted using MPP technique. The AC-DC converter is used to convert the available AC voltage into DC voltage. The solar energy which is abundantly available in nature is given to the PV system to convert into electrical output. By applying appropriate technology for the geographical locations, one can extract huge amount of electrical power from the solar radiations. The MPP technique extracts maximum promising power from the PV module. The DCDC converter is used to boost the DC voltage to a desired level. Various works have been reported for extracting the Maximum Power from both solar and wind. However, the implementation of an adaptive hybrid controller for MPPT is yet in the stage of infancy. Thus, there exists a need to develop a controller combining the advantages of logic for extracting the maximum power from solar and wind. This work presents a renewable energy to grid connected converter which is done in hybrid mode. The output from Wind and PV are connected to a common DC. Conventional approach for controlling power supply to the load requirement according to the demand was used in various hybrid systems.

Renewable Energy Sources along with microgrid acts as a key for assimilating DERs, ESS and AC/DC Load, which can work as standalone or as a grid connected system. ESS includes a battery and a supercapacitor. Due to unpredictable load variations, the instantaneous power variation disturbs the operation of the microgrid. Therefore, an ESS is required to assure a reliable, stable and secured power. Renewable energy sources use to generate green energy for reduce environment pollution problem. In this work build a hybrid model of PV and Wind by generating of energy from these two sources we give this energy to the grid. For grid connected renewable energy sources required an inverter. A controller is needed to change the control plan from Maximum Power Point to regulating voltage plan without affecting the DC bus voltage. Proper monitoring is mandatory to confirm stored energy balance between the units, to avoid High DOD and Low SOC value of a battery.

6. DESIGNING OF PV WITH MPPT MODEL

DC-DC boost converter used for constant output voltage for grid connected photovoltaic application system. The boost converter is designed to step up a fluctuating solar panel voltage to a higher constant DC voltage. It uses voltage feedback to keep the output voltage constant. To do so, a microcontroller is used as the heart of the control system which it tracks and provides pulse-width-modulation signal to control power electronic device in boost converter. The boost converter will be able to direct couple with grid-tied inverter for grid connected photovoltaic system.

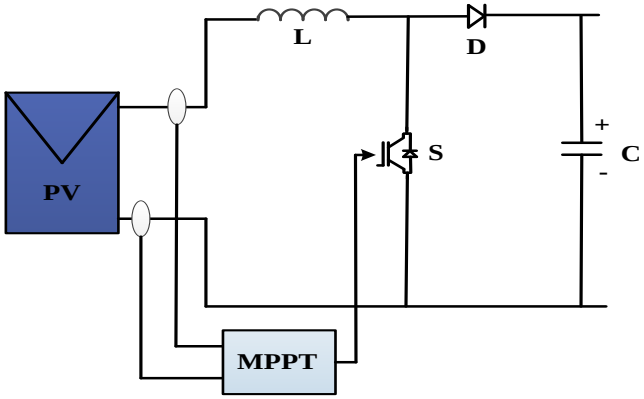

Figure 2: DC-DC boost converter with MPPT tracking

The boost converter is a medium of power transmission to perform energy absorption and injection from solar panel to grid-tied inverter. The process of energy absorption and injection in boost converter is performed by a combination of four components which are inductor, electronic switch, diode and output capacitor. The connection of a boost converter is shown in Figure 4.4. The process of energy absorption and injection will constitute a switching cycle. In other word, the average output voltage is controlled by the switching on and off time duration. At constant switching frequency, adjusting the on and off duration of the switch is called pulse-width-modulation (PWM) switching. The switching duty cycle, k is defined as the ratio of the on duration to the switching time period. The energy absorption and injection with the relative length of switching period will operate the converter in two different modes known as continuous conduction mode (CCM) and discontinuous conduction mode (DCM).

7. CONCLUSION

The world's energy needs are primarily met by renewable energy sources, among which solar energy, fuel cells, and super capacitors are three of the most well-known types. The solar panels transform the photovoltaic energy into electricity. These panels don't guarantee that they will operate at their maximum power point—that is, at full capacity—when they are connected to a load. In order to extract the maximum power from the solar panels, Maximum Power Point Tracking (MPPT), an electronic assistance, adjusts the duty cycle of the DC-DC converter. When operating in stand-alone mode, these solar panels need an energy storage device, such as traditional batteries.

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