MITAGATION OF VOLTAGE SAG AND HARMONICS IN GRID CONNECTED WIND ENERGY SYSTEM USING STATCOM

JidnyasaRamteke, KalyaniDhawad, Swati Shende

Smt. RajshreeMulak College of Engineering for Women, Nagpur.

***Abstract*-When the wind power is connected to an electric grid affects the power quality. Various power quality problems results in failure of mal-operation of end user equipment. Some of the major power quality issues are voltage sag, voltage swell, flicker and harmonics. To solve these problems it is proposed to use Flexible AC Transmission System (FACTS) devices for mitigation of power quality problems. STATCOM is one of the key FACTS controller. The essential features of the STATCOMis that it has the ability to absorb or inject fastly the reactive power with power grid. This paper recommends a control scheme base on Instantaneous PQ Theory with basic PWM technique for compensating the reactive power requirement of a three phase grid connected wind energy generating system along with mitigation of harmonics produced by non-linear load connected at PCC (Point of Common Coupling) using STATCOM. The device is modeled and simulated using MATLAB-SIMULINK. Simulation has been carried out to demonstrate the performance of the STATCOM in achieving the voltage sag and harmonics mitigation and stability of the wind energy grid connected system.**

Keywords-Power quality, voltage sag, harmonics, wind power system, STATCOM (Static Synchronous Compensator).

I. INTRODUCTION

NOWADAYS, wind has a significant proportion of non-pollutant energy generation, is widely used. If a large wind farm, which electrically is far away from its connection point to power system, is not fed by adequate power, it present major instability problems. Induction machines are mostly used as generator in wind power based generation. Induction generator draws reactive power from the grid to which they are

Power quality. A non-linear load on a power system is typically a rectifier load, some kind of arc discharge devices such as fluorescent lamp, electric welding machine, arc furnace; because current in these system is interrupted by a switching action, the current contains frequency components that are multiples of power system frequency. It changes the shape of current waveform and also creates harmonics. It is a sinusoidal component of periodic wave having a frequency that is an integral multiple of the fundamental frequency. Due to instant switching of inductive load voltage profile is disturbed. Voltage sag is defined as a short duration reduction of the root mean square (rms) value of AC voltage lasting between half a cycle and several cycles. STATCOMs are part of the flexible alternating current transmission systems (FACTS) device family. Their primary purpose is to supply a fast-acting, precise, and adjustable amount of reactive power to the ac power system to which they are connected the use of STATCOM helps to regulate system voltage and to improve dynamic stability.STATCOMs can be used for voltage compensation at the receiver end of ac transmission lines, thus replacing banks of shunt capacitors. When used for this purpose, STATCOMs offer a number of advantages over banks of shunt capacitors, such as much tighter control of the voltage compensation at the receiver end of the ac transmission line and increased line stability during load variations.

STATCOM applications include the following;

- Stabilization of weak system voltage
- Reduced transmission losses
- Enhance transmission capacity
- Improve power factor
- Reduce harmonics
- Flicker mitigation
- Assist voltage after grid faults.

II. METHODOLOGY

GTO based FACTS Controller –

The thyristor, having no current interruption capability, changes from on-state to off-state when the current drops below the holding current and, therefore, has a serious deficiency that prevents its use in switched mode applications. With the development of the high voltage, high current Gate Turn-Off thyristors (GTOs), it became possible to overcome this deficiency. Like the normal thyristor, a gate current pulse can turn on the GTO thyristor, while to turn it off, a negative gate-cathode voltage can be applied at any time. This feature and the improved ratings of GTOs made possible the use of Voltage-Sourced Converters (VSC) in power system applications. If a VSC is connected to the transmission system via a shunt transformer, it can generate or absorb reactive power from the bus to which it is connected. Such a controller is called Synchronous Static Compensator or STATCOM and is used for voltage control in transmission systems. The major advantage of a STATCOM, as compared to a SVC, is its reduced size,sometimes even to less than 50 %, and a potential cost reduction achieved from the elimination of capacitor and reactor banks as well as other passive components required by the SVC.

III. STATCOM APPLICATION IN TRANSMISSION LINE

STATCOM is a shunt connected reactive power compensation device. It is a solid state switching converter capable of generating or absorbing reactive power at its output terminals. The STATCOM is a Voltage Source Converter (VSC) in which the input dc voltage produces a set of three phase AC output voltages. All the three phase voltages are displaced equally in phase and coupled to the corresponding AC system voltage through a small reactance. The input DC voltage is provided by an energy storage capacitor. The input capacitor of VSC acts as a DC voltage source. There are two modes of operation of a STATCOM, inductive mode and capacitive mode.

Advantages of STATCOM compared to other shunt compensators include –

- Size, weight and cost reduction
- Precise and continuous reactive power control with fast response
- Possible active harmonic filter capability.

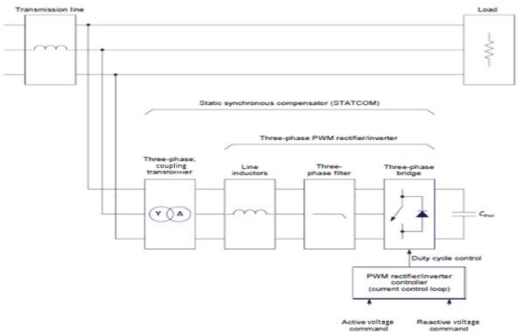


Fig.1 Single line diagram of STATCOM

IV. STATCOM OPERATIONAL SCHEME IN GRID CONNECTD WIND ENERGY SYSTEM

The STATCOM is connected to the power system at a PCC, through a coupling transformer, where the voltage-quality problem is a concern. It provides voltage support by generating or. absorbing reactive power at the PCC without the need of large external reactors or capacitor banks

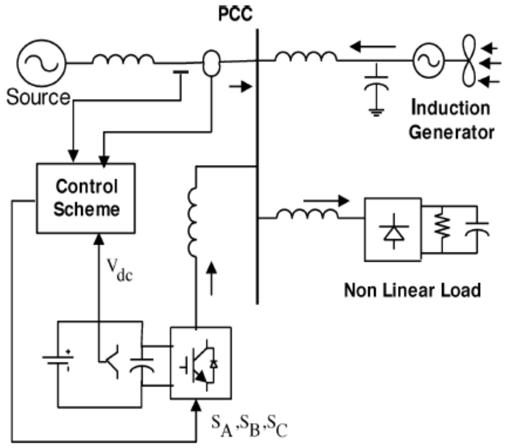


Fig.2 STATCOM control scheme

Figure shows a STATCOM Operation in Power System. The charge capacitor Cdc provides a DC voltage. The converter, which produces a set

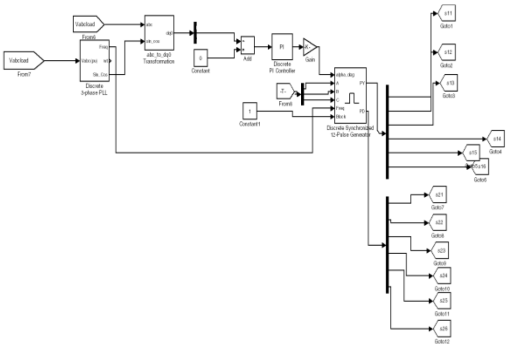
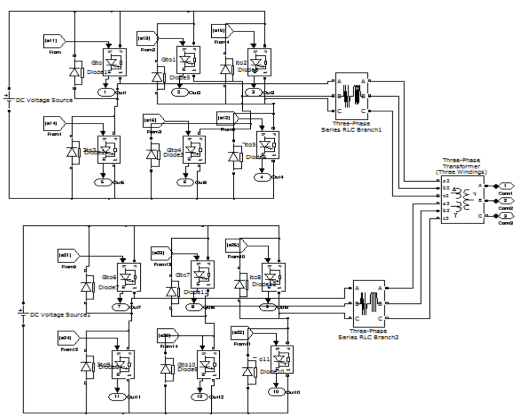


Fig. 3 MATLAB SIMULINK implementation of Control system scheme

The control scheme, for generating the switching signals to the STATCOM is shown in fig. 3. The control scheme approach is based on injecting the current into the grid using controller. Controller uses a basic PWM current control technique. The controller gives correct switching for STATCOM operation. The reference voltage is given as input to three phase PLL block and also to abc_to_dq0 transformation block. The PLL block gives sine angle of voltage and three phase rotating frame parameters converted into two phase stationary frame parameters by Clark's transformation. Zero is added to the signal and then PI controller detects the error signal. Finally discrete synchronized 12 pulse generator is used to generate pulseswhich are given to the converter.



of controllable three phase output voltages. The reactive power exchange between the converterand the AC system can also be controlled by the converter.

Fig. 4. MATLAB SIMULINK model of 12 pulse inverter of STATCOM

Fig.4 shows a three-phase, full-wave 12 pulse GTO based converter which converts DC to AC which is combination of two six pulse converter. It consist of three phase-legs, which operate in 120 degree mode. Control scheme controls the switching operation of GTO valves.

V. RESULTS AND DISCUSSION

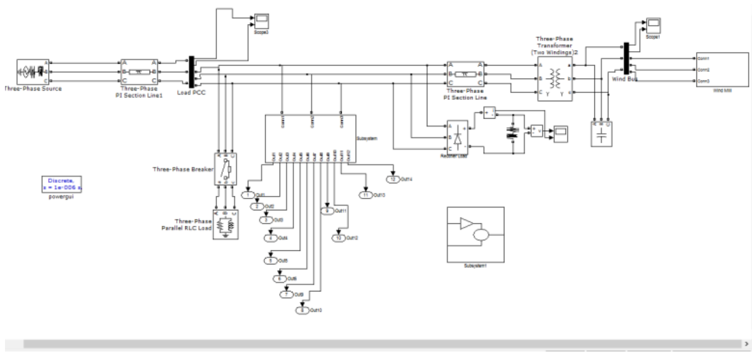


Fig. 5 SIMULINK model of the proposed scheme

This reactive power exchange is the reactive current injected by the STATCOM, which is the current from the capacitor produced by absorbing real power from the AC system.

S.No.	Parameters	Ratings
1	Grid Voltage	11 KV
2	Induction Generator	3 MW, 440V, 50 Hz, 3Ph, Yg

3	Inverter Parameters	3Ph, GTO b ,8I
4	Transmission line	20I
5	Load Parameter	Vn =11KV, 5 MW, Q_L

VI. Graphical Analysis

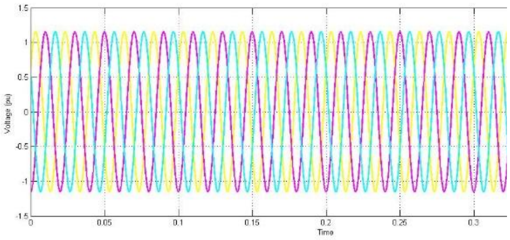


Fig. 6(a) Source Voltage waveform

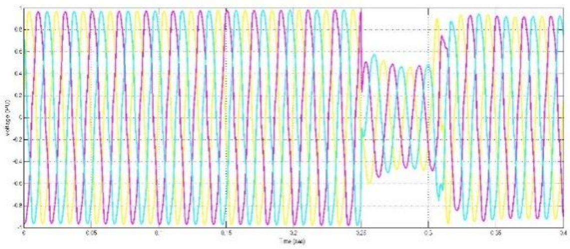


Fig.6 (b) Voltage waveform with Sag

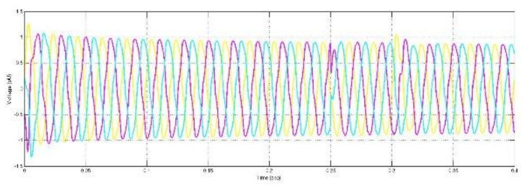


Fig.6 (c) Compansated Voltage Waveform

Fig.6 (a-c) shows the output voltage waveform for voltage sag, when the system is simulated with frequent switching of three phase inductive load.

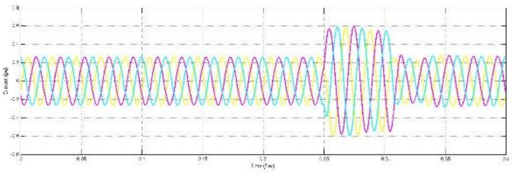


Fig. 7 (a) current waveform after switching of inductive load

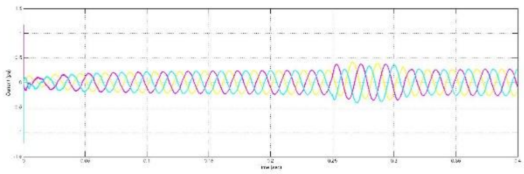


Fig. 7(b) compunsated current waveform

VII. Conclusion

The praposed system has been modeled, simulated and analyzed using matlab. It is found that the bus voltage is maintain within the permissible range to ensure the quality of power using STATCOM. Ractive power compunsation has been carried out succesfully. STATCOM is a most efficient device and it has the higher energy capacity compared to other FACTS devices.

VIII. References

1. *Mounes Alhajali, Brendan Fox, Jason Kennedy and D. John Morrow,* **"Impact of Wind Variability on Weakly Interconnected Power Systems"** 2010 IEEE
2. *Jovica V. Milanovic, Yan Zhang,* **"Modeling of FACTS Devices for Voltage Sag Mitigation Studies in Large Power Systems"** VOL. 25, NO. 4, OCTOBER 2010
3. *G. Elsady, Y. A. Mobarak, and A-R Youssef* **,"STATCOM for Improved Dynamic Performance of Wind Farms in Power Grid"** December 2010, Paper ID 207.

4. *N. G. Hingorani and L. Gyugyi*, **Understanding FACTS: concepts and technology of flexible AC transmission systems**: IEEE, 2000.