STATCOM based Voltage Magnitude improvement in wind system integrated with Grid

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***Abstract*: The present energy scenario indicates that demand for electricity is increasing rapidly andin order to supply this entire demand, utilities are concentrating on non-conventional energy sources; but these non-conventional sources have their owninherent problems when connected to grid, such as voltage swell or sag, flickers, harmonics & transients. In order to make these energy sources to operate with grid feasibly and efficiently a STATCOM controller based strategy is presented in this paper. Wind generation depends upon the wind speed in turn the voltage varies as the wind speed varies Hence, in order to maintain constant output voltage STATCOM can be used. This paper presents the Simulation carried out in Mat Lab Simulink and the results.**

Key words: PCC, STATCOM, wind energy, voltage swell or sag.

I. INTRODUCTION

Electricity is base line for any process or operation in the present 21st century; because of its many advantages it has got huge response in terms of demand. But the fact is that entire demand, can't be met as there are no sources to meet the present load demand. Hence utilities concentrate on harvesting of non-conventional energy sources. One such source is wind energy generation. Wind energy is one of the promising non-conventional energy sources and presently there is 194.4 GW of installed capacity worldwide. But as this is a renewable energy source, which mainly depends on the wind speed hence Whenever there is high wind speed then electricity generation will be high resulting in voltage swell at the common point and similarly when the wind speed is low, generation will be low resulting in voltage sag. These are the two main problems which made integration of wind source with grid difficult. In order to make this interconnection possible, reactive power compensation based approach is presented. Where the compensator is a shunt connected device STATCOM. This is basically a thyristors based controller which has the capacity to either increase the voltage level or to decrease the voltage level where ever it is connected by reactive power absorption or injection.

II. REACTIVE POWER &STATCOM

Reactive power can be defined as **"The fictitious power that is present in AC system which will not do any useful work but the presence is very must for the proper operation of the system".**in the normal operation of power system the presence of reactive power plays a very important role. Variation of reactive power above or below the preset bounds would cause severe malfunctioning of the system. We know that our power system consists of inductive loads and a result the system absorbs reactive power. Hence in order to supply reactive power capacitor banks are been used. Under any disturbance conditions the need of reactive power varies and in order to compensate the system STATCOM can be used. STATCOM is a parallel connected FACTS family device which can be used to maintain the system voltage under normal as well as abnormal conditions. It consists of a VSC and a DC link. In the VSC the converter uses IGBT's to convert AC to DC and vice versa. Where the amount of current flowing through depends on the firing angle, the advantages of STATCOM are:

- Instantaneous operation.
- The need of large space is eliminated as the device is compact.
- The device can be easily relocated to any place.
- STATCOM provides the interconnection to either DC link or real power.
- Voltage magnitude correction.
- Highly efficient and reliable.

Figure shows the block diagram of STATCOM connected to the AC system. It consists of VSC (Voltage Source Converter), leakage reactance, coupling transformer, DC batteries or capacitor bank. The VSC is a 12 pulse IGBT system and the pulses are generated from pulse generating circuit. Batteries acts as an electrical source. Usually instead of battery banks capacitor banks are used.

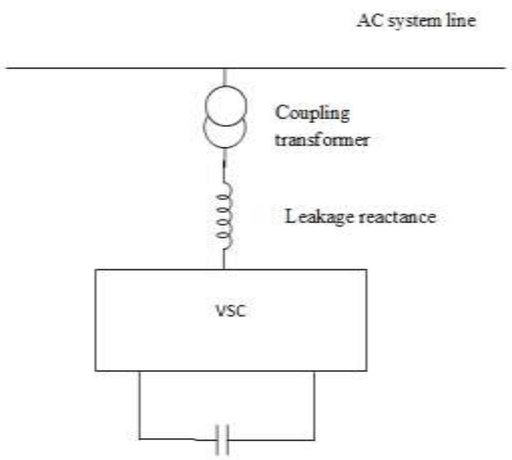

Fig 1: block diagram of STATCOM

The power flow in STATCOM is in either direction depending on the voltage value at PCC. STATCOM will produce reactive power and also absorb reactive power when it is needed

III. MODES OF OPERATION

The operation of STATCOM has been divided into 3 modes based upon the voltage magnitude across its terminals

a) Inductive Mode
b) Capacitive Mode
c) Trickling Mode

A) Inductive Mode:
Whenever the STATCOM terminal voltage is greater than the reference voltage then the operation is termed as inductive mode of operation. Here the STATCOM absorbs the reactive power from the line to charge the batteries. Hence STATCOM basically acts as a load to draw power from the line so as to maintain constant voltage across point of common coupling.
This mode of operation is represented in the right side of the VI characteristics.

B) Capacitive Mode:
Whenever the STATCOM terminal voltage is lesser than the reference voltage then the mode of operation is termed as capacitive. Here the STATCOM injects the reactive power into grid such that the voltage must be equal to the reference voltage. Hence the STATCOM basically acts like a generating source to maintain the voltage at point of common coupling.
This mode of operation is represented in the left hand side of VI characteristics.

C) Trickling Mode:
This is an ideal case of operation where the terminal voltage is equal to the reference voltage hence STATCOM acts as an ideal device and will not do anything.

IV. SIMULATION & CASE STUDY WITH WIND FARMS

In order to verify the STATCOM feasibility and to show the reactive power compensation, a simulative case study with wind farm (asynchronous generation by variable wind speed) is done in MatLab Simulink platform, whose detailed information is given here, the single line diagram of the simulation is as shown in the figure.

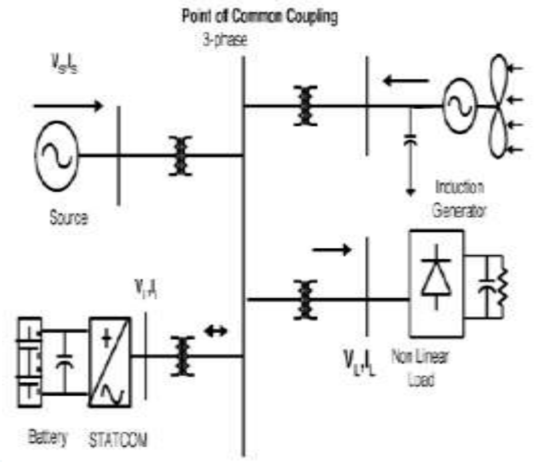

Fig: block diagram of simulation

The case study is based on the following parameters

Parameter	**Rating**
source	120 KV, 250 MVA
Distribution	25 KV, 47 MVA
Transmission line	L=1h, c=11e-9f
Induction generator	10 MVA, R_s=0.004843, R_r=0.004347, L_s=0.1248, L_r=0.1791
Inverter	IGBT 3 arms, 12 pulse, Frequency=1080 hz, Sample time=5 μs.
DC link	2400v
Filter	L=800 mH, C=100 e-06 F
PI controller	Kp=0.8, Ki=200
Wind speed	9m/s

Table: design parameters of the case study

Here a 12 pulse inverter combination is considered because of its advantage of eliminating tripled harmonics. The controller circuit is a PI controller type where the proportional and integral gains are suitably adjusted to operate the STATCOM in corresponding modes. The inductor and capacitor forms the filter circuit to eliminate the unwanted harmonic signals and then transformers step up the voltage level to 25 KV to feed into PCC (point of common coupling).

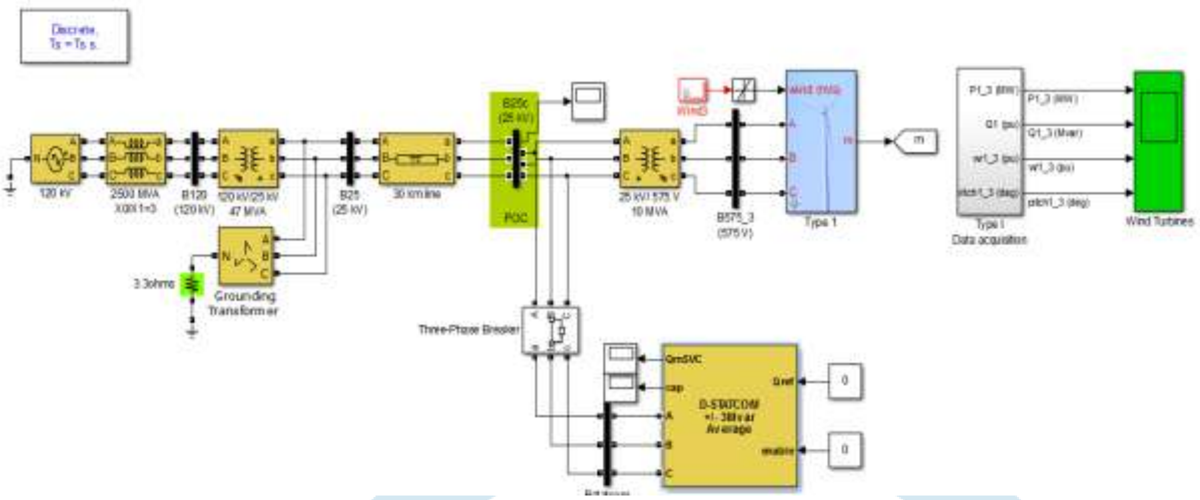

Fig: simulation model of wind energy connected to grid with STATCOM

The overall Mat Lab Simulink model is as shown in figure. The simulation is carried out for 10 second duration with wind variation from 9 m/s to 12 m/s nonlinear. Hence a voltage swells and sag condition is simulated without STATCOM. Next with STATCOM connected at PCC voltage remains constant which can be justified from output voltage waveforms. The PCC voltage when STATCOM is not connected and then when STATCOM is connected is as shown

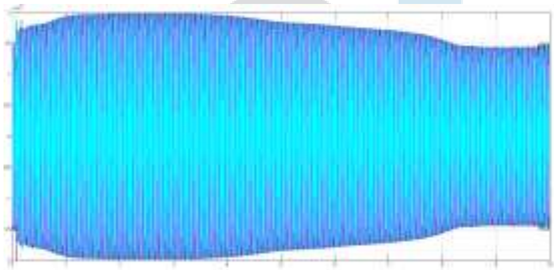

Fig: PCC voltage when STATCOM is not connected

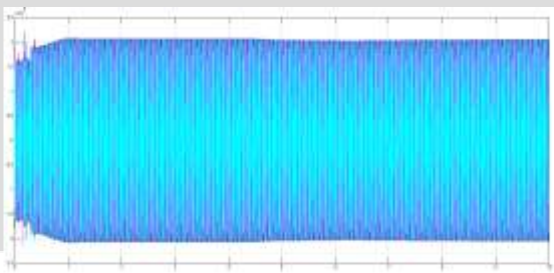

Fig: PCC voltage when STATCOM is connected

V. CONCLUSION & SCOPE FOR FUTURE WORK

From the above simulation and results we can state that this STATCOM based reactive power compensation technique for maintaining the voltage magnitude at PCC is proven feasible and efficient. The future work lies in applying this device for practical testing and development of prototype circuit.

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