



ANALYSIS OF THE BEHAVIOR FOR REACTIVE POWER COMPENSATION USING SVC CONTROLLED HYBRID SOLAR/WIND POWER GENERATING SYSTEMS

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ABSTRACT

In today's world the trend goes on hybrid power generation systems but here the controlling and compensation is necessary. With the growing phase renewable energy resource is immersed to be very important part for today's world. Due to the critical condition of industrial fuels which include oil, gas and others the development of renewable energy sources is continuously improving. This thesis investigates the use of a Static VAR Compensator (SVC) used along with wind farms and solar for the purpose of proper stabilizing the grid voltage after grid-side disturbances such as a temporary trip of a wind solar generation and sudden load changes. Svc has capacity to absorb or inject volt-ampere reactive (VAR) or Reactive power at faster rate. SVC has rehabilitation to control or stabilize the voltage sag after drastic disruption through voltage source converter. It absorbs or injects reactive power at greater rate as compared to other devices. Due to faster dynamic response, it will go from capacitive mode to inductive mode but not vice versa. The strategy focuses on a fundamental grid operational requirement to maintain proper voltages at the point of common coupling by regulating voltage and reactive power. The proposed paper is shown that the use of advanced control methods, such as the standard robust control method, in the control system of FACTS could improve their performance with the help of Simulink MATLAB.

Keywords: SVC, Reactive Power, Wind Turbines, PV Array, MATLAB.

I. INTRODUCTION

Due to the critical condition of industrial fuels which include oil, gas and others the development of renewable energy sources is continuously improving. Due to the reason renewable energy resources has become very important part of life. There is little other reason for that as these type of energy are abundant in nature also the future scope of these resources is quite vital. The ever increasing energy demands, dwindling sources of fossil fuels and concern about pollution levels in the environment has been the driving force behind electricity generation using renewable energy sources. Few other reason include advantages like abundant availability in nature, eco-friendly and recyclable. Many renewable energy sources like solar, wind, hydal and tidal are

there. Among these renewable sources solar and wind energy are the world's fastest growing energy resources. Day by day, the demand for electricity is rapidly increasing. But the available base load plants are not able to supply electricity as per demand. So these energy sources can be used to bridge the gap between supply and demand during peak loads. Tapping the energy available from the renewable resources allows the attainment of notable reductions in the pollution levels and worrying climate changes. On the other hand, the availability of energy from renewable sources like wind energy, solar energy, etc. is unpredictable and is affected by factors beyond human control. They also offer power supply solutions for remote areas, not accessible by grid power supply today around 30,000 wind turbines and more than 1,00,000 off-grid solar PV systems are installed all over the world [1-5]. Wind and solar hybrid model with proper storage system have been keen interest for the last few years. In this paper a hybrid model of solar / wind is developed using 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.

II. SOLAR PANEL MODELING

Solar energy radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, concentrated solar power, solar architecture and artificial photosynthesis. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. In this paper eight photoelectric modules are being used which is shown in figure 1. The characteristics and electrical behavior depends on illumination and temperature. The maximum limit of solar irradiance is 1000 W/m^2 . The circuit diagram is shown in fig 2.

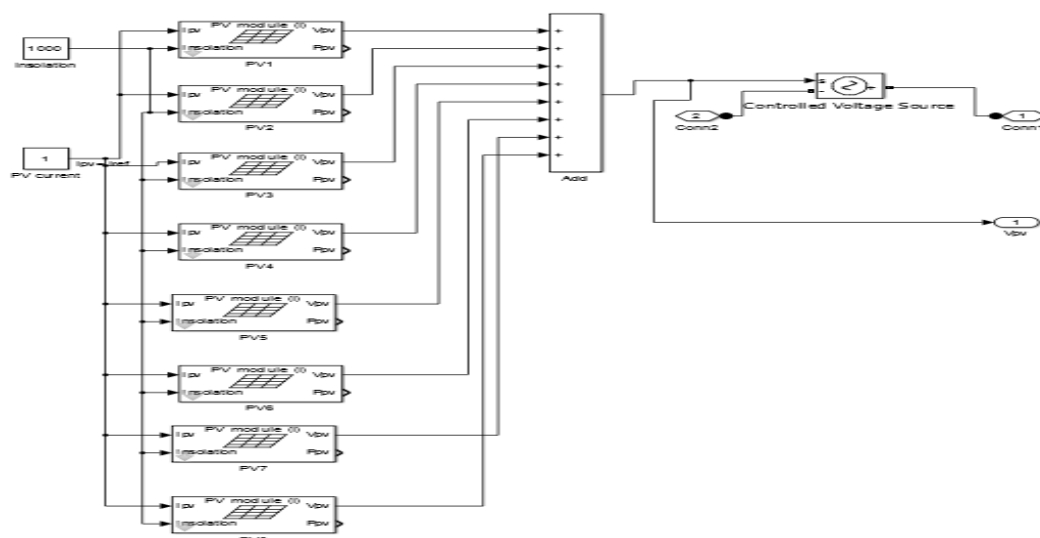


Fig 1: Simulink of Photovoltaic Module

Here is the electrical characteristics of the PV module are generally represented by the current vs. voltage (I-V) and the current vs. power (P-V) curves. The V-I characteristic equation of the PV module is:

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_0 ;

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

III. WIND TURBINE MODELING

Airflows can be used to run wind turbines. Modern utility-scale wind turbines range from around 600 kW to 5 MW of rated power, although turbines with rated output of 1.5–3 MW have become the most common for commercial use; the power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases up to the maximum output for the particular turbine.^[27] Areas where winds are stronger and more constant, such as offshore and high altitude sites, are preferred locations for wind farms. Typical capacity factors are 20-40%, with values at the upper end of the range in particularly favorable sites. In this paper, Permanent Magnet Synchronous Generator is being used because of having better performance due to higher efficiency. It has less maintenance cost due to which it can be used without gearbox as it does not contain rotor current, thus the reduction of weight of nacelle and reduces cost. The mechanical energy is being obtained from Wind and converted into electricity. The Simulink model of wind Turbine is shown in figure 3.

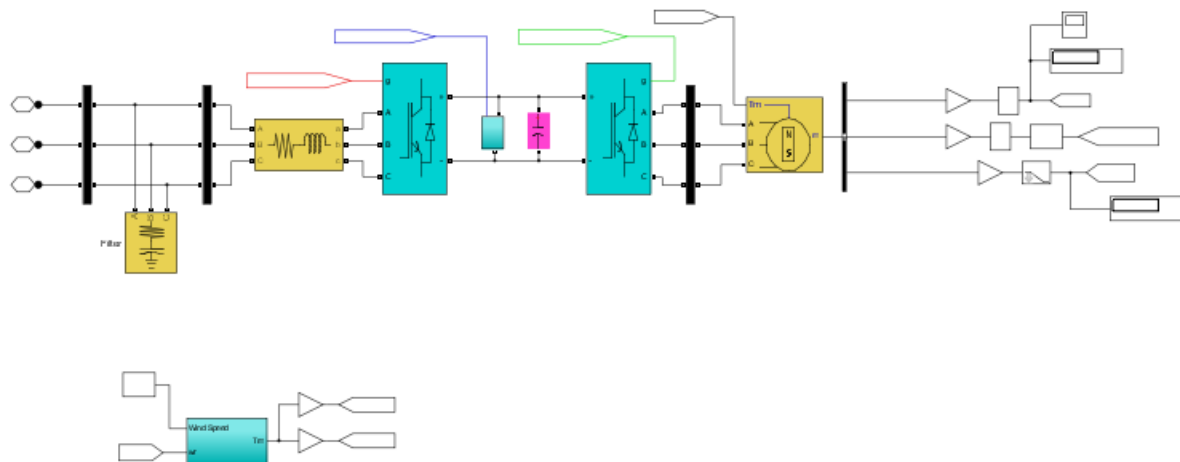


Figure 3: Simulink of Wind Turbine

IV. SVC DESCRIPTION AND MODELLING

SVC is a set of electrical devices for providing fast acting reactive power on high voltage electricity transmission network. SVCs are part of flexible AC transmission system device family, regulating voltage, power factor, and harmonics and stabilizing the system. Unlike a synchronous condenser which is a rotating electrical machine, a SVC has no significant moving part. The SVC is an automated impedance matching

device, designed to bring the system closer to unity power factor. Application of FACT controller called static Varcompensator SVC to improve the performance of power grid with solar wind hybrid system is investigated. 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 help sinrestringthest ability and controlling the voltage dip after severe disturbances such as faults or wind farm mechanical power variation. SVC injects or absorbs the reactive power through a voltage source converter very rapidly. Its multiples 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.

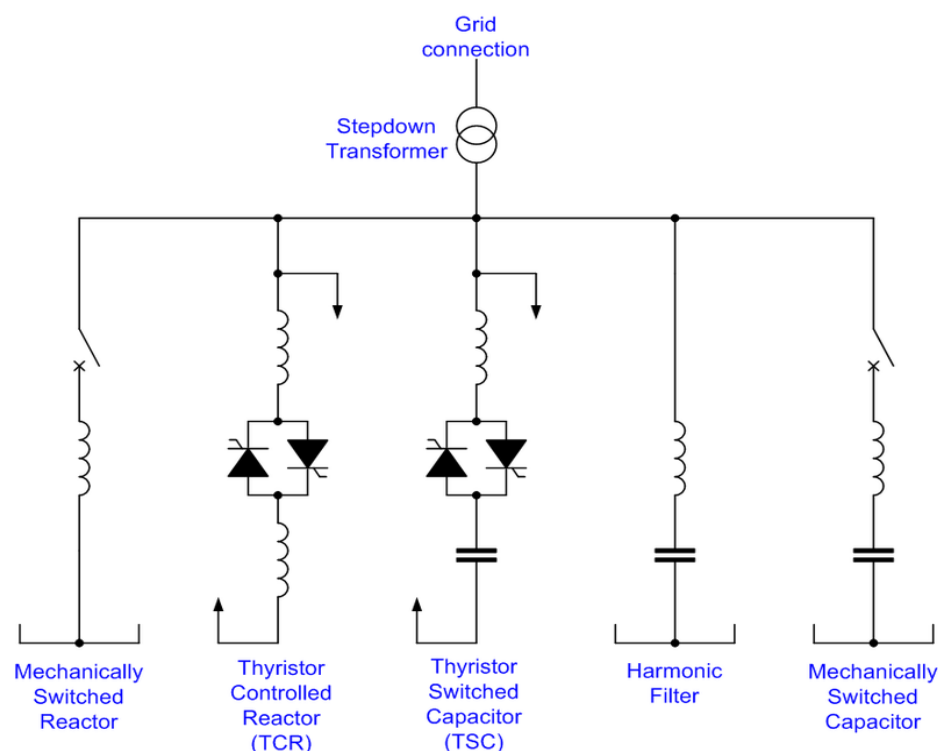


Figure 4: Circuit Diagram of SVC

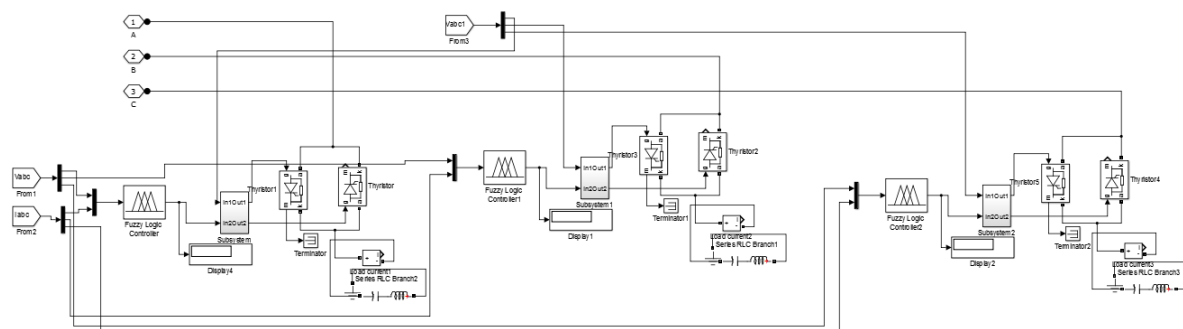


Figure 5: Simulink Model of SVC

V. SIMULATION AND RESULTS

With above based models and methods, The PV/Wind hybrid system with power grid connected has been implemented with SVC in the Simulink/MATLAB as shown in figure. The proposed system consists of PV Panel which is connected to the universal bridge to convert dc into ac supply. The second part consists of Wind Turbine which is connected to the PMSG to obtain the ac supply. The ac supply from hybrid PV/WIND generating system is being supplied to grid which is unbalanced and contains harmonics. To make it stabilized and balanced, we use SVC 100MVAR to this distribution network and the bus feeder is about 100km. The output of SVC is coupled in parallel with 1.25/25 KVA step up delta-star transformer. A filter bank is provided at the end of SVC output to absorb the harmonics. The primary side of this transformer is fed with Voltage source Inverter and 3000 off Capacitor is used as a dc voltage source for inverter. SVC plays a vital role for regulating the bus voltage by generating or absorbing it. SVC will behave as Inductive mode, if the secondary voltage is lower than the bus voltage and it will behave as capacitive mode if bus voltage is lower than secondary voltage.

The output voltage waveform of PV system is shown in figure 6. The output range of PV system is 401.2V DC.



Figure 6: Output of PV as source of SVC

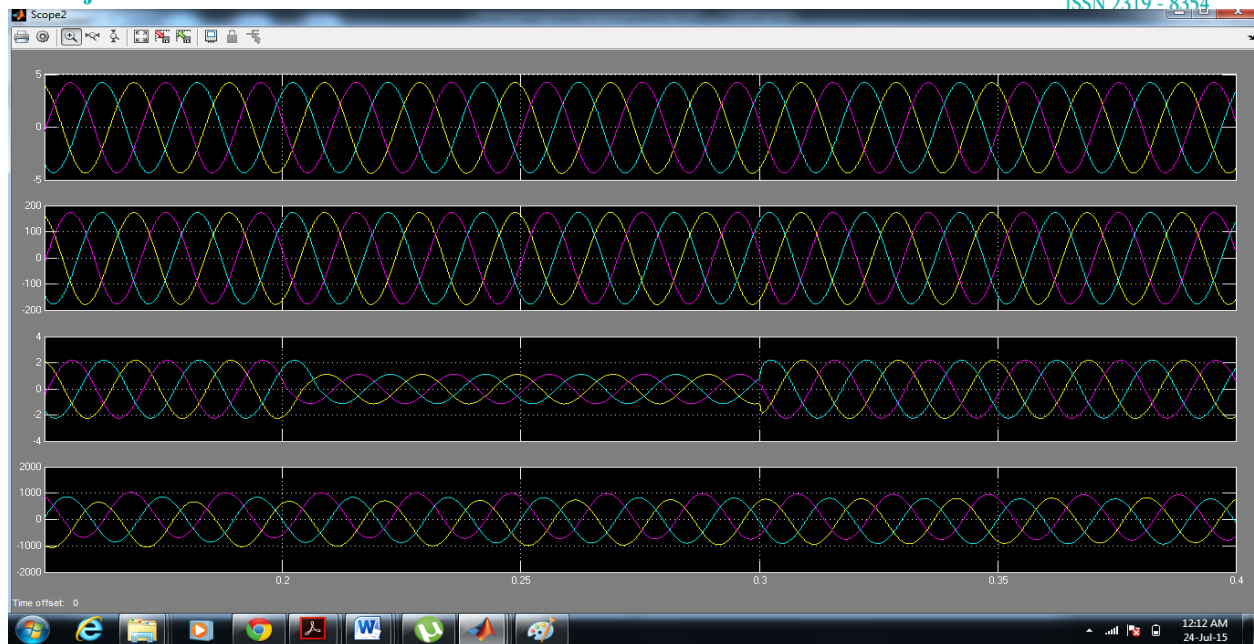


Figure 7: Voltage and Current waveform without using STATCOM

From above Waveforms, we see the Current is unbalanced and contains harmonics from the hybrid PV/Wind generating power system.

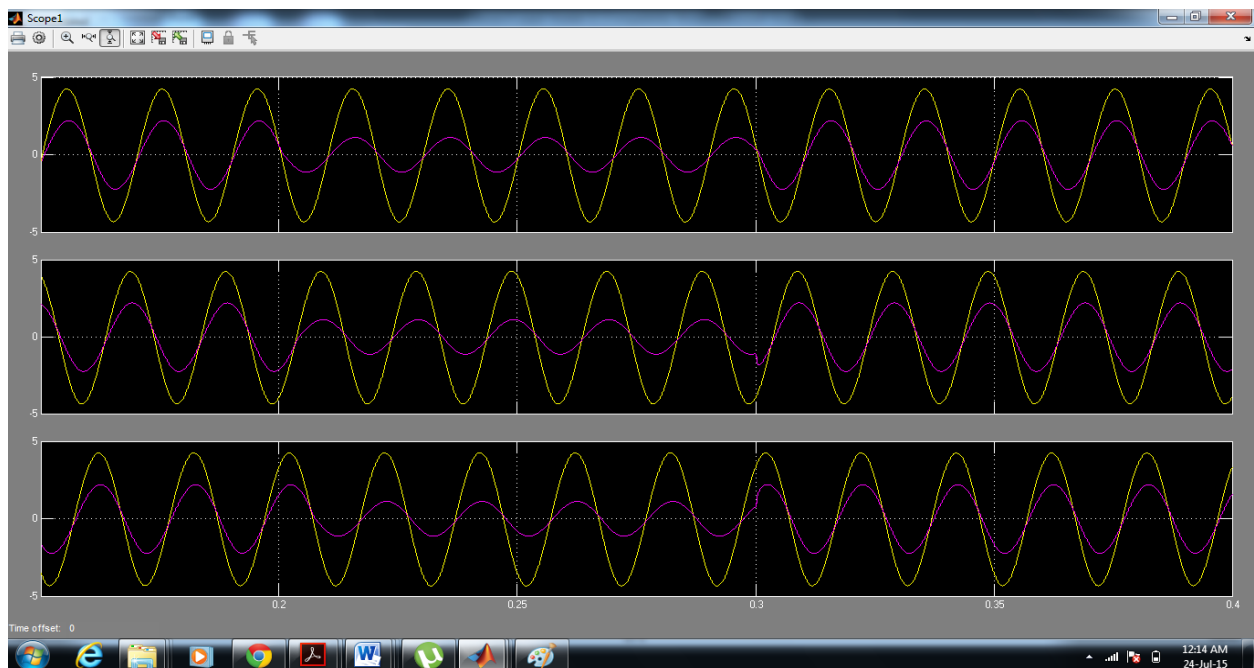


Figure 10: Voltage and Current Waveforms With Improved Phase Difference Due to High Power Factor Using SVC.

VI. CONCLUSIONS

In this paper, the power quality improvement with the help of SVC has been analyzed. SVC synchronizes the bus voltage and maintains the reactive power. The hybrid PV/Wind generating system with SVC is being analyzed with the help of MATLAB/Simulink. SVC improves the performance of power system and makes it balanced as



shown in various waveforms. The voltage stability of the SVC is shown by altering the inductive load which regulates the load side voltage and current almost constant.

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