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HYBRID SOLAR/WIND GENARATION CONTROLLED BY FUZZY SYSTEM BASED STATIC VAR CONTROLLER (SVC)

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ABSTRACT

In today's growing phase where there is a limit of non-renewable source of energy we have to move towards renewable source of energy for the production of electricity. Till now various methods have been observed for generation of electricity using renewable sources of energy like Solar power, Wind energy, Hydro power etc. While some have extended towards making the Hybrid model of above given sources of energy for generation. In this paper we have explained the hybrid model of wind and solar by using Fuzzy based SVC to achieve a pure sinosodial output. SVC has been used as a controlled device to control the output waveform of the hybrid system and to minimize the effect of reactive power. The essential feature of the SVC is that it has the ability to absorb or inject the reactive power with power grid at a faster rate. SVC also helps in restoring the stability and controlling the voltage dip after severe disturbances such as faults or wind farm mechanical power variation. It injects or absorbs the reactive power through a voltage source converter very rapidly. Its multi pulse configuration generates voltage waveforms with lesser harmonics in it. The SVC's dynamic response is very fast and is able to pass from capacitive to inductive mode of operation in few cycles. When the ac voltage of the system decreases the SVC reacts by injecting reactive power in the system and the SVC is said to be in capacitive mode. The dynamic model of the proposed system is simulated using Simulink MATLAB software. To validate the effect of SVC the solar wind hybrid system is subjected to different disturbances. Here I have used SVC in conjugation with solar and wind hybrid model to show the controlled output. The SVC here is controlled by fuzzy logic controller.

Keywords: SVC, Fuzzy Logic Controller, Wind Energy, Solar Energy, MATLAB, Reactive Power.

I. INTRODUCTION

Energy can be considered as the most useful and primary for all universal measure kinds of work by human beings. Renewable energy which is spread throughout the world helps to have different resources from it.Renewable energy is an important attractive technology than the conventional energy technologies .These renewable energy sources are spread in a very large scale and can provide energy with a quality and quantity that we require for a specific task.Thus helps to use lesser quantity offuels or electric energy and gives low grade forms of energy such as a hot water that can have application through many ways .This renewable energy can be often created in large numbers and can be produced quickly .Since it does not have large power stations with moving parts so its maintenance becomes easy. Like the sun is considered to be the most important source

of energy that gives us replacement of oil, coal and gas .The radiations that are radiating from the sun is absorbed by the earth's atmosphere that is equal to $3.8 \dot{x} 10^{24}$ J .The radiations that are radiating from the sun has to go through the different layers of atmosphere to the earth's surface, while going through the different atmospheric layer there are various dust particles, gas molecules that decreases the concentration of radiation, But there may occur a failure in the system of solar panel or in the sites which are remotely located wind turbines or wave energy converter which might have temporary inconvenience but this effect is not long-lasting damage, and can be easily rectified whenever we require, but there are various several major consequences that could direct us a major failure of large hydroelectric dam, damage of methane digester or fire in a biomass plantation .Anything that is in the world implies the flow of energy in one of energy into different form of energy .Word energy can be described as an input source for any type of body or for the machines .Thus crude fuels, natural gas, oil, electric energy and nuclear energy are the main sources of energy. Solar energy, windenergy, water energy are the other forms of energy source. In this paper a hybrid model of solar and wind is developed by using fuzzy system based on SVC. In this paper, it is an effective way to get the electric power by integrating the Hybrid solar/wind generating system and then regulated and stabilized with the help of Static VAR Compensator which includes wind power/voltage stabilization and harmonic filtering. The simulation circuit will include all realistic components of the system along with fuzzy based controller for SVC. The SVC based system with Fuzzy controller gives the best output which we will not get in previous case. The SVC model used here is controlled by fuzzy based controller.

II. SOLAR ENERGY

Photovoltaic cell is a device used to convert solar energy into electrical energy. They generate electricity when they absorb the sunlight .Photovoltaic cells are made of semiconductor devices and when these absorb photons present in the sunlight free electrical charges are generated which can be collected on the contacts present on the surfaces of the semiconductors. Photovoltaic cells are not like heat engines, so do not require to operate at high temperature, they usually operate at room temperature as they are adapted to the weak energy flux of solar radiation. There theoretical efficiency is of the order of 45%. Their efficiencies decrease very rapidly with the increase in temperature. Photovoltaic cells are famously known for power generation in space craft in which the silicon solar cells is most widely developed. The silicon cell has a crystal of silicon on which the doping material is concentrated to form a semiconductor. The efficiency of the photo cell is defined as a power developed per unit area of array divided by solar energy flux in the free space.

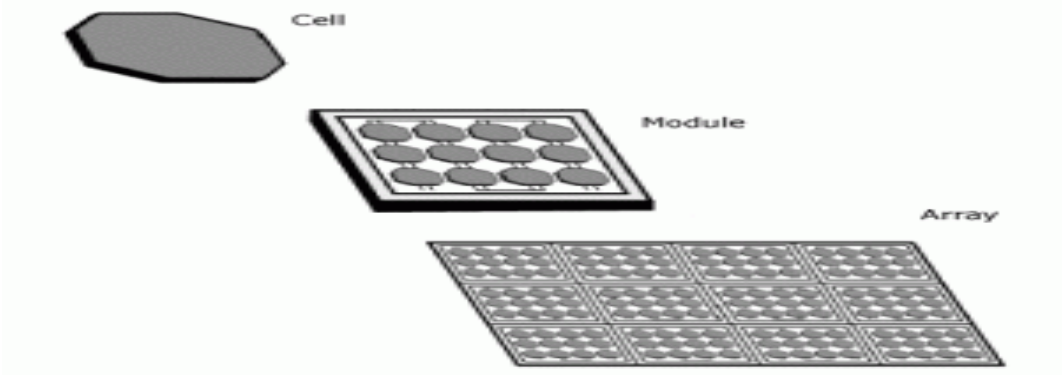

Figure1: PV Module Array.

Photo- current of the module:

$$I_{ph} = [I_{scr} + K_i(T-298)] * \lambda/1000$$

Reverse saturation current of the module:

$$I_{rs} = I_{scr} / [\exp (qV_{oc}/N_S KAT)-1]$$

Saturation current module I_o;

$$I_0 = I_{rs} [\frac{T}{T_r}]^3 \exp[\frac{qE}{BK} \{\frac{1}{T_r} - \frac{1}{T}\}]$$

III. WIND ENERGY

It is defined as the system in which the kinetic energy of the wind is converted to mechanical energy which in turn is used to generate electrical energy. The machines which are used to convert the kinetic energy of the wind into mechanical energy usually consist of sails, vanes or blades radiating from the hub or the central axis. The axis can be horizontal in most of the cases or vertical in some cases. When the wind hits the blade it rotates around the axis and the motion of the blades can be put to useful work .The devices which are used in wind conversion system are known as wind turbines because they convert the kinetic energy of the wind into the rotational energy and the device used for this is known as rotor. These wind turbines are connected to electrical generator to the required electrical energy and the connection of these two devices is known as aero generator. A transmission system is usually used to increase the speed of the rotor with the help of gear system. Wind mills are in the usage for more than dozen centuries for grinding grain and pumping water and now scientists are looking to generate electricity in large quantity with the help of wind turbines and interest in this field is increasing .Wind energy system can play an important role in reducing the energy crises of the world and can be used to produce efficient energy in remote areas. The wind speeds in India usually remain in between 5 to 20 km/hr. There are usually three factors which determine the output of the electrical energy generated from the wind energy, wind speed, cross section of wind swept by rotor, the conversion efficiency of the rotor, transmission system and the generator.

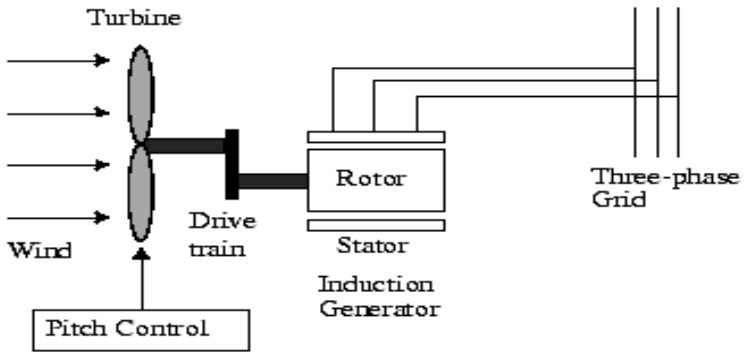

Figure 2: Wind Energy System.

There is no device designed to extract all the wind energy because the wind will be brought to rest and this would prevent the passage of wind into the rotor. An efficient aero generator can only extract 60% of the total energy present in the wind into the mechanical energy. The available wind power is directly proportional to the square of the diameter of the horizontal axis of the wind turbine and the velocity of the wind speed as it passes though the rotor. The wind energy conversion system components are aero turbine, gearing, coupling, electrical generator.

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IV. PERMANENT MAGNET SYNCHRONOUS GENERATOR (PMSG) USED IN WIND ENERGY SYSTEM

PMSG isused in WE CS because of its advantage such as better reliability, lower maintenance and more efficient. The model of PMSG is established in the d-q synchronous frame as shown in figure 3.

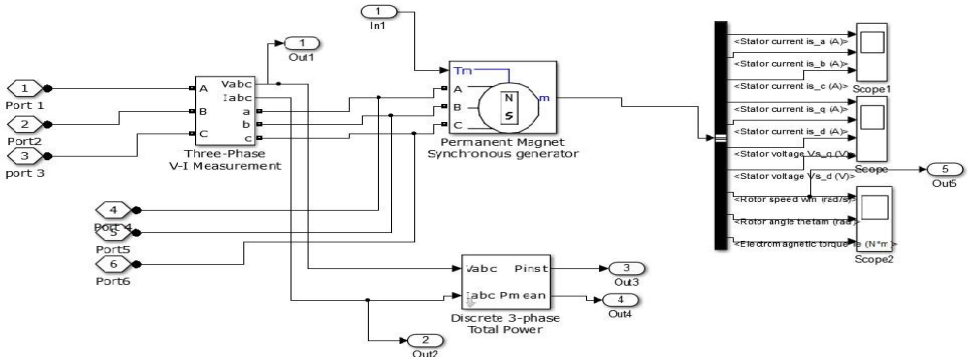

Figure3: Simulink Model of PMSG.

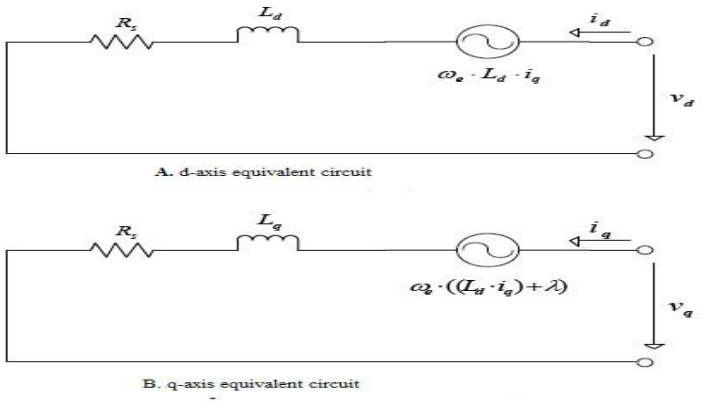

Figure4: Equivalent Circuit of PMSG in d-q Reference Frame.

V. STATIC VAR COMPENSATOR WITH FUZZY BASED CONTROLL

Static VAR Compensator is an electrical device for providing fast acting reactive power compensation on high-voltage electricity transmission network. SVC is a part of the flexible ac transmission system (FACTS) family of devices. The svc is an automated impedance matching device if the power system's reactive load is capacitive (leading), the svc will use reactors to supply VAR's to the system, bringing the system closer to unity power factor and lowering the system voltage. A similar process is carried out with an inductive (lagging) condition and capacitor banks. Thus providing a power factor closer to unity and consequently a higher system voltage svc's are used both on bulk power transmission circuits to regulate voltage and contribute to steady state stability. They also are useful when placed near high and rapidly varying loads, such as are furnaces, where they can smooth flicker voltage. The term "static" refers to the fact that the svc has no moving parts other than circuit breaks and disconnects, traditionally, power factor correction has been done with synchronous condensers, enormous externally-excited motors, whose excitation determines whether they absorb or supply reactive power to the system.

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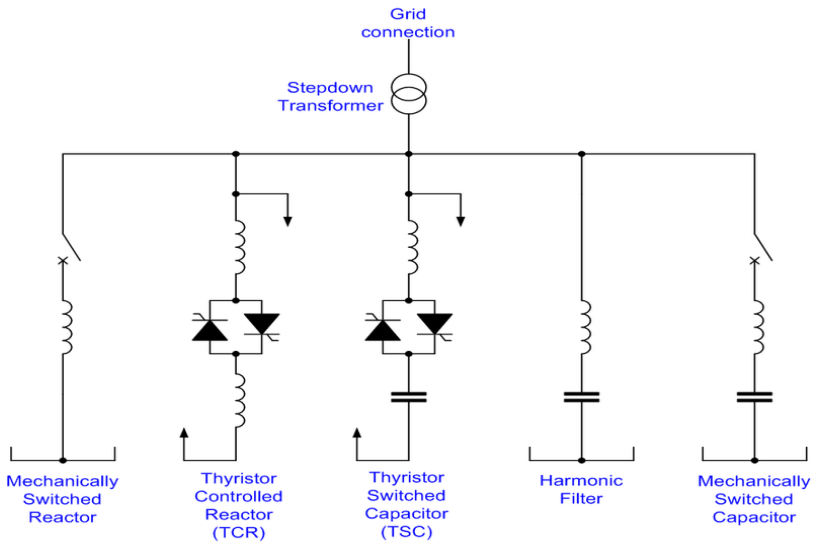

Figure6: Circuit Diagram of SVC.

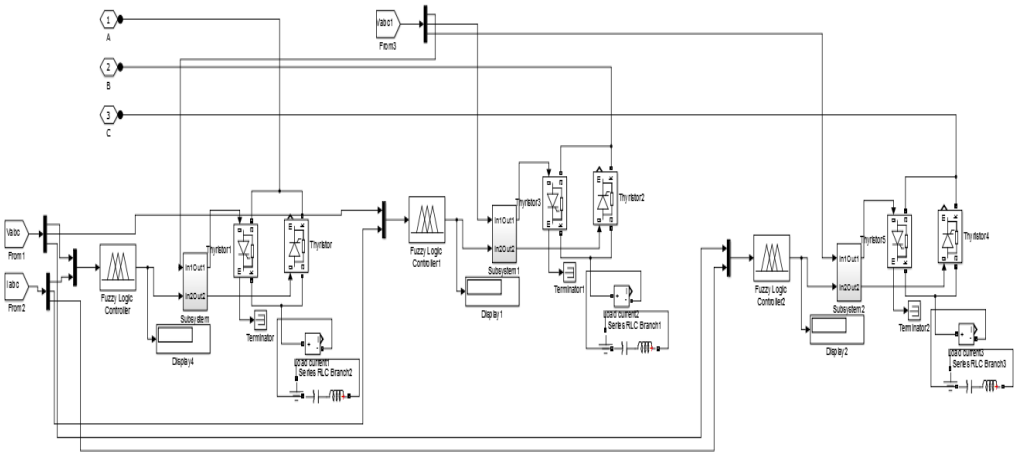

Figure7: Simulink Model of SVC with Fuzzy Based Controller.

VI. SIMULATION AND RESULTS

With the help of above discussion we see that the hybrid solar and wind energy system is connected and the resultant output from PV cell is purely DC. From next step we will see that the system DC voltage is converted into AC with the help of bridge we will convert DC into AC. The output which we will get from wind energy system is fed to the permanent magnet synchronous generator which will give AC output directly. The combination of both outputs which we will get from bridge and from permanent magnet synchronous generator contains distorted output. Also the waveform is also not sinusoidal due to presence of harmonics in it.

The harmonics can be controlled by providing the filter bank at the end of SVC. Also the SVC will act as inductive or capacitive mode in accordance with the output which we will get from it. The reactive power compensation is also done by this method. A transformer is also used in the system to change the voltage rating of the output voltage in accordance with the system.

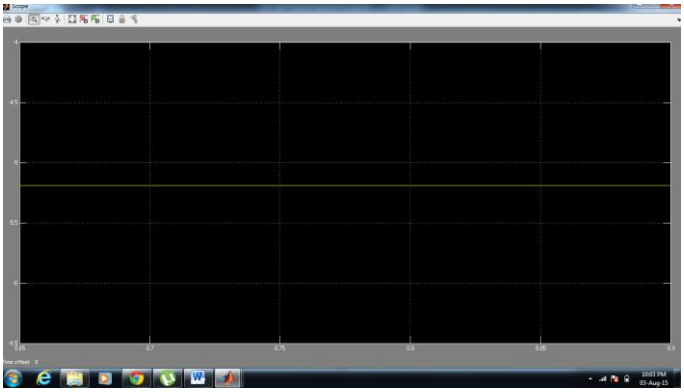

Figure8: Output Waveform of PV Cell.

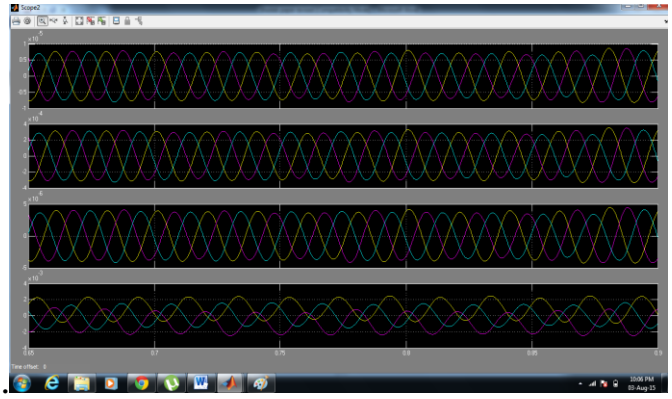

Figure 9: Combined Voltage and Current Waveform for Hybrid Solar/Wind Plantwith/Without Using SVC.

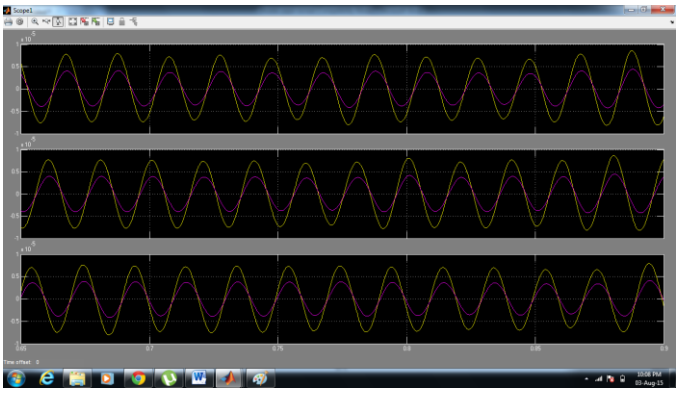

Figure 10: Voltage and Current Waveform with Improved Phase Difference with the Help of SVC Using Fuzzy Controller.

VII. CONCLUSION

As from the above discussion we have seen that the SVC maintains the pure sinusoidal waveform with the help of fuzzy based controller for controlling of a Hybrid Solar/Wind based electricity generation plant. Also we have seen that the power quality of the system gets improved by the use of SVC which is not in the case when we are using only simple hybrid solar/wind model. From the Simulink model and its result we have seen that the difference in both the waveforms, without using SVC and by using SVC. The SVC is an automated impedance matching device if the power system's reactive load is capacitive (leading), the svc will use reactors to supply

VAR's to the system, bringing the system closer to unity power factor and lowering the system voltage. Hence, we see here that the output gets controlled with the help of SVC based hybrid system.

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