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Performance Comparison of SVC and STATCOM controlled Wind farm Energy System

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Abstract: This paper deals with performance comparison of a Static VAr Compensator (SVC) and Static Synchronous Compensator (STATCOM) controlled Wind Farm Energy System. Stability of wind form distribution system is one of the important issues of renewable energy system. The simulation of Fixed Speed Induction Generator (FSIG) is done using MATLAB SIMULINK, and functioning of SVC and STATCOM controlled system has been analyzed for different fault conditions. It is found that during fault condition, the performance of STATCOM controlled system provides better results.

Keywords: Fixed Speed Induction Generator (FSIG); Static Synchronous Compensator (STATCOM); Static VAr Compensator (SVC; Wind Farm Energy System.

INTRODUCTION

Renewable Energy is one of the alternative sources of energy that has become very important and relevant at present day. Renewable energy can be used without using fossil fuels and can be renewed and sustained but were as it is not possible through non-renewable energy. Renewable energy sources are being used in agriculture, industry and social service sector. Renewable energy can be used again and again without depleting. These sources preserve the nature, reduce the health problems and are cost effective, economic and eco friendly. Hence renewable energy sources are crucial for sustainable human life as they do not emit carbon dioxide. Renewable energy has positive effect on the environment, house owners and businesses [1].

Wind energy has confirmed its viability for generation of electricity. Wind farm located in rural areas, which are far away from the grid, generally experience problem in interconnection with grid. Earlier it was a common practice to isolate the wind energy sources on the occurrence of transient disturbance but now a days fault ride through is possible in which they remain connected with power system if a fault occurs near wind farms [2].

The fast development of distributed generation (DG) technology is gradually reshaping the conventional power systems in a number of countries. Wind energy is among the most actively developing distributed generation. Capacity of grid connected wind farm is undergoing the fastest rate of growth of any form of electrical power generation, reaching global yearly growth rates on the range of 20 - 30%.The presence of wind power generation is likely to effect the operation of the existing power system networks. Dynamic changes of wind speed make amount of power injected to a network highly variable. Based upon the intensity and rate of changes, fluctuations in frequency, stability and voltage regulation, could make a visible impact to quality level of electrical energy delivered. In this condition, connection of wind turbine generator with disseminated generation of electricity, calls for an elaborated technical analysis. Majority of the wind power based DG technologies utilize induction generators rather of synchronous generators, for the technical specifications of induction machines like: reduced size, enlarge robustness, decrease cost, and enhanced electromechanical damping [3].

The stability of a system decides whether the system can steady down to the original or close to the steady state after the transients vanish. Transient stability refers to the potentiality of a system to hold synchronous operation in the event of large disturbances such as LG, LLG, LLLG etc. short-circuit faults or switching of lines. The resulting system response affects large excursions of generator rotor angles and is determined by the nonlinear power angle relationship. Stability counts upon both the initial operating conditions of the system and the nature of the disturbance. Recent growth of power electronics brings in the use of FACTS controllers in power systems. FACTS controllers are capable of monitoring the network condition in a rapid manner and this feature of FACTS can be put upon to improve the voltage stability, and steady state and transient constancies of all over power system [4].

To reduce reactive power supplied by grid to wind generators, dynamic compensation of reactive power can be used. Further, the normal operation after the clearance of an external system fault can be improved with dynamic reactive compensation. Without the proper reactive power compensation, it is possible that at some locations only a small rating or less number of wind turbines could be linked due to feeble voltage conditions. Shunt FACTS devices (STATCOM and SVC) can be used for dynamic reactive power compensation of power systems to provide voltage support and stability improvement. The effect of STATCOM and SVC in improving the stability performance of WTIG is analyzed before and after the fault for different sample test systems. [5]

WIND FORM DISTRIBUTION SYSTEM

The MATLAB/SIMULINK can be used for modeling and simulation of the wind farm distribution systems is shown in fig1.The system consists of a 220KV,50-Hz, sub transmission system with short circuit capacity of 2500 MVA, runs a 33 KV distribution system through 220 kV/33kV step down transformer. A test system consisting two wind farm of 24MW (each 12MW) and each wind farm having three unequal capacity (3 MW,4 MW &5 MW) WTIGs are connected to the 33KV distribution system, exports power to 220KV grid through a 50 km transmission line and two loads have been connected to the network. A 20MVA FACTS device is used as reactive power compensator at the common point of coupling.

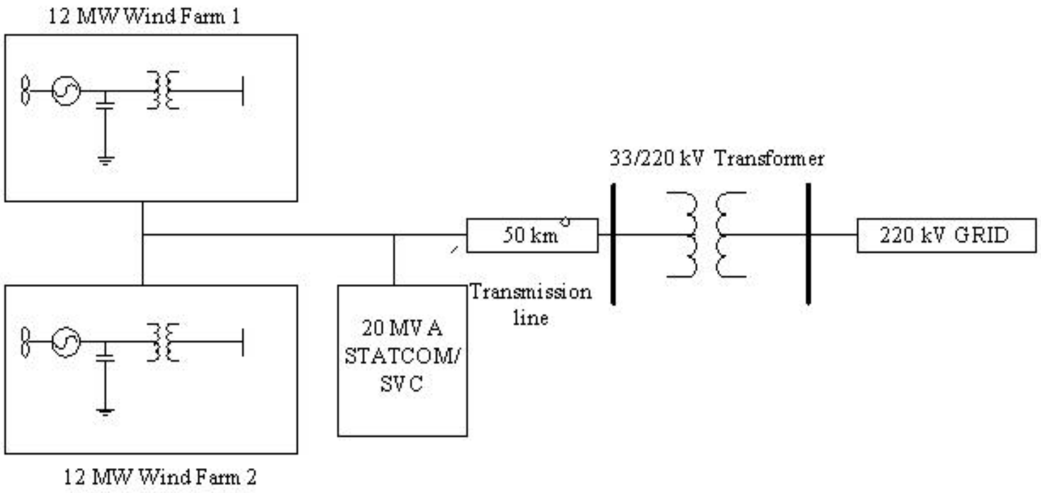

Figure 1. Wind Farm Distribution System

SIMULATION RESULTS AND DISCUSSIONS

Simulation consequences are determined by means of the usage of MATLAB/SIMULINK toolbox. The output of the Voltage, Active, Reactive power and WTIG speed are decided for the Wind Farm distribution system with and without FACTS device before and after fault are shown in fig 2-14. X axis represent Time in Seconds. Four cases are considered for Wind Farm distribution system as explained below.

a) Case 1 (without Fault and without FACTS device):

The reactive power is not enough. So, all WTIGs fail after a few second. There is no lively power injection into the grid from WTIGs. The response of the voltage at common coupling point, active power injected by WTIGs to the grid, reactive power supplied by grid and WTIG speed is shown in Fig 2.

b) Case 2 (With Fault and without FACTS device):

An outside 3 phase fault is implemented close to grid at t =3s in wind farms and the fault is cleared after 3.1s. The device is made to run without facts device. All wind turbines found in wind farms fail to run after few second. Therefore, the system is volatile. There may be no active electricity generation at wind farms. The response of the voltage at common coupling point, active power injected by WTIGs to the grid, reactive power supplied by grid and WTIG speed is shown in Fig 3.

c) Case three (without Fault and with FACTS device):

To restore the stability of the system, a SVC/STATCOM is connected up on the common point of connection. Its miles discovered that a records tool is essential for solid operation of the wind farms. The information tool generates the reactive power required to hold the nominal voltage i.e. 1 p.u. The response of the voltage at common coupling point, active power injected by WTIGs to the grid, reactive power supplied by grid and WTIG speed is shown Fig4.

d) Case 4 (With Fault and with FACTS device):

An external 3 phase fault is applied near grid at t =3s. In wind farms and the fault is cleared after 3.1s. A SVC/STATCOM of 20 MVA is connected on the common point of connection. Now the machine is stable.The result data are shown in table 1 to 5 and response are shown in fig5 to 9 for system with SVC and fig10 to 14 for system with STATCOM with different fault (LG,LLG,LLLG,LL & LLL).

Table 1: For LG Fault.

System with	Voltage (p.u)	Active power (MW)	Reactive power (MVAR)	WTIG speed (p.u)
SVC	0.57	19.48	-8.92	1.019
STATCOM	0.57	20	-9.7	1.018

Table 2: For LLG Fault.

System with	Voltage (p.u)	Active power (MW)	Reactive power (MVAR)	WTIG speed (p.u)
SVC	0.46	13	-16	1.026
STATCOM	0.50	14.65	-18	1.024

Table 3: For LLLG Fault.

System with	Voltage (p.u)	Active power (MW)	Reactive power (MVAR)	WTIG speed (p.u)
SVC	0.25	3	-26.3	1.036
STATCOM	0.28	5.02	-29.4	1.033

Table 4: For LL Fault.

System with	Voltage (p.u)	Active power (MW)	Reactive power (MVAR)	WTIG speed (p.u)
SVC	0.46	15.2	-12.85	1.024
STATCOM	0.58	16.28	-14.75	1.022

Table 5: For LLL Fault.

System with	Voltage (p.u)	Active power (MW)	Reactive power (MVAR)	WTIG speed (p.u)
SVC	0.25	3	-26.5	1.036
STATCOM	0.27	5	-29.5	1.035

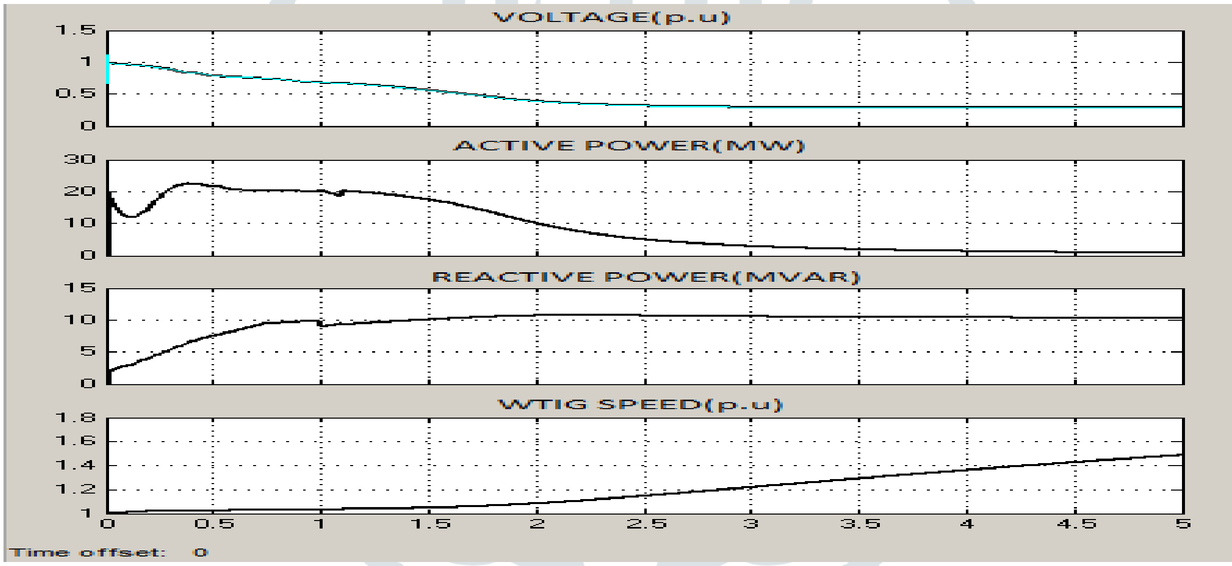

Fig 2:Case1 (without Fault and without FACTS device)

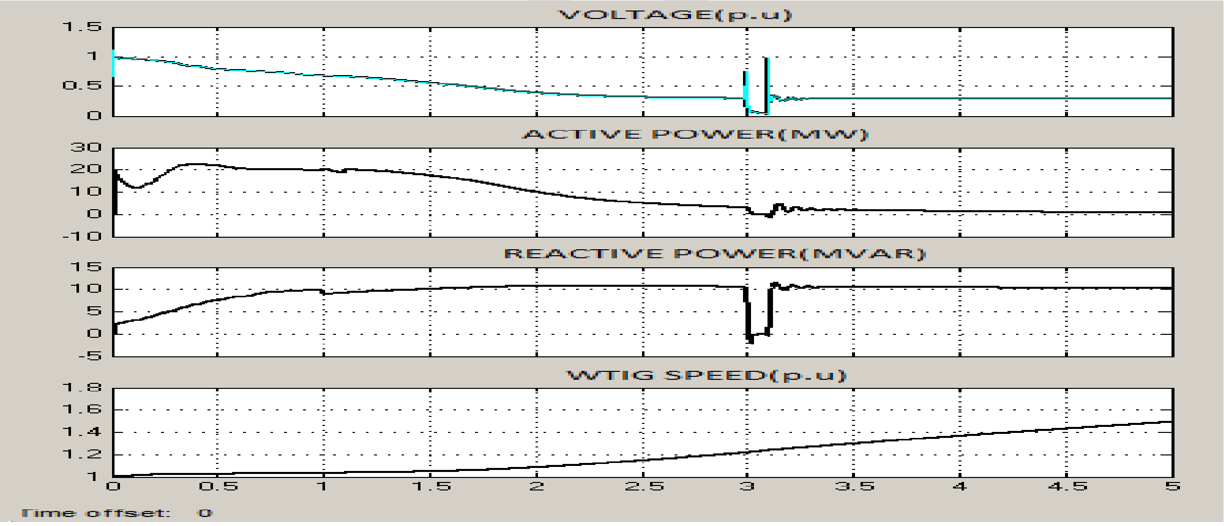

Fig 3:case2 (With Fault and without FACTS device)

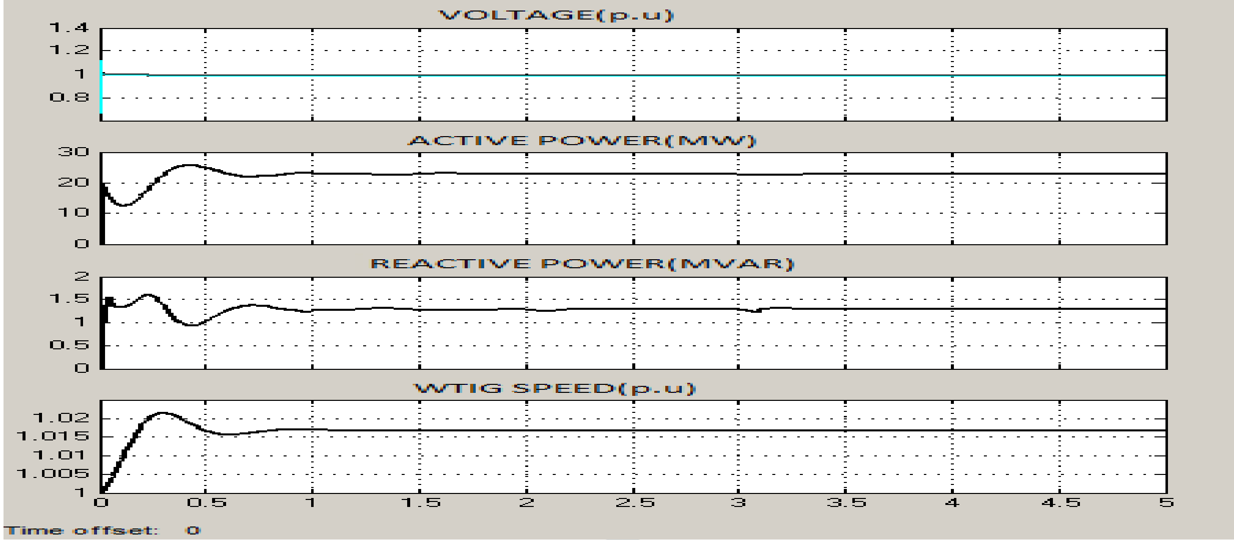

Fig 4:case3 (without Fault and with FACTS device)

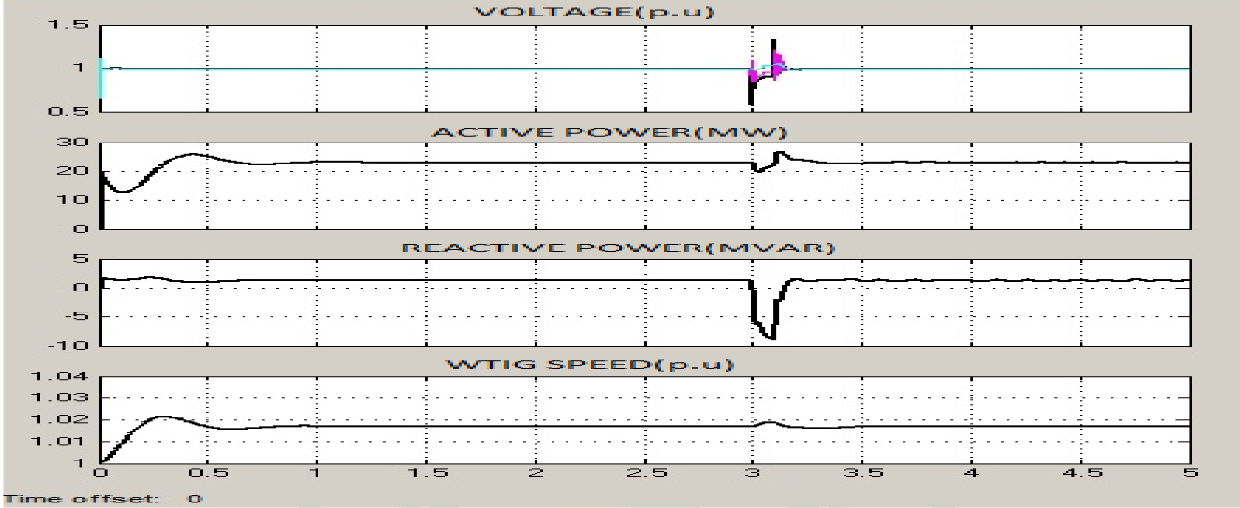

Fig 5:case4 (LG fault) with SVC

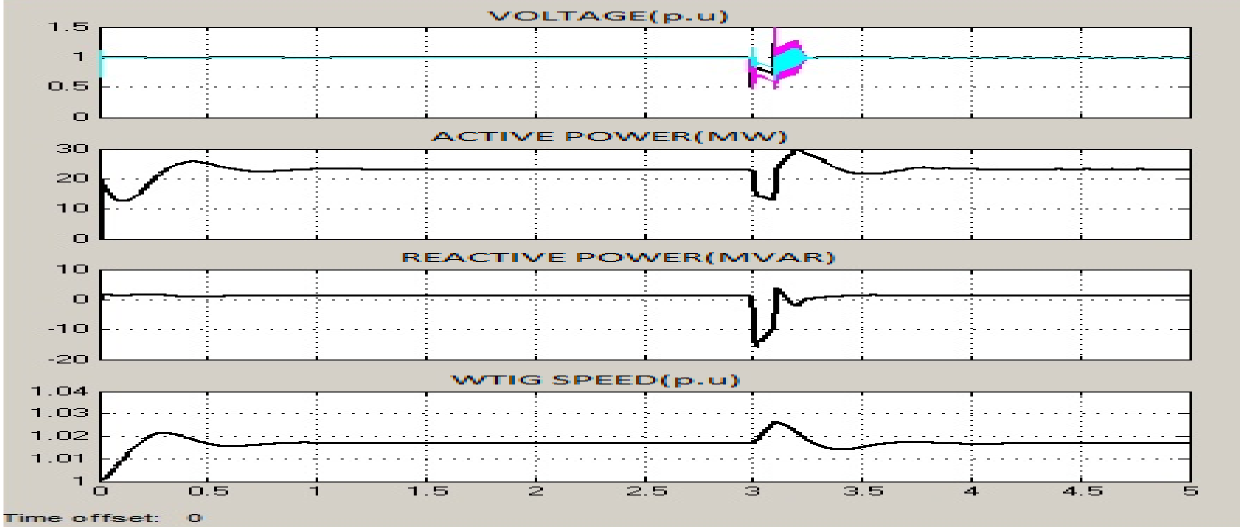

Fig 6:case4 (LLG fault) with SVC

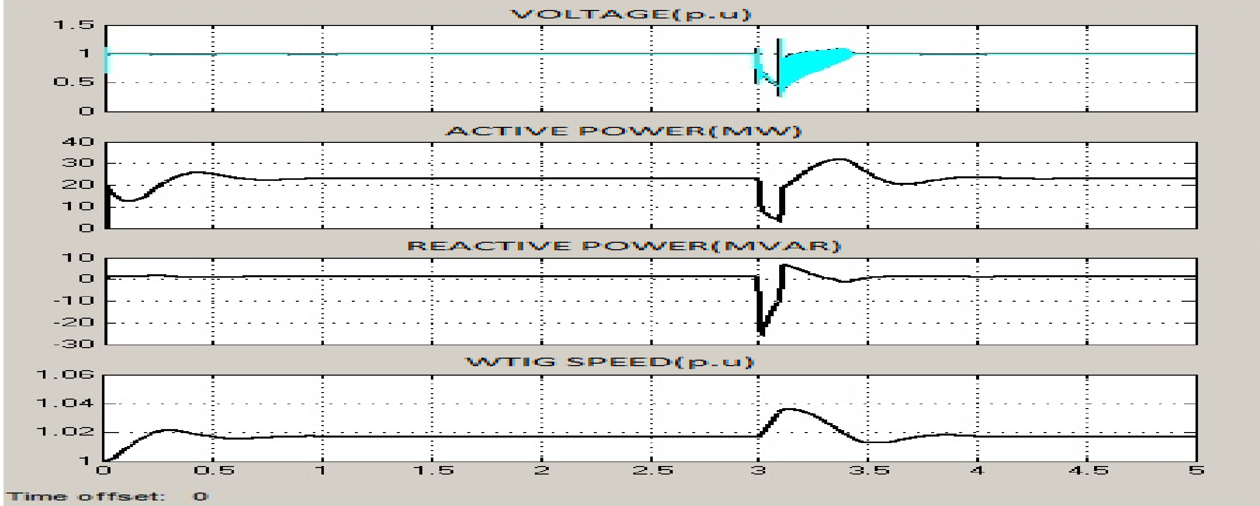

Fig 7:case4 (LLLG fault) with SVC

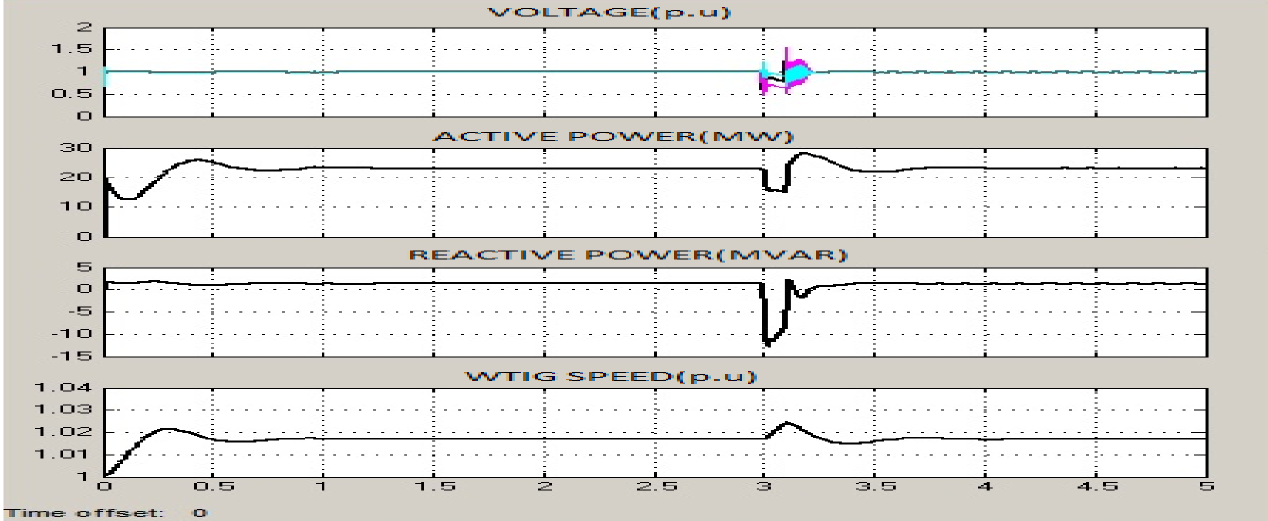

Fig 8:case4 (LL fault) with SVC

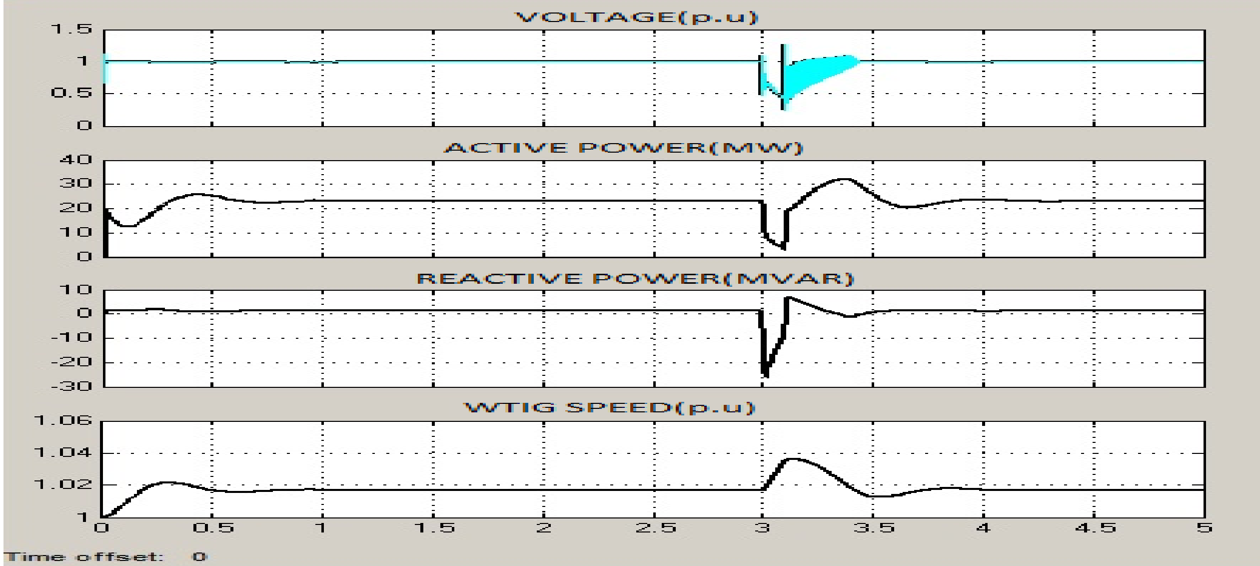

Fig 9:case4 (LLL fault) with SVC

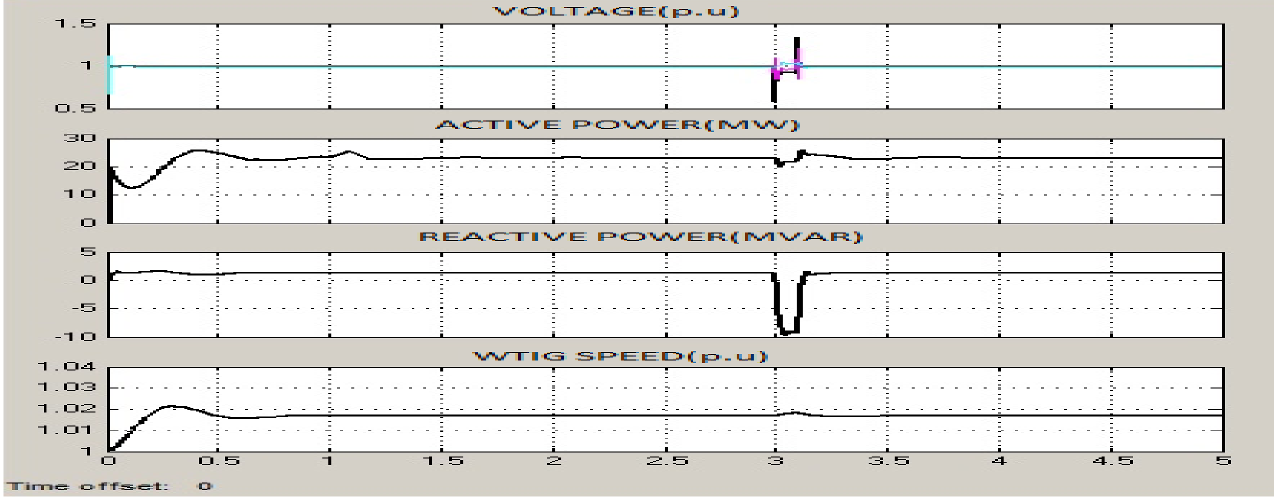

Fig 10:case4 (LG fault) with STATCOM

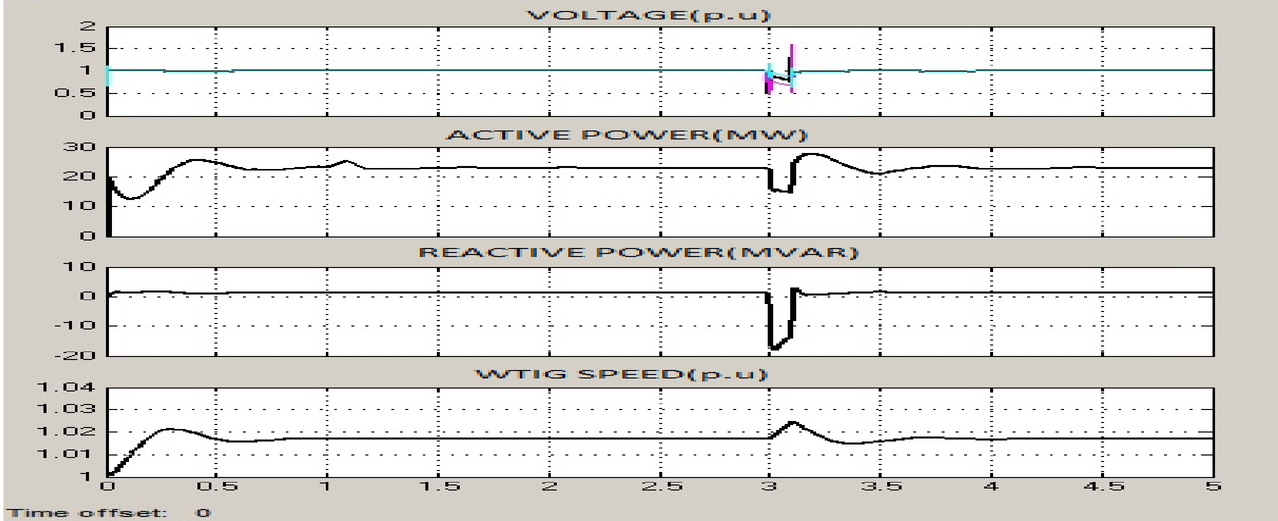

Fig 11:case4 (LLG fault) with STATCOM

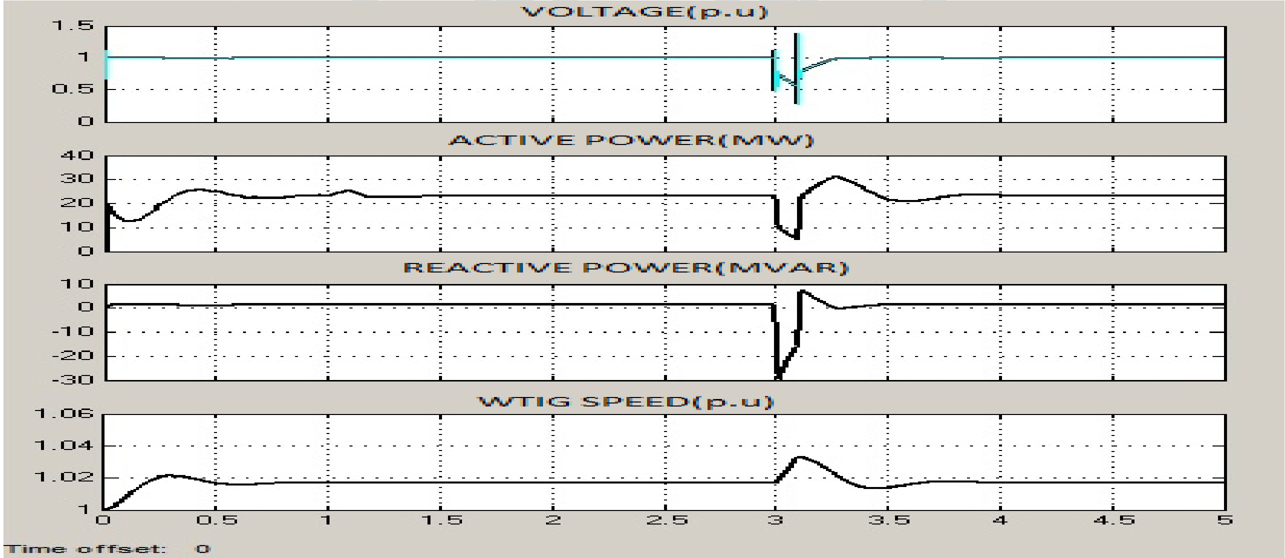

Fig12:case4 (LLLG fault) with STATCOM

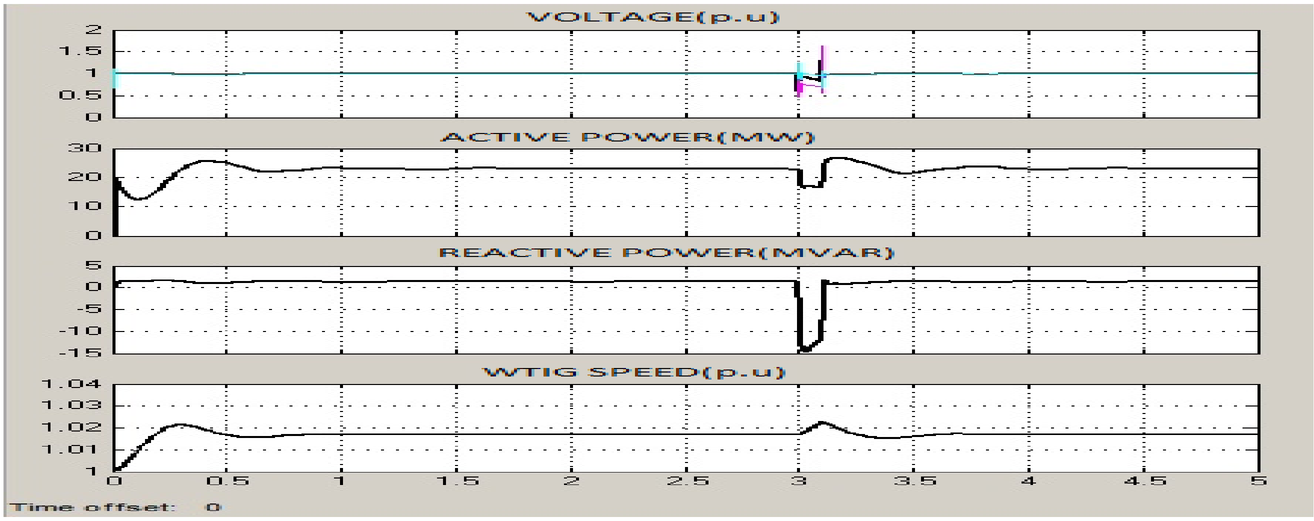

Fig 13:case4(LL fault) with STATCOM

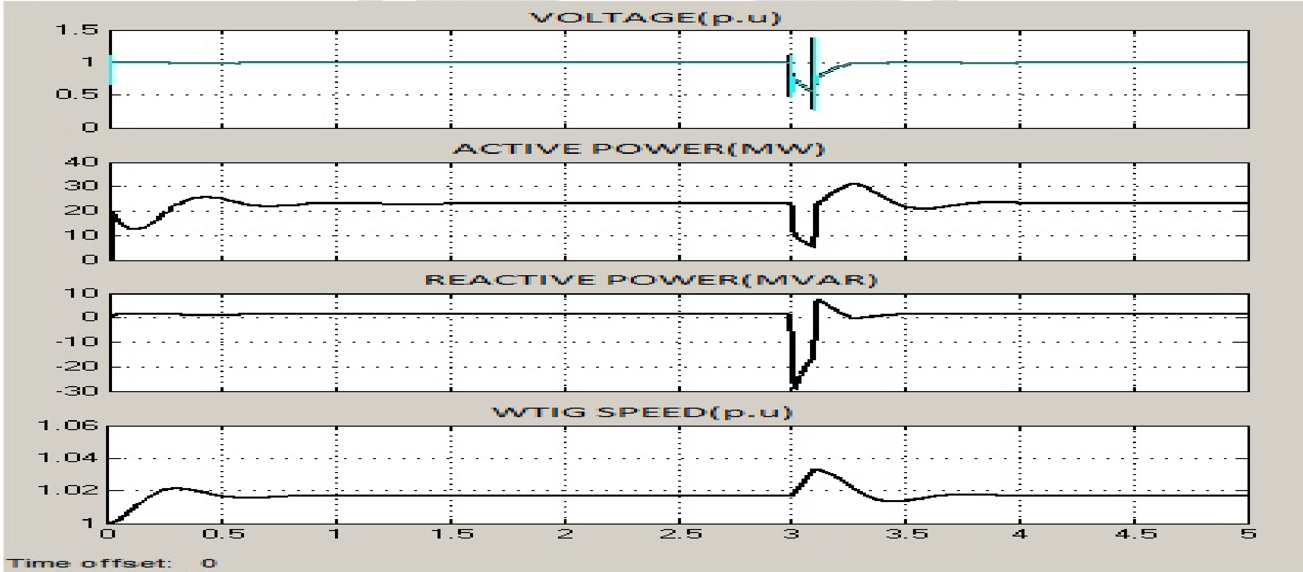

Fig14:case4 (LLL fault) with STATCOM

CONCLUSIONS

FACTS devices are power electronics based reactive compensators that are connected in a power system and are capable of improving the power system performance and the quality of supply. In this thesis system stability of FSIG (fixed speed induction generator) wind farms has been investigated. The dynamic behaviors of the test system with and without the application of an external three-phase fault with and without FACTS devices are investigated. The amount of active power supplied to the grid is more for the cases with FACTS devices than for the cases without FACTS device. It is also found that the WTIG with FACT devices has higher value at terminal voltage then without FACTS device. Consequently, the reactive FACTS device has the ability to raise voltage of the WTIG under disturbance conditions. The performances of a large wind farm equipped with point of common coupling only and equal ratings of FACTS like SVC & STATCOM have been studied. The capacitors connected at the wind generator terminals during faults cannot provide sufficient reactive power especially when the wind generator is connected with a weak grid. Hence FACTS devices like SVC & STATCOM can be used to provide dynamic reactive power support leading to improvement in power system stability. It can be seen from the results obtained from simulation that if the MVA ratings of both the FACTS devices (SVC&STATCOM) is same, STATCOM is the most effective of them during fault and after clearing of fault condition as it is the fastest for improving the system stability as compare to SVC.

APPENDIX

1) Parameters of the wind Generator: Stator resistance=0.016 p.u., Rotor resistance=0.015 p.u., Stator leakage inductance= 0.06 p.u. , Rotor leakage inductance= 0.06 p.u., Mutual inductance= 3.5 p.u., lumped inertia constant=2S.
2) Parameters of SVC: Nominal Voltage= 33 KV, Reactive Power limits= +/-20 MVAr, Frequency= 50HZ, Kp, Ki= 0,300.
3) Parameters of STATCOM: Nominal Voltage= 33 KV, Converter rating= 20 MVA, D.C link Nominal Voltage= 40,000, Frequency= 50 Hz, Kp, Ki= 5, 1000.

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