# Reactive Power Compensation in Wind Power Plant Using SVC and STATCOM

**Saeed Amini, Md. Tavakoli Bina, Amin Hajizadeh**

***Abstract*_The WECS is a fixed speed/constant frequency system that is equipped with an induction generator driven by an unregulated wind turbine Although integration of high levels of wind power into an existing transmission system does not require a major redesign, it necessitates additional control and compensating equipment to enable recovery from severe system disturbances. This thesis investigates the use of a Static Synchronous Compensator (STATCOM) along with wind farms for the purpose of stabilizing the grid voltage after grid-side disturbances such as a three phase short circuit fault, temporary trip of a wind turbine and sudden load changes. The strategy focuses on a fundamental grid operational requirement to maintain proper voltages at the point of common coupling by regulating voltage. The DC voltage at individual wind turbine (WT) inverters is also stabilized to facilitate continuous operation of wind turbines during disturbances. 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.***

***Keywords – Wind Energy Conversion System (WECS); FACTS; STATCOM,SVC, voltage control, reactive power compensation.***

## I. INTRODUCTION

Wind energy is a fast-growing interdisciplinary field that encloses many different departments of engineering and science. According to the American Wind Energy Association, the used capacity of wind grew at an median rate of 29% per year over the years 2002-2007 [3]. At the end of 2007, the installed capacity in the United States was closely 17,000 megawatts (MW) and the worldwide installed capacity was over 94,000 MW [3], [4]. Fig. 1 shows a conventional wind generator that has an induction generator directly connected to the grid. These types of generator are simple, robust and cheap. In order to link the turbine to the utility grid a soft-starter (consisting of anti-parallel thyristors) is employed in order to obey the currents under rated when the turbine is being connected to the utility grid. Phase-compensating capacitors are utilized to reimburse for the no-load consumption of the generator, or in some cases also for full-load working [5].

In the past, the total installed wind power capacity was a small fragment of the power system and ongoing connection of the wind farm to the grid was not a important worry. With raising portion from the wind power sources, it has become important for stable connection of the wind farm to the system to make capable uninterrupted power supply to the load even in small disturbances.

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**Saeed Amini,** Department University of Electrical Engineering Islamic Azad University Damghan Branch,Damghan,Iran.

**Mohammad Tavakoli Bina,** Department University of Electrical Engineering Islamic Azad University Damghan Branch,Damghan,Iran.

**Amin Hajizadeh,** Department University of Electrical Engineering Islamic Azad University Damghan Branch,Damghan,Iran.

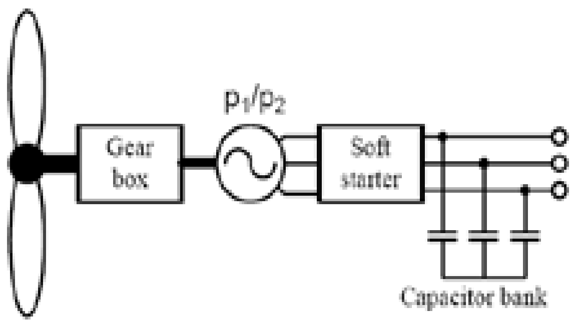


Fig 1. Fixed speed induction generator

Under these conditions Standard devices used to supply the needed reactive recompense are mechanically switched capacitor banks. Flexible AC transmission system (FACTS) devices can be use. They are capable to provide quick active and reactive power compensations to power systems, and hence can be used to provide voltage support and enhance power oscillation damping. properly located FACTS devices enable additionally efficient employment of existing transmission lines. amid the FACTS family, the shunt FACTS devices such as the static synchronous compensator (STATCOM) has been greatly used to provide flat and fast steady state and transient voltage control at points in the network[1].

## II. DOUBLE FED INDUCTION GENERATOR (DFIG) WIND TRUBINE

The DFIG wind turbine is a wound-rotor induction generator operates by controlling slip rings or by the power converter interconnected with the grid. See Figuer 2 for the DFIG wind turbine schematic[1]. The stator is directly connected to the grid and the rotor is interfaced through a crowbar and a power converter. The voltage on the stator is applied from the grid and the voltage on the rotor is induced by the power converter.

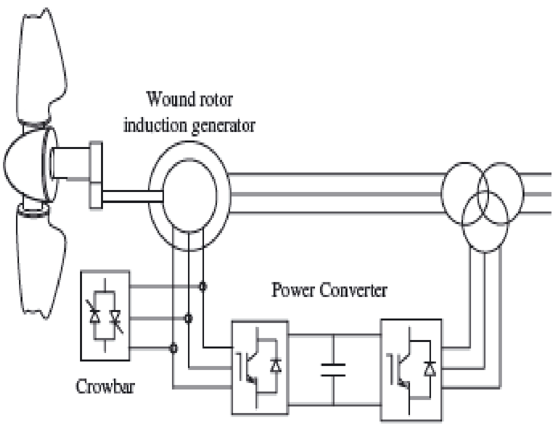


Figure 2 DFIG wind turbine model (Anaya-Lara et al, 2009)



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DFIG wind turbine deliver power through the stator and rotor of the generator, while the rotor can also absorbe power depends on the rotational speed of the generator[4]. If the generator operates above synchronous speed, the power are deliverd from the rotor thorugh the power converter to the grid. If the generator is operates below sychronous speed, then the rotor will absorb power from the grid thorugh the power converter. The power converter are consists of a Rotor-side converter (RSC) and a Grid-side converter (GSC). The power converter controls the active and reactive power flow, and the DC voltage of the DC-link capacitor between the DFIG wind turbine and the grid by feeding the pulse width modules (PWM) to the converters (Seyedi, 2009). In addition an crowbar is implemented to pervent short circuit in the wind energy system that result in high current and high voltage. The RSC converter opertaes at the slip frequency that depends on the rotor speed, and controls the flux of the DFIG wind turbine. The power rating of the RSC is determined according to the maximum active and reactive power control capability. The RSC can be simplified as a current-controlled volatge sources converter. The GSC operates at a network frequency and controls the voltage and current level in the DC-link circuit. It is used to regulate the voltage of the DC-link capacitor (Akhmatov, 2003). Hence, DFIG wind turbine have the capability for generating or absorbing reactive power and control the reactive power or voltage at the grid side.

## III. METHODS OF DYNAMIC REACTIVE POWER COMPENSATION

Reactors are typically mechanically switched devices.Again, it is only possible to control slow variations in reactive power. The inductive VAr output is a function of the voltage such that the VArs decrease with the square of the voltage (i.e. 90% voltage will provide 81% VAr capability). Regulated shunt reactors are shunt reactors equipped with a tap-changer as used for voltage control with a transformer. Using such a ”regulated shunt-reactor”, a more smooth control of reactive power can be achieved [3]. A study presented in [5-9] shows the feasibility of this tool for reactive power control with large wind power plants *Static Var Compensator* An SVC is typically a fixed shunt capacitance in parallel with reactance that is controlled using thyristors. This type of controller is made using static components that shown in figure 3. When the thyristors are used in the control process, then the controller is considered dynamic. These allow for a control of reactive power at time scales down to the order of a 100 milliseconds. Additional filters must be used to avoid harmonics which are created when the current wave shape distorts from the thyristor switching. Further details on SVC can be found in IEEE Std.1031.

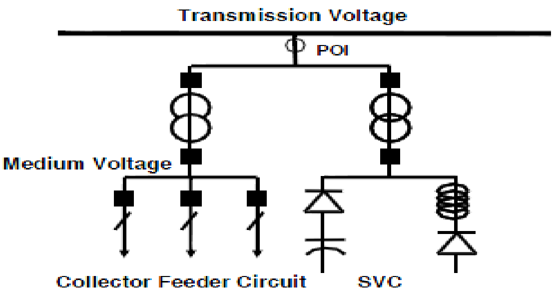


Figure 3. Typical configuration of SVC for WPPs.
Static Synchronous Compensator

A STATCOM[9-11] is a voltage-source converter. It does not use thyristors for switching, but instead uses IGBT (Insulated-Gate Bipolar Transistor) or IGCT (Integrated Gate Commutated Thyristor) switching devices to either source or sink reactive power to the electric network. Some STATCOM units may have short-time overload capabilities for 2 to 4 seconds that shown in figure 4. The VAr output is a linear function of the voltage, VArs decrease linearly with the voltage (i.e. 90% voltage will provide 90% VAr capability) since they are constant current controllers.

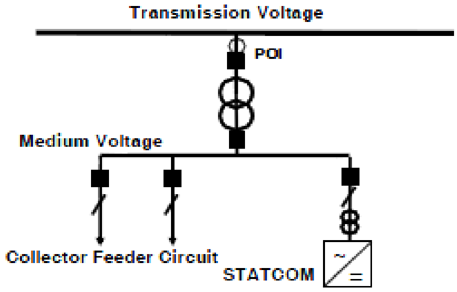


Figure 4. Typical configuration of STATCOM for WPPs.

## IV. SIMULATION AND RESULT

Conventional and FACTS-based devices are applied inorder to flatten voltage profile, preserve stability, correct power factor, and decrease power and energy losses by minimising reactive power flow in the network. The system detiles showing in the figure 5 that simulation in matlab software. Within a scope of voltage control and reactive power compensation problem, power conditions are analysed as a part of the whole problem related to technical aspects of grid integration of the WECS. The WECS is of a fixed speed/constant frequency type equipped with an induction generator that is driven by unregulated wind turbine. Power conditions at network buses are dynamically analysed as functions of wind speed changes. Conditions of increased interaction between the WECS and the LTC distribution transformer are predicted in times of extremely turbulent winds. Transfer of the WECS from an infinite-bus operating mode to an isolated one is also analysed.We will study capacitor banks denoted as the typical case and FACTS devices (STATCOM and SVC)[3] as compensation devices. We use first FACTS devices with PI controller then apply robust control theory for control STATCOM.. The result of active and reactive profile and voltage profile showing in figures 6-14. When SVC or STATCOM exists in system or whitout them. The figurs 15-17 discribed magnitude voltage at bus7 when no fact device using or ,svc and statcom used in system.

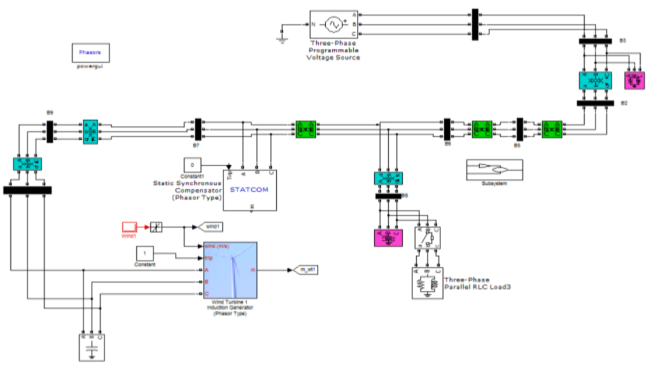


Figure 5. Wind farm station with reactive power compensation (STATCOM)



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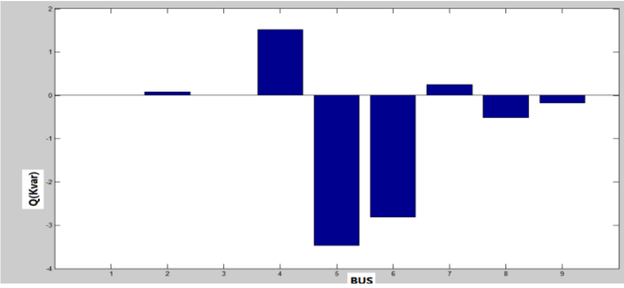


Fig 6:reactive power profile when fault in .6 s whitout statcom or svc

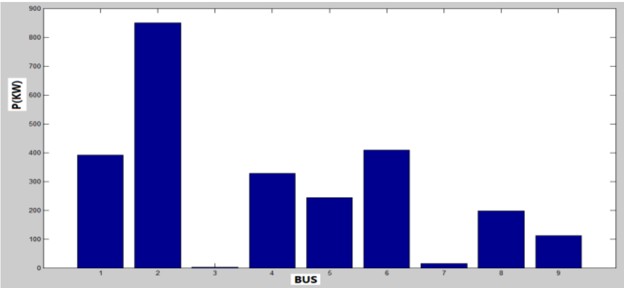


Fig 7:active power profile when fault in .6 s whitout statcom or svc

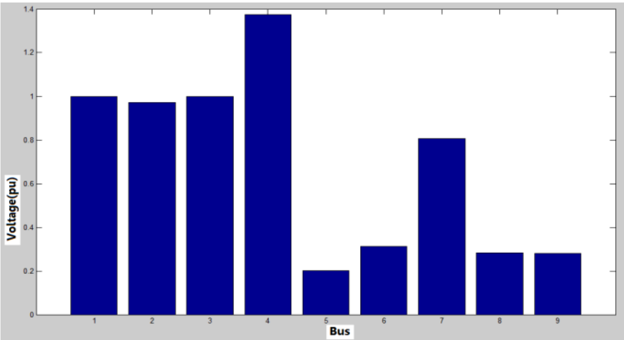


Fig 8:Voltage profile when fault in .6 s whitout statcom or svc

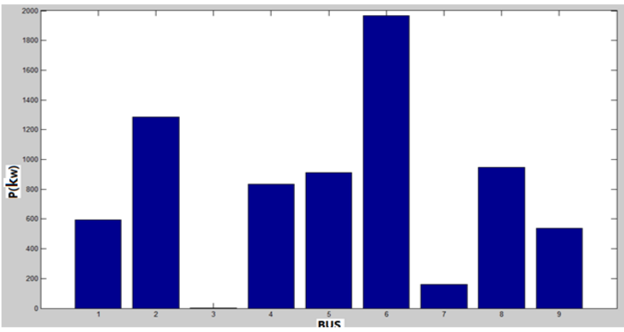


Fig 9:active power profile when fault in .6 s by statcom

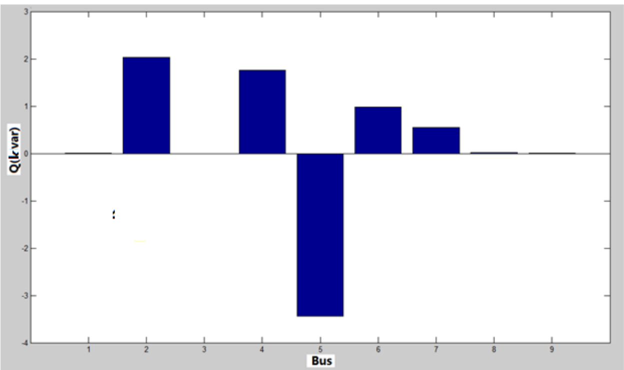


Fig 10:reactive power profile when fault in .6 s by statcom

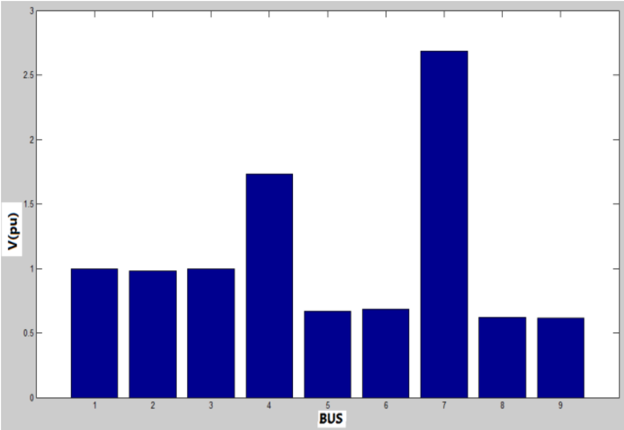


Fig 11:Voltage profile when fault in .6 s by statcom

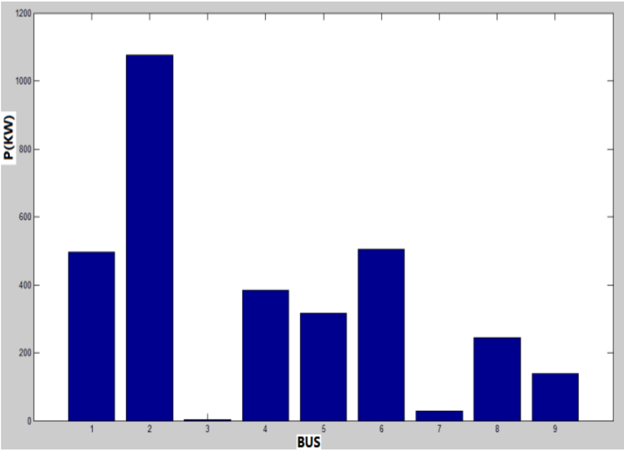


Fig 12:active power profile when fault in .6 s by statcom

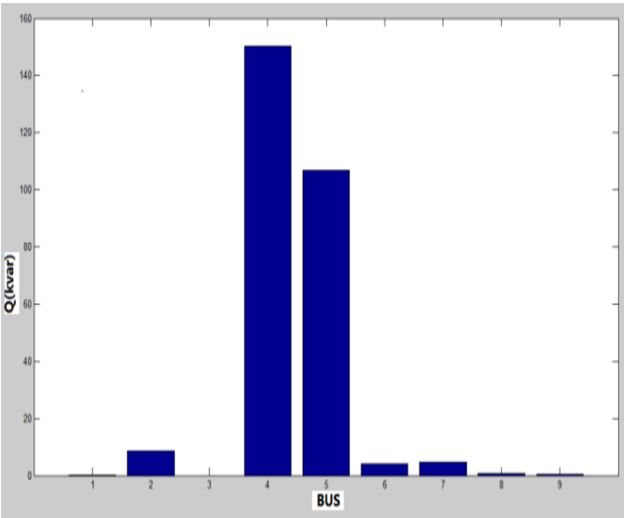


Fig 13:reactive power profile when fault in .6 s by statcom

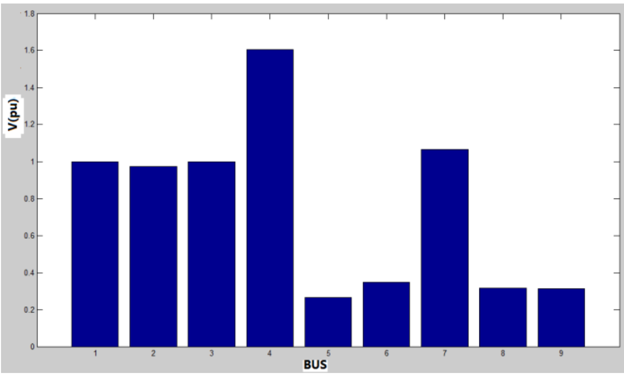


Fig 14:Voltage profile when fault in .6 s by statcom



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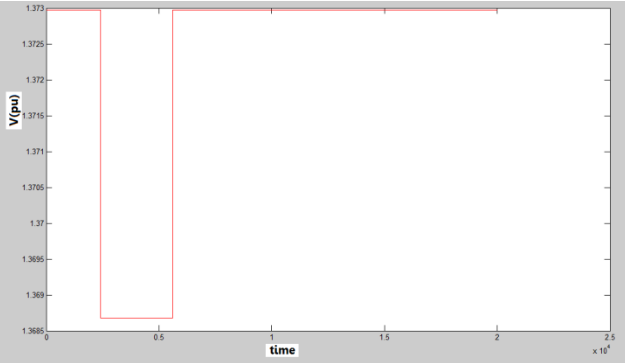


Fig 15:Voltage of bus 7 without svc or statcom

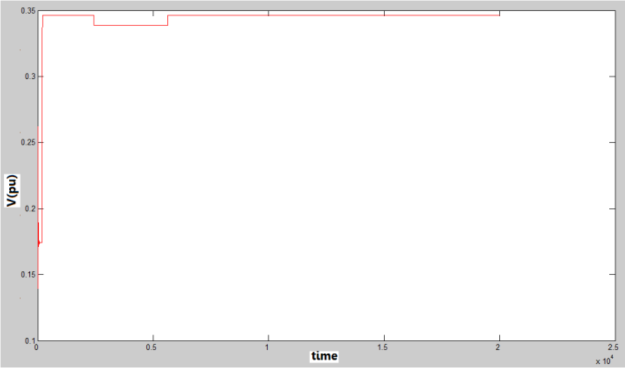


Fig 16:Voltage of bus 7 by svc

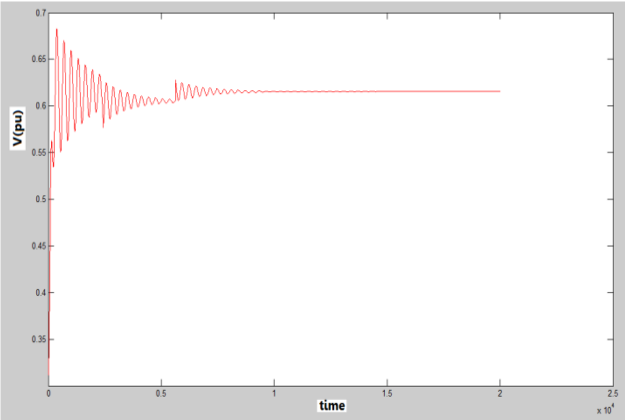


Fig 17:Voltage of bus 7 by statcom

## V. CONCLUSIONS

The reactive power control of isolated wind-diesel and wind-diesel-microhydro systems has been investigated in this paper. The controlled reactive power has been investigated by using STATCOM and SVC. For the laboratory work, only the STATCOM part of the system was implemented,due to limited time. The results from this practical implementation showed the same general patterns as those of the STATCOM simulations, expect the controllers not being tuned to a response of the same level of accuracy as those found in the simulations. It has been shown that STATCOM is a better choice for compensation in the system than the SVC.

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