# Comparative Analysis of FACTS Controller for IG Based Wind Farms in Grid Connected System

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***Abstract*— The renewable energy sources are the alternative energy sources. There are various types of renewable energy among those wind farms are becoming important distributed renewable energy resources. Wind turbines with induction generator (IG) are the most commonly used for wind power generation. The IG consumes reactive power and also there is some disturbances in power system such as voltage variation can lead to over speeding of IG and cause voltage instability. The injection of power from wind farms employing fixed speed IG concerns power quality problem such as voltage instability, variation of voltage, flicker and harmonics. FACTS devices have the capability to increase stability limits and improve system dynamic response. This project focuses the performance of FACTS devices such as SVC and STATCOM to improve system dynamic response has been analyzed using MATLAB/SIMULINK. This analysis is performed to find out the better compensator among these FACTS devices.**

## I. INTRODUCTION

Now a days it is necessary to utilize the energy from renewable resources like wd, solar, biomass, hydro etc.,[1]. Among these wind energy is mostly used source due to its free, clean, renewable character and it have large potential. Wind generating system is to use induction generator (IG) connected to the grid system because of its advantages such as cost effectiveness and robustness [3,4]. In wind turbine induction generator stator is directly connected to the grid and rotor is driven by wind turbine as shown in Fig.1 The power captured by the wind turbine is converted into electrical power by using induction generator and is to transmit it to the grid by stator windings. In order to generate power the IG speed must be slight above the synchronous speed. But the speed orientation is typically so small that the WTIG (Wind Turbine Induction Generator) is considered to be the fixed speed generator. However IG requires reactive power for magnetization [1]. The generated power varies due to wind and also due to absorption of reactive power. Due to this terminal voltage of an IG can also be affected. So a proper control scheme is required for control over the active power production. In early days, shunt capacitors are used to fully compensate this reactive power it will be only able to compensate during steady state operation. This device exhibit poor performance during transient condition.

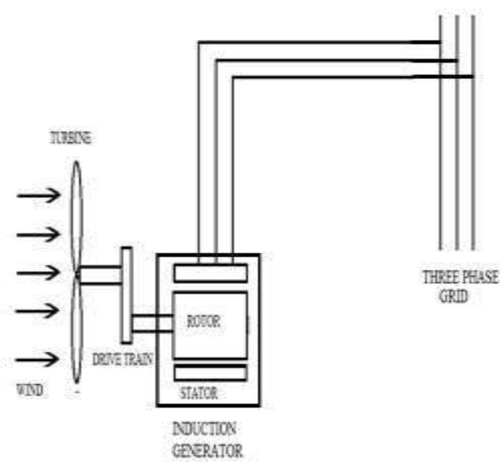



Fig.1. Wind turbine induction generator

When the wind energy is integrated into power system presents technical challenges such as voltage regulation, stability and power quality problems such as voltage sag, swell, instability, flicker etc. Power system disturbances can lead to over speeding of IG and it cause voltage instability. The reactive power absorbed by IG can be provide by using power electronic compensation devices such as SVCs (Static Var Compensator) and STATCOM (STATic synchronous COMpensator) [4]. Application of these FACTS devices is to improve power quality and stability [2]. Since FACTS device is based on power electronic controllers to enhance the transmission networks by increasing their capacity [5]. Both SVC and STATCOM are shunt compensator. The main objective of shunt compensator in transmission line is to increase the transmittable power. This paper proposes the use of SVC and STATCOM to improve the wind farm stability which is connected to the power system. The paper is organized as follows. The section II introduces the Static Var Compensator. The section III introduces the Static Synchronous Compensator.

The section IV and V describes the simulation, results and conclusion respectively.

*STATIC VAR COMPENSATOR*

A shunt connected static Var compensator is a first generation of FACTS devices [6]. It performs reactive power compensation which leads to an increase in network voltage during and after fault. Thus voltage at a particular bus by means of reactive power compensation is maintained.

SVC is the combination of TCR and TSC. The SVC is connected to the coupling transformer and it is connected the AC bus whose voltage has to be regulated. The regulation can be performed effectively by controlling the firing angle. The firing angle can be controlled through a PI controller in such a way that the voltage of the bus, where the SVC is connected is maintained at the reference value.

A single line diagram of SVC is shown in Fig.2.

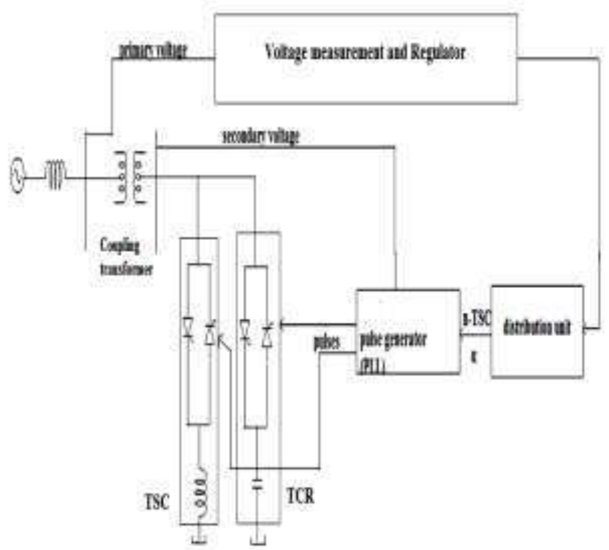



Fig.2. Single line diagram of SVC

## II. STATIC SYNCHRONOUS COMPENSATOR

A Static synchronous compensator is a shunt connected device. It based on voltage source converter technology and equipped with gate turn off thyristor (GTO) as semiconductor device. When the developed voltage is higher than the system voltage STATCOM will supply reactive power. STATCOM will absorbs reactive power when developed voltage is lower than the system voltage. STATCOM control scheme for power quality improvement in grid connected wind energy generation and also it supports reactive power to wind generator and load. Compared to SVC, STATCOM has better performance, faster response, smaller size, reduced cost and it can be able to provide both active and reactive power. STATCOM can be effectively used to improve power system stability [8]. A single line diagram is shown in Fig.3.

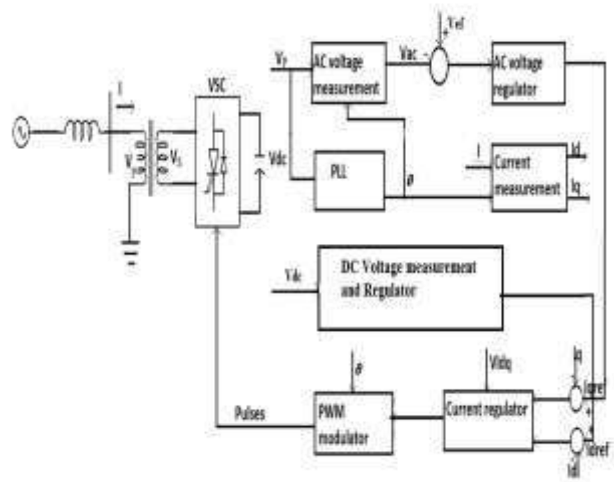



Fig.3. Single line diagram of STATCOM

## III. SIMULATION RESULTS

The grid connected wind turbine based induction generator is simulated without any compensator as shown in Fig.4. The fault is generated at 1.2 to 1.36 seconds. During the fault period real power, reactive power increases due to three phase fault as shown in Fig.4.1 and Fig.4.2. Real power across wind turbine induction generator will neither be generated nor absorbed as shown in Fig.4.3. The reactive power across wind turbine induction generator is absorbed during fault period as shown in Fig.4.4. During fault period more power will be absorbed by induction generator in grid connected wind power system. This can be compensated by using FACTS devices such as SVC and STATCOM.

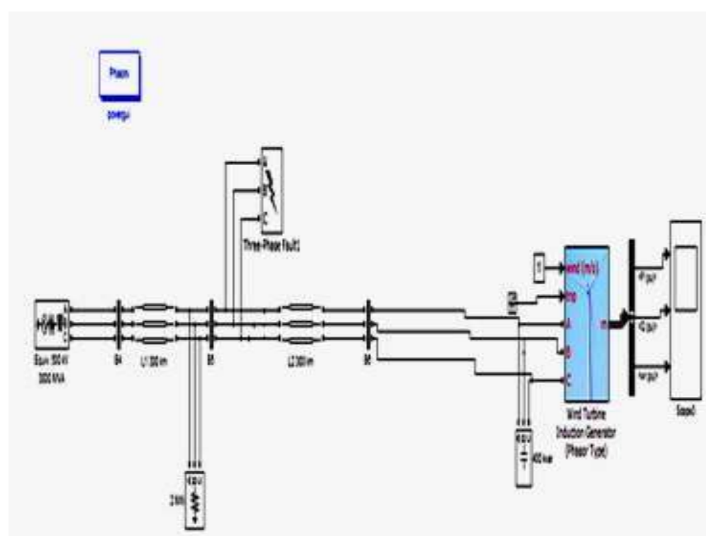


Fig.4. Simulation without compensator

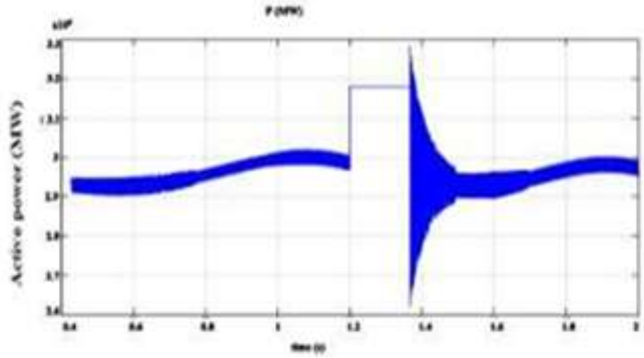



Fig.4.1.Real power in grid without compensator

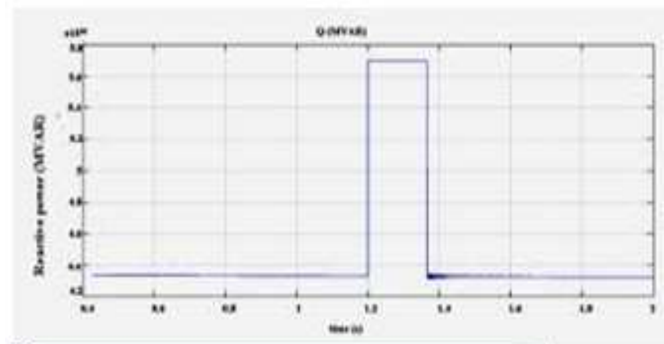



Fig.4.2. Reactive power in grid without compensator

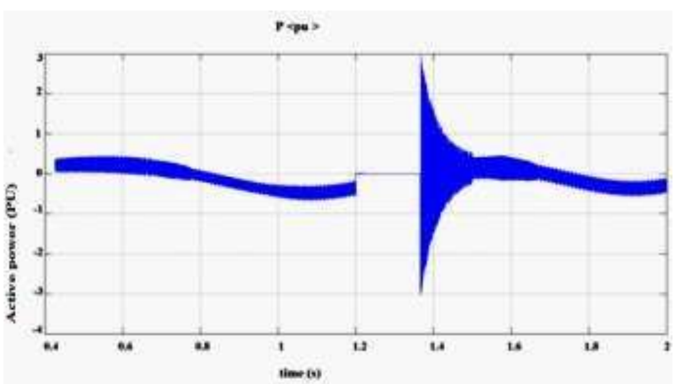



Fig.4.3.Real power of wind without compensator

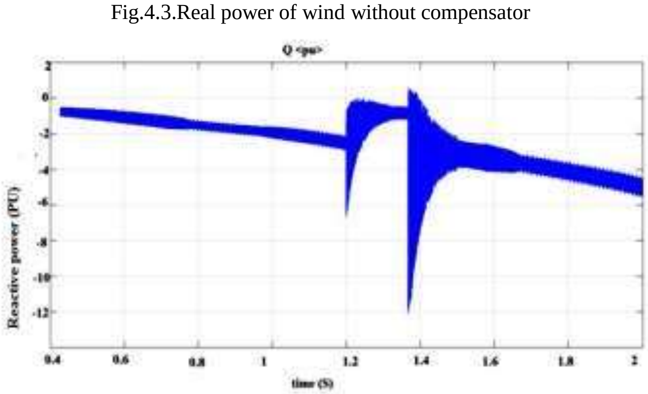



Fig.4.4.Reactive power of wind without compensator

The grid connected wind turbine based induction generator is simulated with Static Var Compensator as shown in Fig.4.5. The fault is generated at 1.2 to 1.36 seconds. SVC is connected to wind turbine induction generator to improve wind power generation. The real power and reactive power across the grid increases during fault period as shown in Fig.4.6 and Fig.4.7. The positive sequence measured voltage is drops to zero as shown in Fig.4.8, which leads to voltage instability problem. The Static Var Compensator is used to control power flow and to improve transient stability on power grid. The power injected by SVC during fault condition as shown in Fig.4.9. By this power the stability problem can be minimized. Wind turbine induction generator output real power is measured, during fault condition the power will be neither absorbed nor generated as shown in Fig.4.10. Wind turbine induction generator output reactive power is absorbed during fault as shown in Fig.4.11.

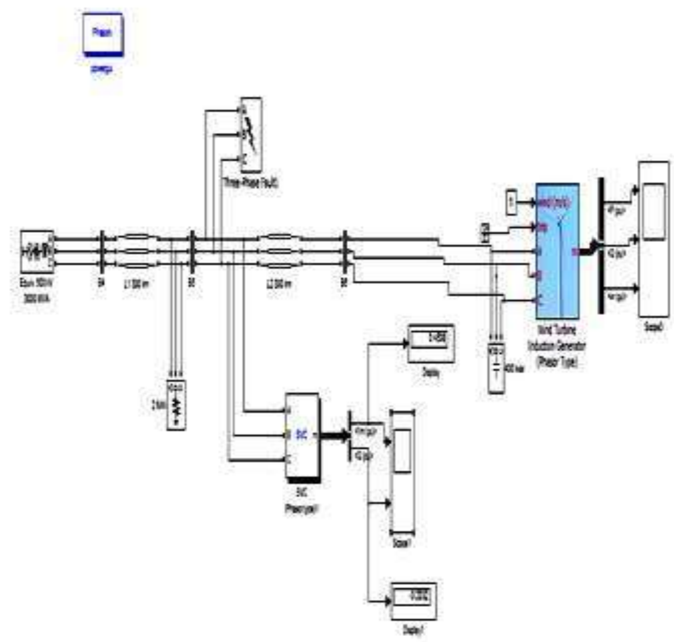


Fig.4.5. Simulation with SVC

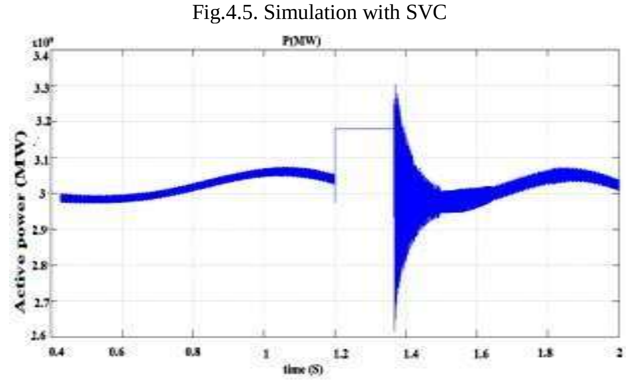



Fig.4.6. Real power in grid with SVC

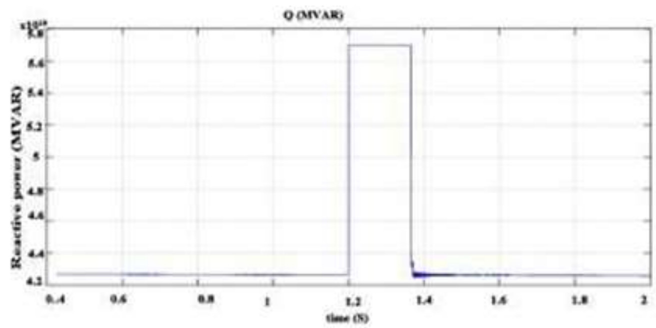



Fig.4.7 Reactive power in grid with SVC

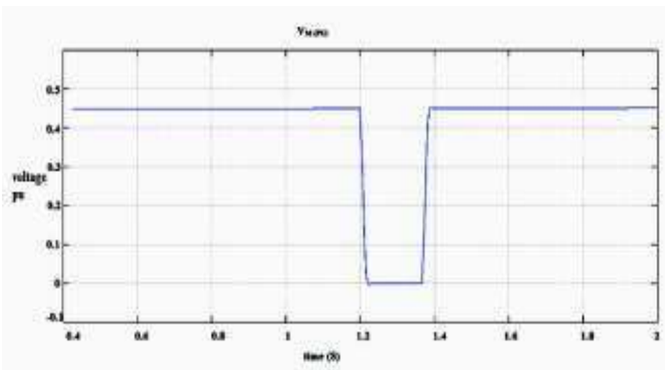



Fig.4.8. Measured voltage by SVC

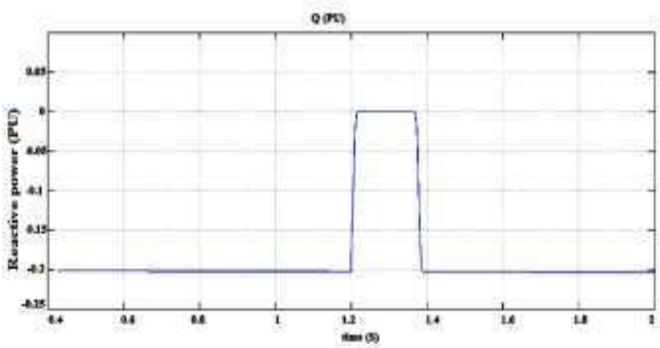



Fig.4.9. Power injected by SVC

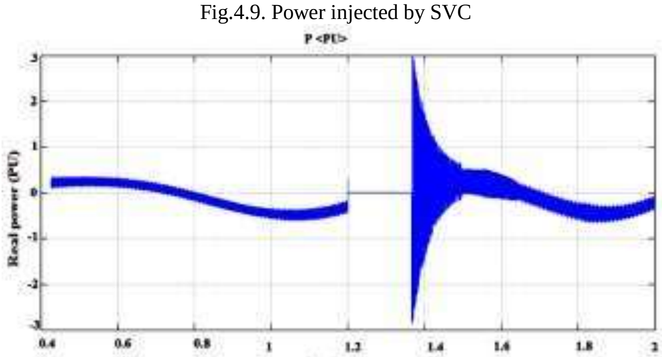



Fig.4.10 Real power for wind turbine with SVC

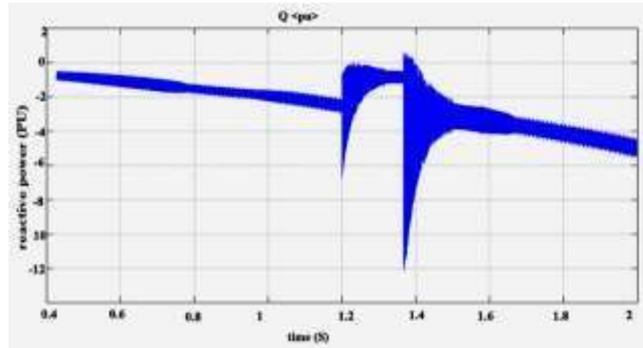



Fig.4.11 Reactive power for wind turbine with SVC

The grid connected wind turbine based induction generator is simulated with Static Synchronous Compensator as shown in Fig.4.12. The three phase to ground fault is generated at 1.2 to 1.36 seconds. During the fault period real and reactive power increase as shown in Fig.4.13 and Fig.4.14. The positive sequence of measured voltage is drops during fault condition as shown in Fig.4.15, which leads to voltage instability problem. This voltage instability problem can be minimized by injecting reactive power during fault period as shown in Fig.4.16. In the case of SVC, the positive sequence measured voltage will drops to zero but in STATCOM it will not drops to zero. The wind turbine based induction generator output real power is measured as shown in Fig.4.17. Due to STATCOM the real power will be generated during fault period. In case of SVC real power is neither generated nor absorbed during fault period. The reactive power is absorbed during fault period as shown in Fig.4.18.

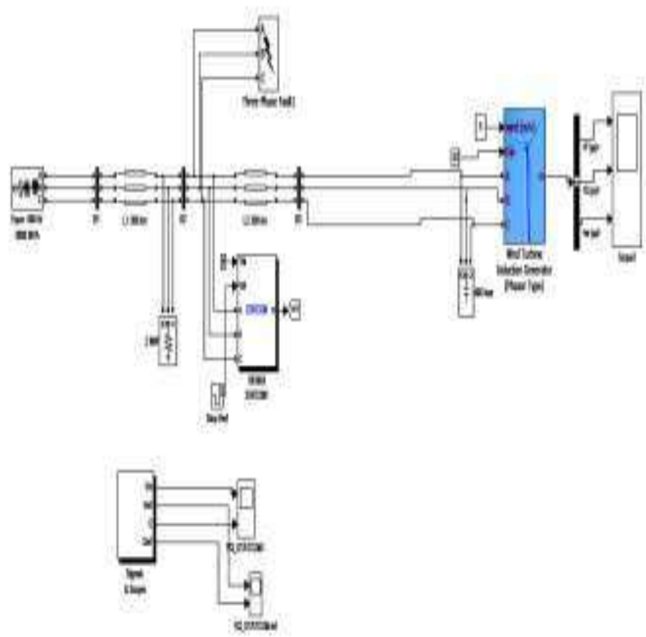


Fig.4.12. Simulation with STATCOM

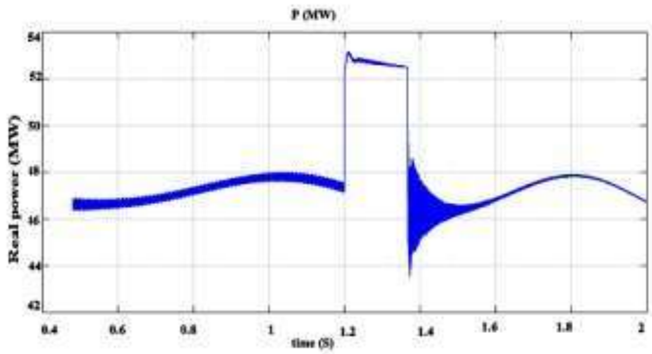



Fig.4.13. Real power in grid with STATCOM

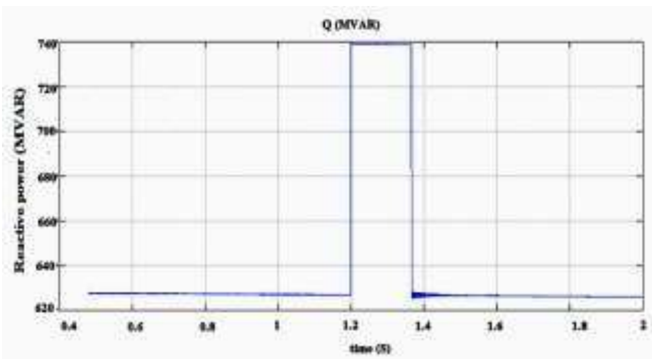



Fig.4.14. Reactive power in grid with STATCOM

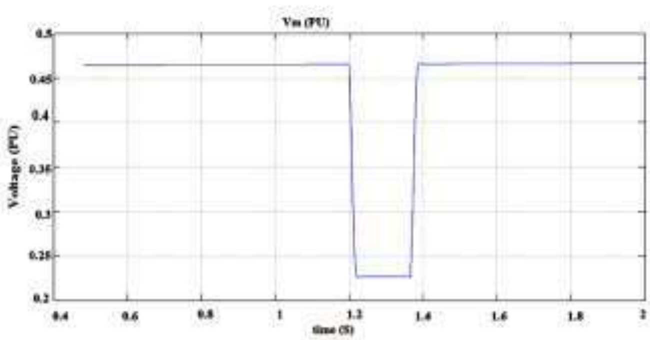



Fig.4.15. Measured voltage by STATCOM

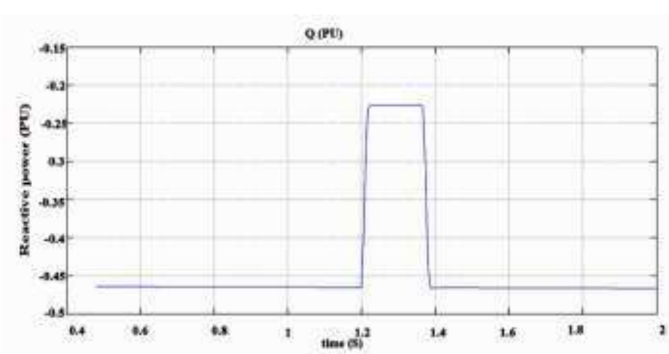



Fig.4.16 Power injection by STATCOM

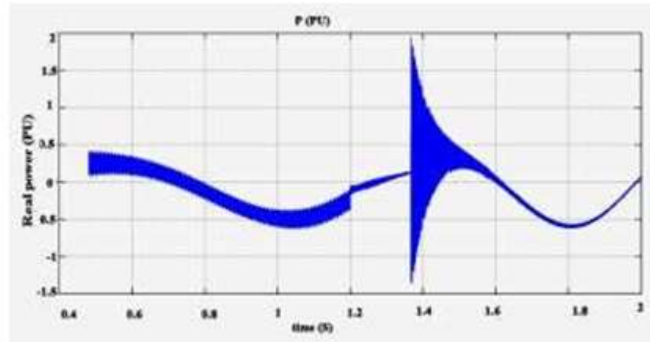
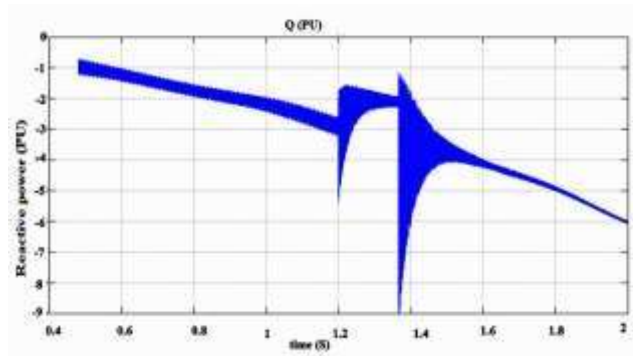



Fig.4.17 Real power for wind turbine with STATCOM




## V. CONCLUSION

When the wind energy is integrated into existing power system will lead to power quality problems. Voltage instability is the major problem which lead to power quality issues. This problem can be solved by injecting or absorbing necessary amount of reactive power. Thus the required amount of reactive power can be supplied to the grid by SVC and STACOM. When comparing the simulated results the injection of reactive power to reach voltage stability can be satisfactory by STATCOM when compared to SVC.

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