REACTIVE POWER COMPENSATION BY STATCOM IN MULTI MACHINE POWER SYSTEM INTEGRATED WITH WIND POWER

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***Abstract*: This thesis deals with the process of Voltage Adjustments at the Bus near the wind turbine which is connected to a 9 bus power system. The process of varying the Voltage is carried out by using Shunt FACTS Device STATCOM.As the wind power input to the wind turbine is variable time to time. This leads to the variations in the bus voltage due to the variations in the reactive power drawn by the wind turbine. So, in order to overcome this problem, we are using a power electronic based FACTS Controller device STATCOM. The variations in the magnitude of the bus voltage near Wind turbine are stabilized by the process of Automatic Voltage Control mode of operation in STATCOM.**

***Keywords*: 9-Bus power system, STATCOM, FACTS Controllers, Doubly Fed Induction Generator Wind Turbine.**

I. Introduction:

Power system Interconnection is the common thing now a day's which means the connection of various types of Generating stations and loads in a specific area. Instead of connecting a single source to load and delivering power, we have a provision of drawing power from multiple sources at a time. So, the reliability of power supply to the consumer increases by using this technique. The interconnected power system will run in stable region if all the Generating sources are capable of producing constant power. But, it is not possible when a Wind power system is a part of the interconnected network. Because, the input torque for the wind power generation is not constant and in addition, it draws Reactive power from the power system. This might not disturb the power system if the rating of the Wind Energy system is smaller compared to other sources. If the rating of the wind power system is same or more than the ratings of other sources(which is not practical), it will definitely causes disturbance to the connected network, so, suitable measures such as usage of FACTS devices should be implemented to avoid disturbances at the bus where a wind energy system is connected.

II. Modeling of DFIG Wind Turbine:

DFIG wind turbine is the most reliable and high power generation capable device. This device differs from other in the rotor side connection. The rotor of this type of turbine is connected to the power system through a bi directional converter. The schematic diagram of DFIG is as shown below.

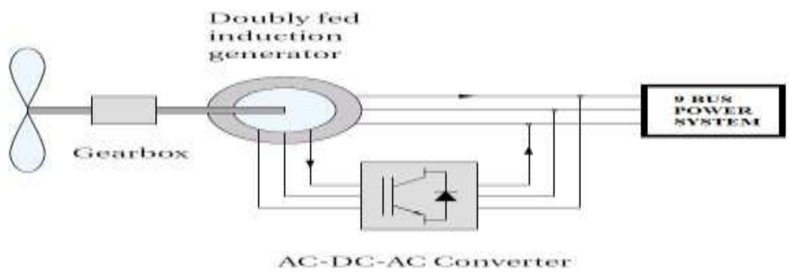

Fig.1. Schematic arrangement of a DFIG wind Turbine.

The arrangement of stator and the rotor connections will be as shown in above figure. The rotor side connection is basically meant for the exchange of Reactive power and the stator is meant for supplying the apparent power to the power system network. When the turbine is running at low speed i.e., at sub synchronous speed, rotor absorbs reactive power from the power system network through converter. When it is run at higher speeds i.e., super synchronous speeds, the converter supplies the power to the powers system network through Converter. As the power exchange is going on from both rotor side and stator side, the power capability of the wind turbine will be increased when compared to the singly fed wind turbine.

The Blade pitch angle adjustment based on the input wind will be controlled by using a PI controller. When the electrical power generated is below its nominal value, the pitch angle will be zero. When electrical power generated is more than the nominal value, the pitch angle is increased by PI controller to pull it back to its nominal value. The conventional diagram and Simulink diagram of the DFIG Wind turbine will be as shown below.

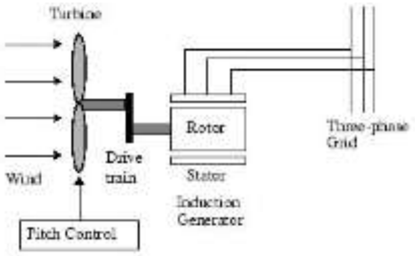

Fig.2: Conventional model of Induction type wind Turbine.

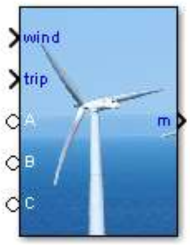

Fig.3:Simulink model of Wind Turbine Induction generator

III. Modeling of STATCOM:

STATCOM is a shunt type of FACTS device which is used to regulate the voltage at the point where it is connected. As the process of voltage stabilization is required by the Wind turbine, the shunt type of device called STATCOM is chosen. STATCOM constitute of a converter and an energy source (basically Capacitor) in parallel. Firing angle of the switches controls converter configuration based on the required amount of voltage to be compensated. The conventional model of STATCOM will be as shown in Fig.4. And the Simulink model of STATCOM will be as shown in Fig.5.When the terminal voltage at the STATCOM is reduced than the previous value, STATCOM injects the leading Vars to improve the voltage to the normal value. If the terminal voltage is more than the normal value, the STATCOM absorbs the power from the terminal to reduce it to normal value.
STATCOM has two Operating modes based on the controlling procedure. They are as below:
1) Var Control Method
2) Automatic Voltage Regulation method.
In Var control method, the reference s taken from the remote location i.e., Reactive power or the Active power and is compared with the pre existed values and the STATCOM are operated based on the change in the reference values.
In AVR method, the reference is not taken from anywhere else. The connected terminals of the STATCOM itself acts as sensing and the STATCOM delivers power based on the change occurred. As in this method no other reference is taken and STATCOM terminals itself acts as sensing elements, this is said to be Automatic Voltage Regulation Method.

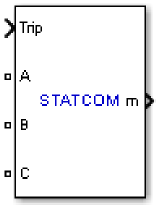

Fig.4: Simulink model of STATCOM

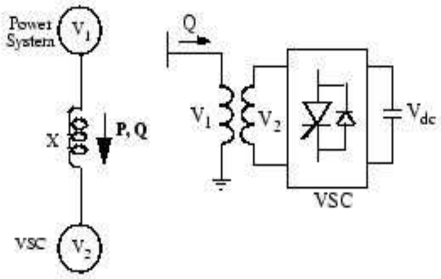

Fig.5: Conventional Model of STATCOM

III. Modeling of a Nine Bus Power System:

The Nine Bus power system is designed such as to meet the practical power system Considerations. By doing this the power flow analysis can be carried on the realistic power system and the implementation of the modern techniques can be easily done. The basic block diagram will be as shown in Fig.6. And the Simulink diagram designed using MATLAB software is as shown in fig.8. The different elements that are used in the Nine Bus power System and the ratings of them are shown in Fig.7.

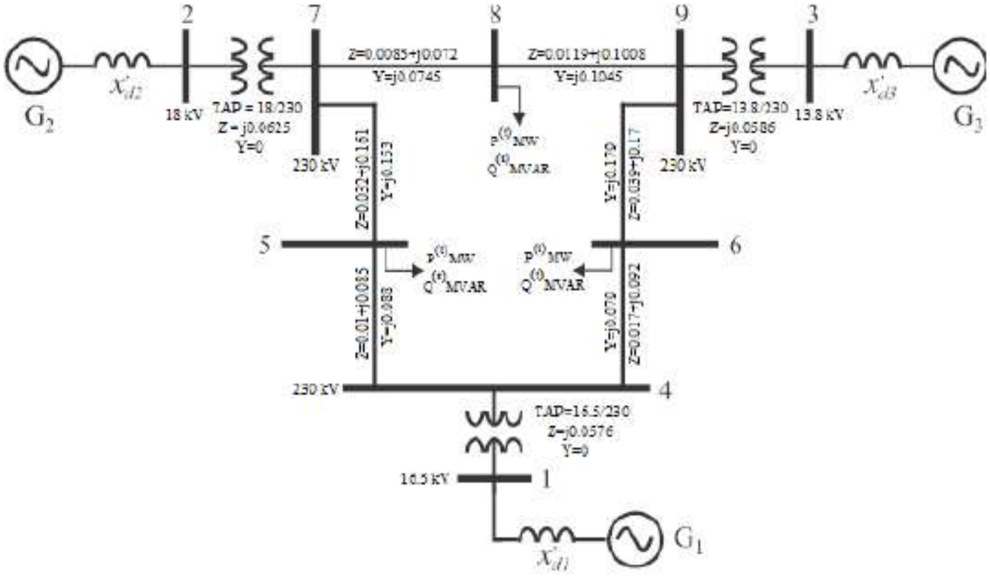

Fig.6. Conventional Diagram of a 9 bus Power System.

Name of the Equipment	Number	Rating of the Equipment
Alternator	1	3-ph, 50HZ,16.3 KV, 72MVA
	1	3-ph, 50HZ,18KV, 163 MVA
	1	3-ph, 50HZ,13.8 KV, 85MVA
Transformer	1	3-ph, 50HZ, 16.3KV / 230 KV, 72MVA
	1	3-ph, 50HZ, 18KV/ 230KV, 163MVA
	1	3-ph, 50HZ, 13.8KV / 230 KV, 85MVA
Series RLC Load	3	3-ph, 50HZ,230 KV, 125MW,50MVAR, RL-LOAD
		3-ph, 50HZ,230 KV, 100MW, 35 MVAR, RL-LOAD
		3-ph, 50HZ,230 KV, 90MW, 30MVAR,R L-LOAD
STATCOM	1	3-ph,50HZ,575V,200KVA
Wind Turbine	1	3-ph,50HZ,575V,400KVA

Fig.7. Ratings Description of Equipment used.

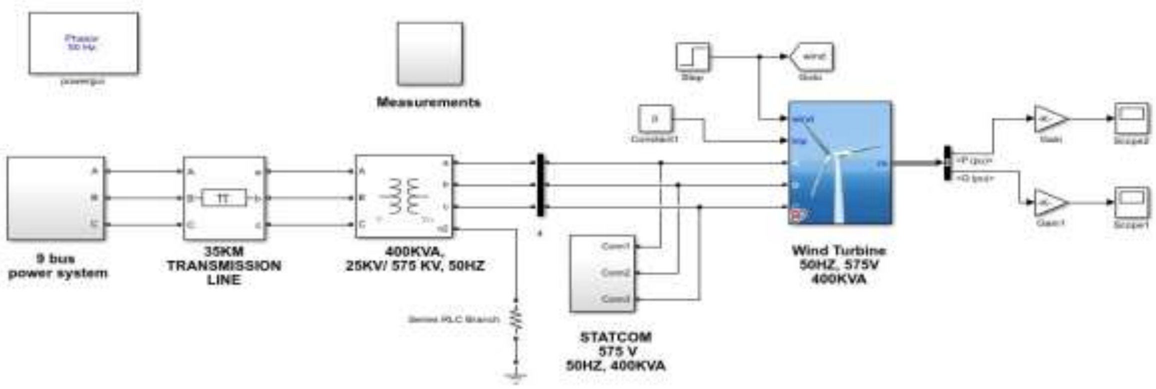

Fig8: Overall Simulink Diagram

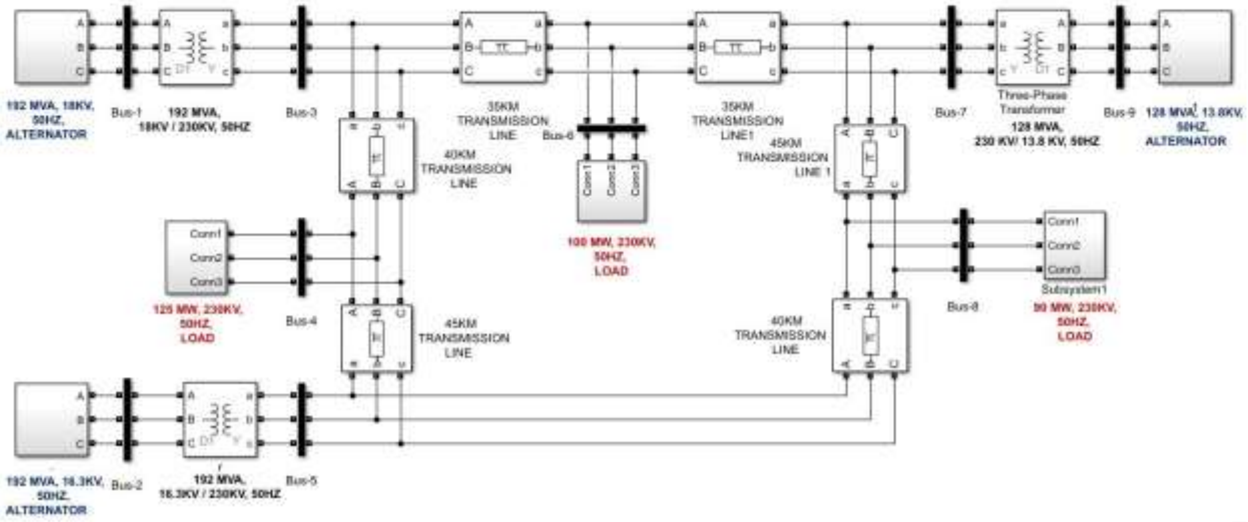

Fig.4: Simulink diagram of a 9 Bus power system.

IV. Responses:

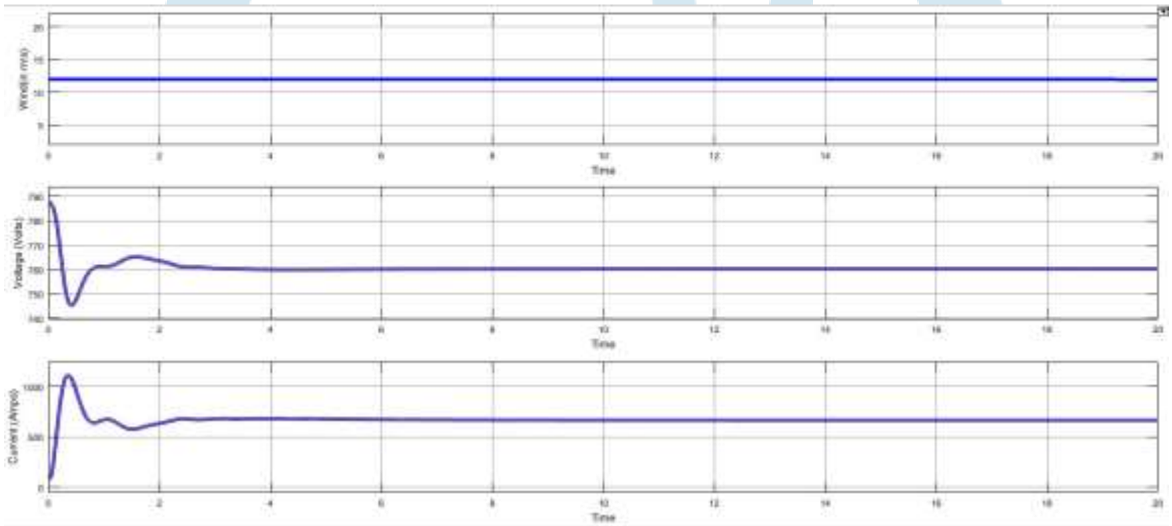

Fig.5: measurements at the Wind turbine without STATCOM.

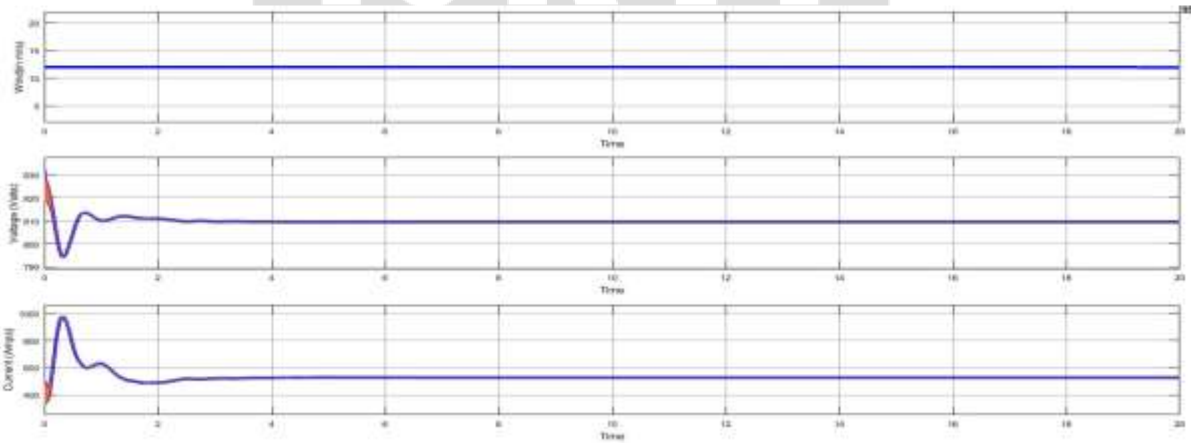

Fig.6: measurements at the Wind turbine with STATCOM.

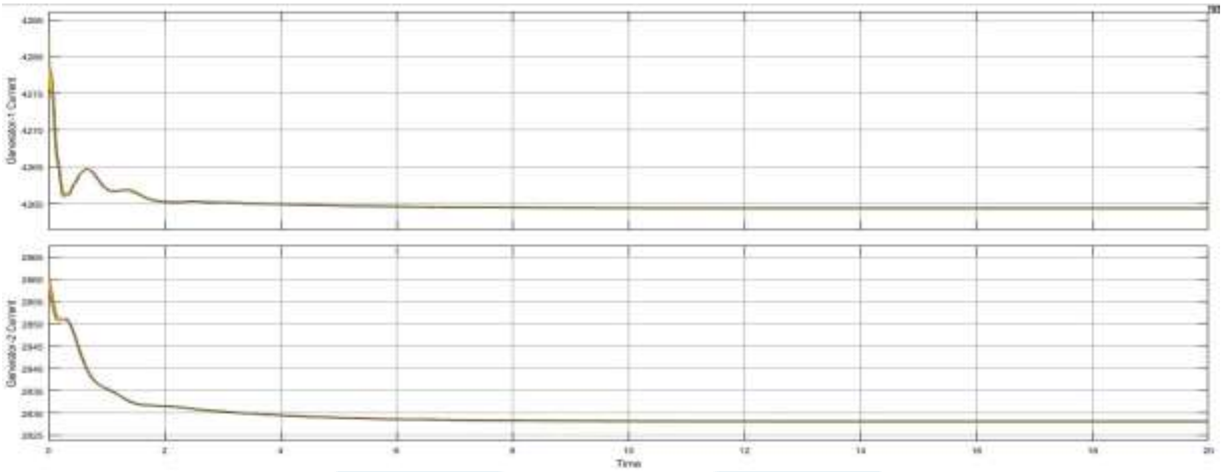

Fig.7: Generator Currents without STATCOM.

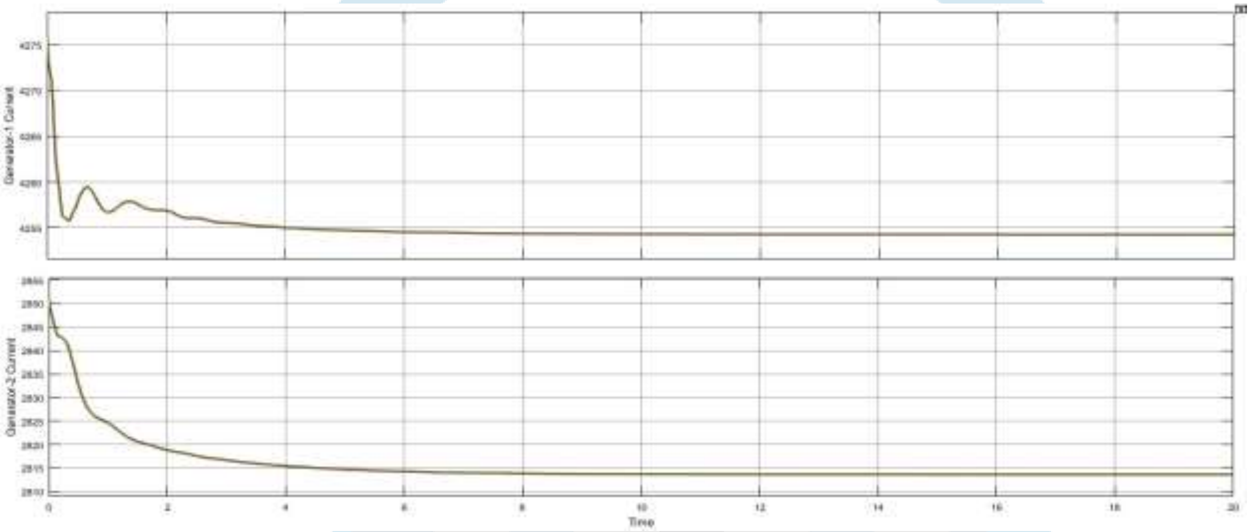

Fig.8: Generator Currents with STATCOM.

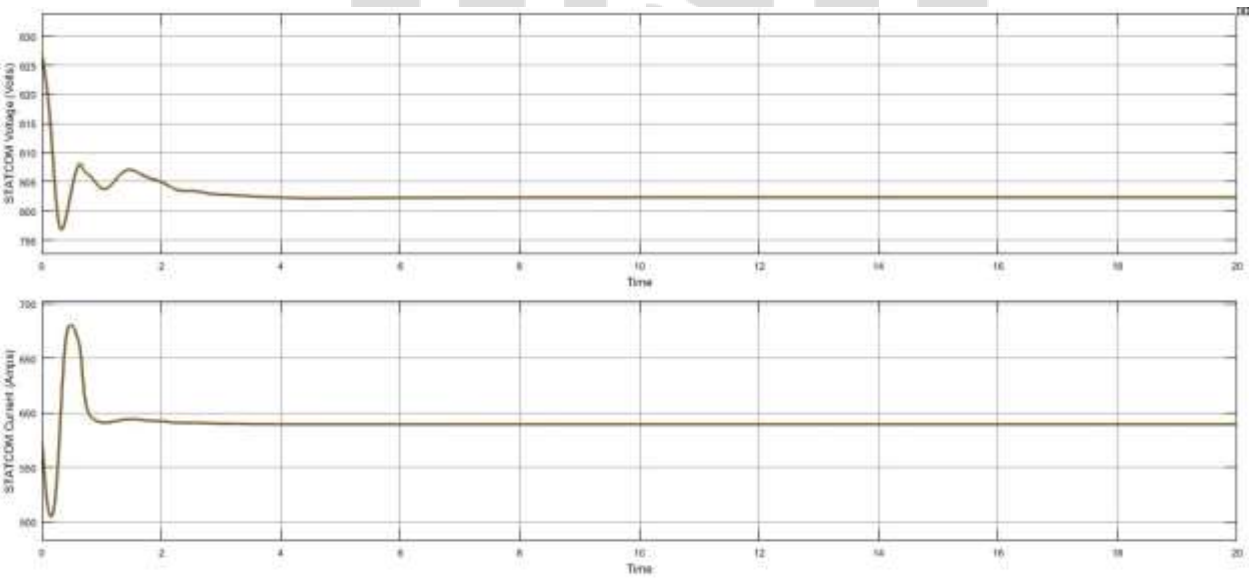

Fig.9: STATCOM Voltage and Currents.

V. Observation from Results:

Quantity	Without STATCOM	With STATCOM
Vwind (volts)	760	810
Iwind (Amps)	600	550
Igen1(Amps)	4260	4250
Igen2(Amps)	2830	2813
Vstat (volts)	0	802.5
Istat(Amps)	0	590

VI. Conclusion:

By the process of implementing AVR method of STATCOM, the Voltage of the Bus where the STATCOM is connected is sensed automatically and the voltage is balanced by the process of exchanging the power between the Bus and STATCOM. The Indirect help the STATCOM is doing in the power system is reducing the burden on the Sources used in the power system by supplying the required Reactive power by the Wind Turbine. This method further improves the Power transfer capability of the transmission lines used in the power system.

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