

# Design and Implementation of an Voltage Compensation with SSSC for Distributed Energy Systems

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*Abstract – Today's modern interconnected power system is highly complex in nature. Reliability and security are one of the most necessary requirements of an electric power system during the normal operation. Wind Energy Conversions Systems (WECS) has reached a level of most importance during recent years. A primary source of distributed generation systems has the variable speed wind turbines along with a direct driven PMSG and power electronic interfaces. These are the most frequently used systems that are displaying the variability in output power levels as a result in change of the prime mover speed. When the grid is interconnected with such a configuration then it will introduce various challenges to the network related to stability, power quality and voltage regulation issues. It can cure by providing modern power electronic devices known as FACTS (Flexible AC Transmission System) devices, along with their controllers. Among the FACTs device, Static synchronous series compensator (SSSC) due to high speed changes its reactance characteristic inductive to capacitive, is effective power flow controller and proposes a Sliding Mode Controller (SMC) for FACTS controller which has the ability to withstand all the faulty conditions that are taken into considered. The Stability of WECS can be enhanced by using a FACTS based device which is a Static Synchronous Series Compensator (SSSC) that can improve the voltage compensation capability.*

**Keywords:** Facts, Sliding Mode Controller (SMC), Permanent Magnet Synchronous Generator (PMSG), SSSC, WECS.

## I. INTRODUCTION

Most of the basic wind energy conversion systems uses the generators that are either permanent magnet synchronous generator (PMSG) or a doubly fed induction generator (DFIG). A DFIG is of low cost, size and weight but their applications are limited because of the unreliability of the associated gear box, brushes and slip rings [1]. But PMSG does not have a gear box so its reliability is high and it require only less maintenance. Also, due to the presence permanent magnet it has high power density. So its efficiency is also high when compared to all other types of WECS generators. Due to the stochastic nature of wind input power the output from a WECS is not much reliable. Also the output contains power quality problems like voltage sag, harmonics, etc. High level penetration of WECS into grid causes the migration of the above stated power quality problems into the power grid [2]. Also the interconnection of WECS with power grid causes voltage fluctuations, power system operation and control, regulation of power system stability.

## II. EXISTING SYSTEM

The PMSG machine is the most efficient of all electric machines since it has a movable magnetic source inside itself and the use of permanent magnets for the excitation consumes no extra electrical power. This feature also increases its efficiency [3]. The recent introduction of high-energy density magnets causes the achievement of extremely high flux densities inside the PMSG. This results compact structure for PMSG than a same rated induction generator [4]. Also, the only heat production is on stator, which is easier to cool down than the rotor because it is on the periphery of the generator.

Also, PMSG have very long lasting winding insulation, bearing, and magnet life length [5].

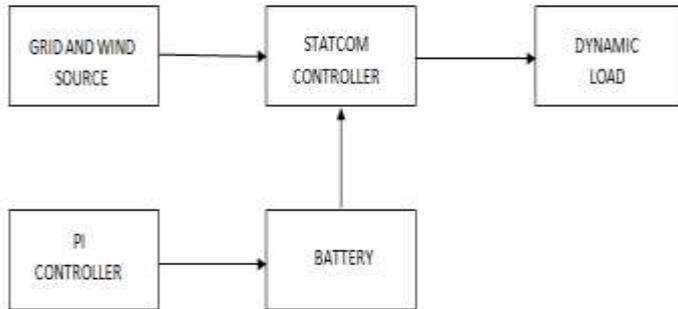


Figure-1: Existing System

It needs few maintenance services because of its simplified mechanical design. Also, PMSG possess highest power-to-weight ratio. All the above advantages causes the usage of PMSG in wind integrated system.

### III. PROPOSED SYSTEM

Sliding mode control (SMC) is basically a nonlinear control strategy that features the important properties of robustness with easy tuning, accuracy and implementation [6]. Sliding mode system is designed to operate in system states in a specific surface in the space states that are in sliding surface. Sliding mode control maintains the states in the closer levels of sliding surface, once the sliding surface is reached.

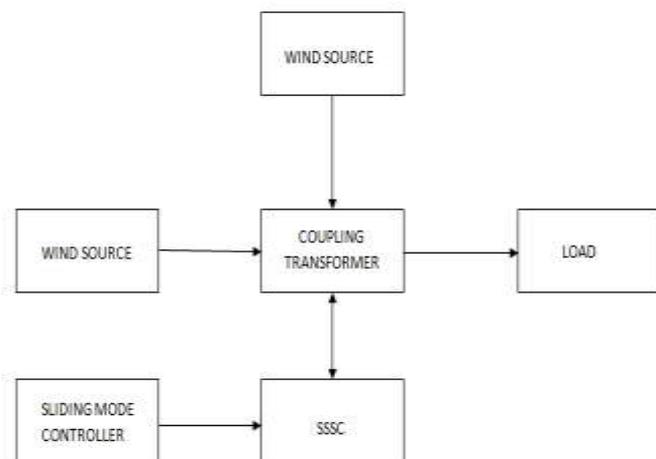


Figure-2: Proposed System

The sliding mode control technique has a two part controller in its design in which the first part is involved in designing of a sliding surface in which the sliding

motion has to satisfy the design specifications. The second part of the design deals with the selection of a control laws which can make the switching surface to be more relevant to the system states.

The sliding mode control mainly has two main advantages, in which the first one is the dynamic behavior of the system which may be modified by the particular choice in the sliding functions of the system. Second important factor is the closed loop system response that results in an output totally insensitive to some of the particular uncertainties [7]. To model the disturbances, parameter of uncertainties and non-linearity extends that are bounded with this principle.

### IV. RESULT & DISCUSSION

#### a) Simulation Circuit

The Sliding mode control design for the distributed wind energy conversion system is designed and the proposed circuit diagram is simulated in MATLAB SIMULINK as shown in the figure-3 with the necessary input and output are displayed.

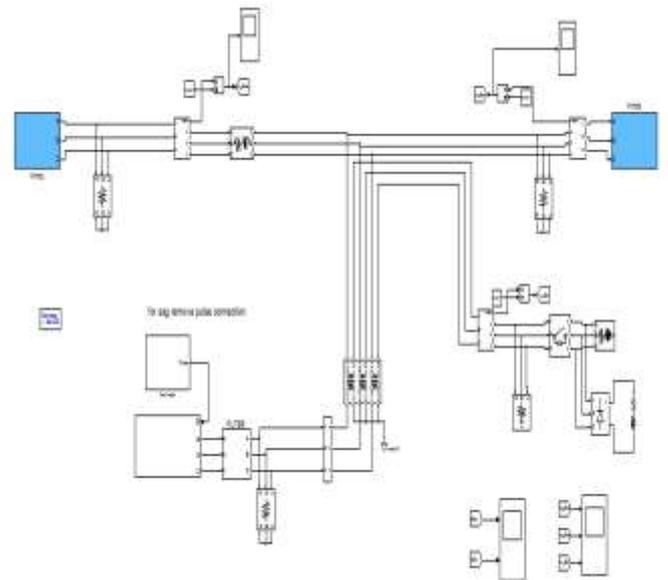


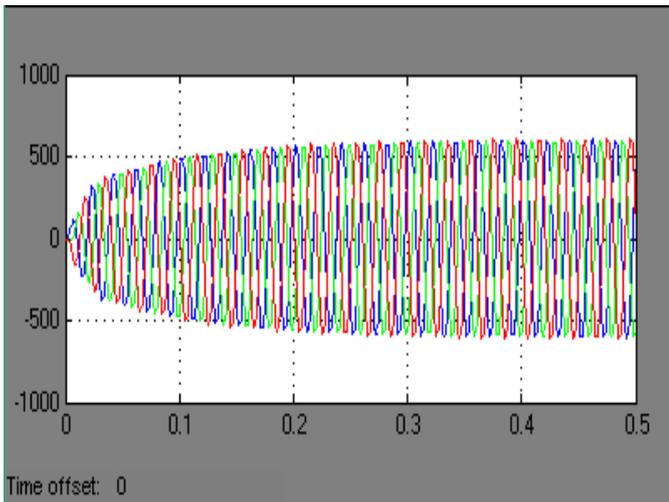
Figure-3: Simulation Circuit

High power quality is becoming desirable for industrial factories and commercial building. The use of electronic devices has improved the manufacturing process by providing a means for automated production.

Automated production processes are particularly sensitive to electrical disturbances such as voltage sags and swells, voltage flicker, and harmonic interference.

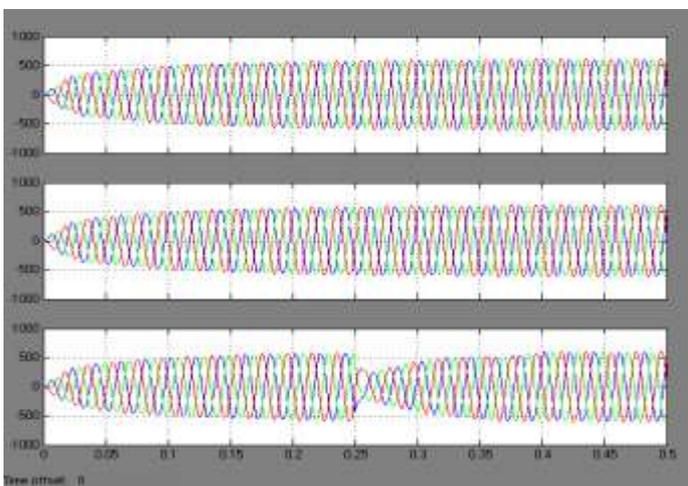
**b) Simulation Result**

Voltage sags that last for only a few milliseconds can cause entire production processes to stop. The loss in production or damage to products due to these sags accounts for considerable financial losses to industry.

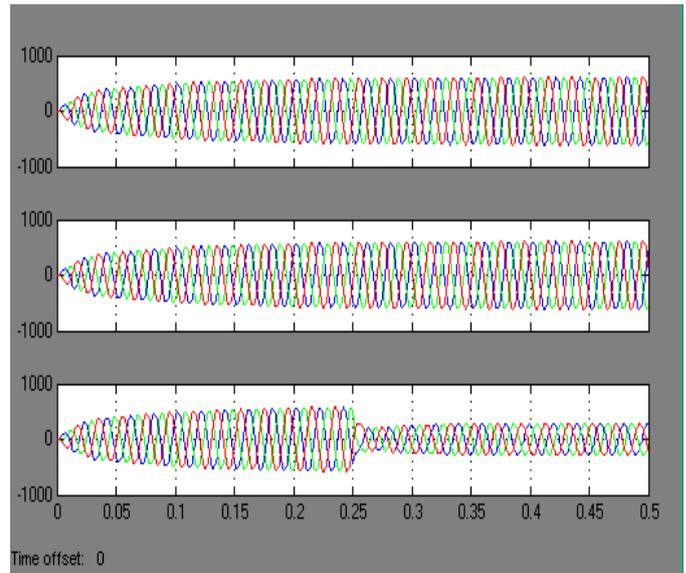


**Figure-4: output for wind turbine model with measurement block**

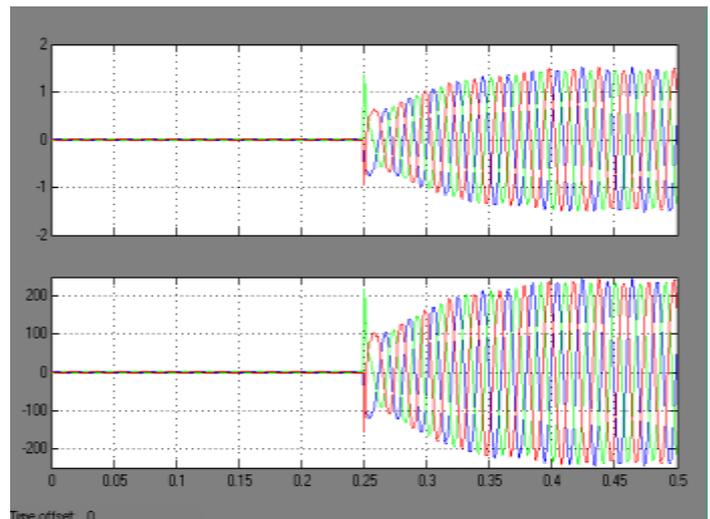
Advances in semiconductor technology as well as power electronic technology have provided a way to protect sensitive loads against the effects of poor power quality.



**Figure-5: output voltage & current with fault after compensation by SSSC**



**Figure-6: output voltage & current with fault before compensation**



**Figure-7: current rating for wind 1 & 2**

**c) Applications of SSSC:**

The SSSC are mainly used in power flow control systems which requires good voltage stability and accurate phase angle stability. An SSSC can raise or down the power flow in a power transmission line. The conventional controllable series capacitor connected with the SSSC can induce a capacitive along with the inductive series voltages on a transmission line. Also the SSSC can have a wider operating range compared to all of the traditional series capacitors. The SSSC damps out electromechanical oscillations in a better way compared to fixed capacitors.

## V. CONCLUSION

A method for enhancement of transient stability as well as the power quality in PMSG based wind integrated system was done using SSSC incorporated with a FOD controller. Modeling of permanent magnet synchronous generator is presented. This method make the machine as a fault tolerant one. The SSSC provide necessary compensation to the system as the system requirements. Also SSSC minimize the harmonics inside the system.

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