PV-FUEL CELL SYSTEM HYBRID COMBINATION WITH SUPER CAPACITOR SUPPORT

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Abstract: The majority of global energy demand is satisfied by fossil fuels; however, these resources have numerous environmental drawbacks and are not sustainable. Photovoltaic power's unpredictable nature, in which generation capacity may abruptly drop or vary due to, for example, sudden foggy circumstances, challenges integration with traditional generation. Traditional generation is less adaptable in terms of adjusting power output, and adding more units to the system is not instantaneous because generator initiation takes time.

Because 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. The implementation of energy storage units is one option to reducing the impact of this unpredictability. These units are used to match the dynamic resource to the electricity demand. 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

Key Words: Solar Cells, Fuel Cell, Green Energy.

1. INTRODUCTION

As the world's demand for energy rises, the future looks to renewable energy options. Solar energy is one of the most established renewable energy sources. Solar energy is an uncontrollable source that generates fluctuating amounts of power. Depending on climatic circumstances, location, time of day, and season, produced power may differ from dynamic load needs. In this paper, 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.

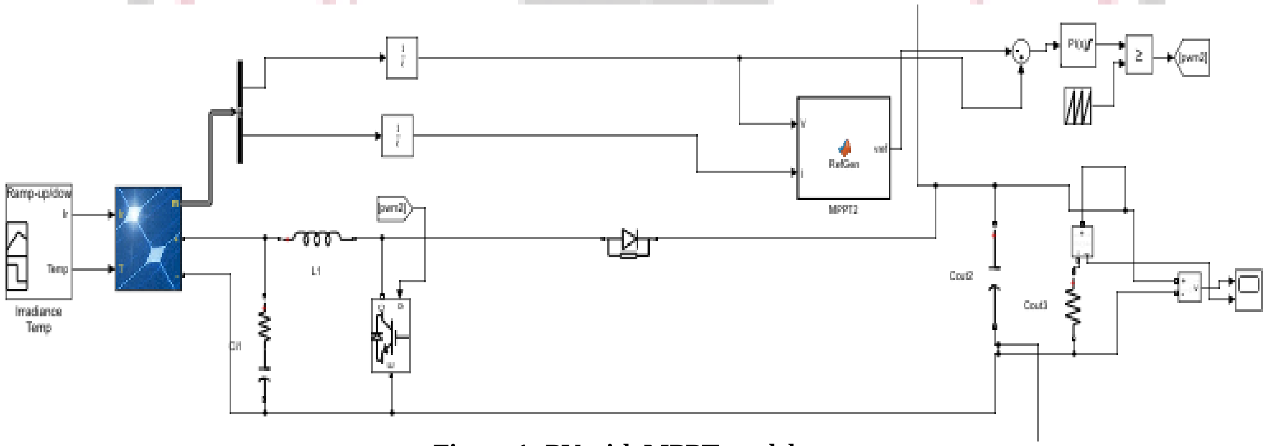

Figure 1: PV with MPPT model

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.

2. DESIGNING OF PV WITH MPPT MODEL

Photovoltaic energy conversion in solar cells has two essential steps. First one is the absorption of light which generates an electron-hole pair. The electron and hole are separated by the structure of the device. The electrons go to the negative terminal and the holes go to the positive terminal. 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%. The PV model with MPPT is given in Figure 1.

3. PROPOSED MODEL

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.

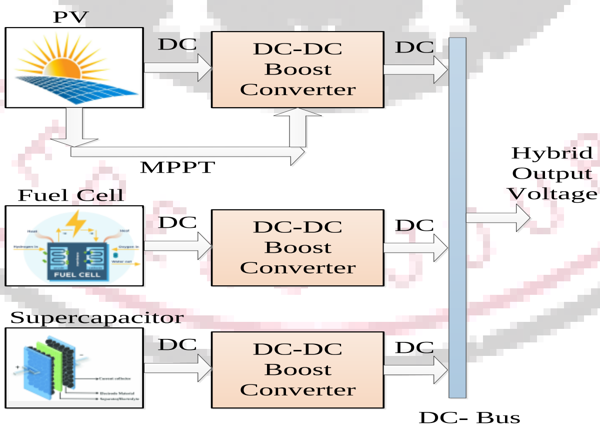

Figure 2: General representation of Hybrid System

5. DESIGNING OF FUEL CELL MODEL

Combustion of fossil fuels for power generation results in the emission of oxides of sulphur, nitrogen and carbon and particulates, which causes health hazards and global warming. The depletion of fossil fuels and climate change due to pollutants has motivated the research and development of more efficient and cleaner alternate energy sources. Simulation model of fuel cell shown in figure 4.5 along with a DC-DC boost converter. The other alternate energy sources are wind, solar, geothermal etc. The intermittent nature of wind and solar energy warrants the need for alternate energy sources which can supply continuously.

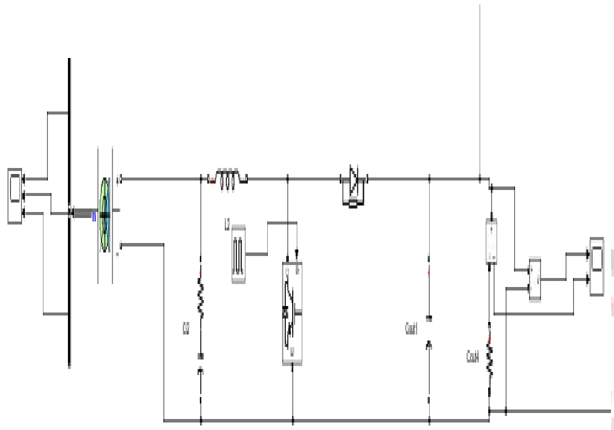

Figure 3: Simulation Model of Fuel Cell

The Current- Voltage (I-V) characteristic can be described by the Shockley solar cell equation given as;

$$ID = Iph - Io\ (eqV/KT-1) \quad [1]$$

Where, q is the electron charge, V is the voltage at the terminal, k is the Boltzmann constant, T is the absolute temperature, Io is the diode saturation current and Iph is the photo generated current. The I-V and P-V characteristic of solar cell is shown in Figure 4. In the ideal case, the short circuit current Isc is equal to the photo-generated current Iph, and the open circuit voltage VOC is given by

$$VOC = (KT/q) \ln (1+ Iph/Io) \quad [2]$$

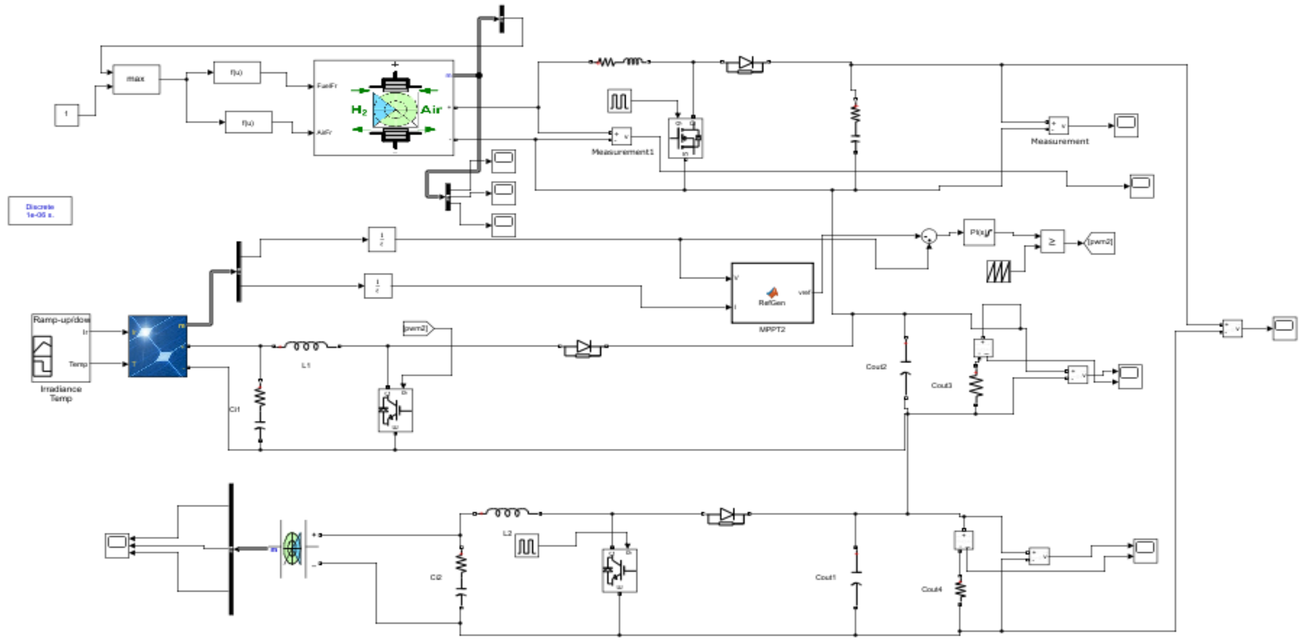

Figure 4: Simulation model of Hybrid System

Simulation model of fuel cell shown in Figure 1 along with a DC-DC boost converter. The other alternate energy sources are wind, solar, geothermal etc. The intermittent nature of wind and solar energy warrants the need for alternate energy sources which can supply continuously. The cleaner fuel could be hydrogen and hydrogen containing compounds due to their high fuel value. Unlike conventional combustion using carbon-based fuel, hydrogen can be used electrochemically without any pollutants and also increasing the energy efficiency. The electrochemical energy devices to convert the fuel to electricity are known as fuel cells and batteries. The batteries differ from fuel cells in terms of their chemical reactants storage and they are consumed even when they are not in use. However, fuel cells utilize the fuel only when they are in need, thereby reducing the wastage of fuel. The fuel cell has no moving parts, noise or vibration and its modular nature, makes it highly reliable for distributed power generation, transportation applications and portable power requirements.

6. DESIGNING OF SUPERCAPACITOR MODEL

Recent development in capacitor has given rise to a concept supercapacitor, which has got higher life than many other storage devices. Supercapacitor gives faradic capacitance value and hence it is referred as supercapacitor. Simulation model of supercapacitor is shown in Figure 4.

7. SIMULATION RESULTS

This work simulates at a 100 KW power rating and use a PV module as 47 parallel and 10 series connected string at specific module. Also, specified 300 maximum dc output voltage. Graph plot of current and power with respect to voltage shown in Figure 5.

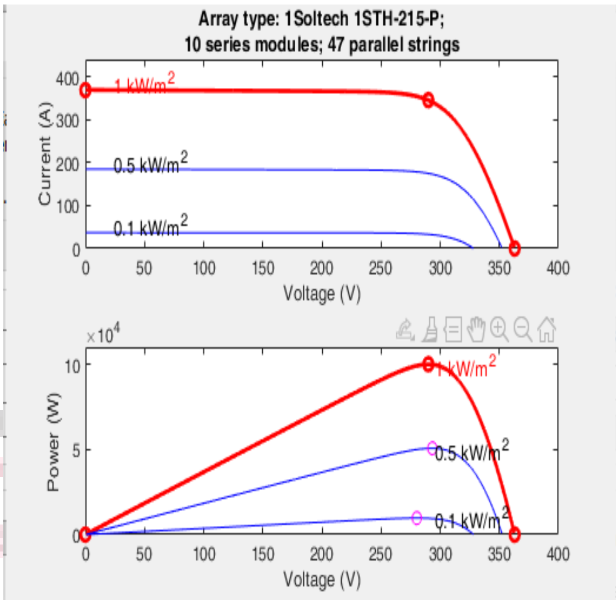

Figure 5: Graph plot of current and power

This high voltage ripple can damage a system and reduces the efficiency also increases the losses of the system. DC voltage of the PV output shown in Figure 6

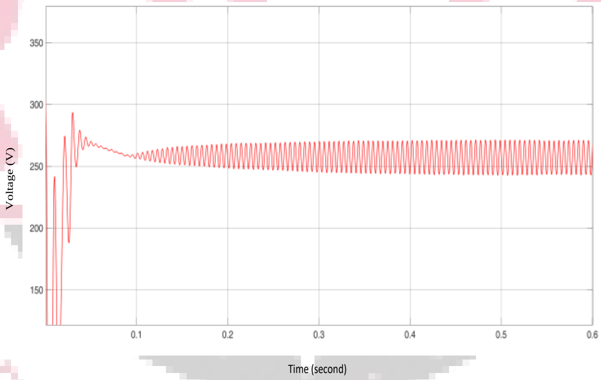

Figure 6: PV output DC voltage with 50V ripple

8. SIMULATION RESULTS FOR HYBRID HIGH VOLTAGE DC OUTPUT

For the application of high voltage source in generation of renewable energy or energy storage system for the battery we required to connect these modules in the form of hybrid and generates high DC voltage. Figure 7 shows the output DC voltage of the hybrid system.

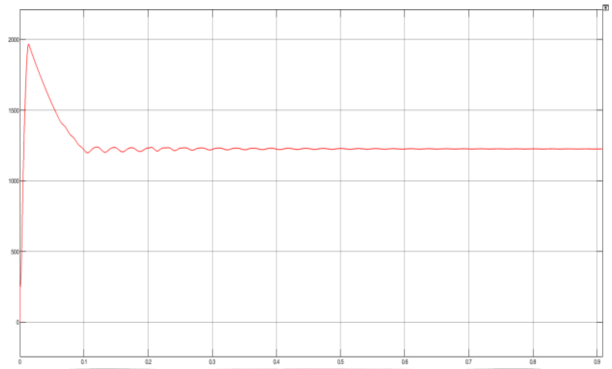

Figure 7: Hybrid high voltage DC output

By the validation of all the simulation results in MATLAB/Simulink justified the performance of the solar panel, fuel cell and supercapacitor as a hybrid system and also battery energy storage system.

CONCLUSION

The renewable energy sources are the focal points for the energy requirements of the world today and one of the most prominent sources of this renewable energy is photovoltaic energy, fuel cell and super capacitor. The photovoltaic energy is converted to the electricity by the solar panels. When these panels are connected to the load, it doesn't give guarantee to run at their full potential, i.e. it does not operate at the maximum power point. Maximum Power Point Tracking (MPPT) is an electronic aid to the photovoltaic panels working on duty cycle adjustment of the DC-DC converter to retrieve the maximum power form the solar panels. These solar panels, when running in the stand-alone mode requires the energy storage medium like the conventional batteries. But these batteries have the limitations like; they cannot supply the pulsed loads or else trying for the same, they will get deep discharge and their life will be shortened. Fuel cells are a device which take stored chemical energy and converts it to electrical energy directly. Essentially it takes the chemical energy that is stored within whatever energy source you have such as hydrogen, gasoline or methane and then through two electrochemical reactions it converts it directly to electricity. Much like a battery, a cell creates energy by converting chemical energy into electrical energy. Unlike a battery, it produces electricity from external supplies of fuel (on the anode side) and oxidant (on the cathode side). These react in the presence of an electrolyte. Generally, the reactants flow in and reaction products flow out while the electrolyte remains in the cell. Cells can operate virtually continuously as long as the necessary flows persist. Supercapacitors (SCs) are energy storage devices that bridge the gap between batteries and conventional capacitors. They can store more energy than capacitors and supply it at higher power outputs than batteries. These features, combined with high cyclability and long-term stability, make SCs attractive devices for energy storage. SCs are already present in many applications, either in combination with other energy storage devices (mainly batteries), or as autonomous energy sources. Porous carbons are presently used in the electrodes of commercial SCs due to their high surface area and their good conductivity. By the validation of all the simulation results in MATLAB/Simulink justified the performance of the solar panel, fuel cell and supercapacitor as a hybrid system and also battery energy storage system.

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