International Journal of Electronic and Electrical Engineering.
ISSN 0974-2174 Volume 8, Number 1 (2015), pp. 47-55

http://www.irphouse.com

Power Quality Improvement In Grid Connected Wind Energy System

Mr.Ramesh Daravath and E.Deepika

Assistant Professor, Dept. of Electrical and Electronics
Gitam University, Hyderabad,India
ram1sahara@gmail.com
Dept. of Electrical and Electronics, Gitam University, Hyderabad,India
deepikadruv70@gmail.com

ABSTRACT

The primary aim of shunt compensation in a distribution system are to cancel or suppress the effect of harmonic contents in load such that current drawn from the source is nearly sinusoidal. When induction machine driven by wind turbine is synchronizing with electrical grid system, various power quality problems arise such as voltage sag, swell,flicker,harmonics etc.In this scheme the STATCOM is connected at the point of point of common coupling with a Battery energy storage system(BESS) to mitigate power quality problems.The control scheme used is Bang-Bang controller. A Bang-Bang controller also known as on-off controller or hysteresis controller is a feedback controller that switches abruptly between two states.These controllers may be realized interms of element that provide hysteresis.This control scheme will be simulated using MATLAB/simulink.

Keywords: STATCOM,power quality, Wind generating system, Battery Energy Storage system(BESS),Bang-Bang current controller.

1 INTRODUCTION

Modern day power systems are complicated networks with hundreds of generating stations and load centers being interconnected through power transmission lines. An electric power system has three main components-power generation,power transmission, and power distribution.The loads mainly being Non-Linear loads as result they is a chance of harmonics being injected to the source side.

A STATCOM is connected at the point of common coupling (PCC) along with Battery energy storage system(BESS) to make source current harmonic free and to improve the system performance.

The STATCOM is built around a voltage source inverter, which is supplied by a dc capacitor. The inverter consists of GTO switches which are turned on and off through a gate drive circuit.

The proposed STATCOM along with hysteresis current control scheme for improving the power quality has following objectives

- Maintain the source side power factor at unity.
- For fast response bang-bang controller is implemented in STATCOM.
- Minimize the THD percentage at the PCC waveform.

2 POWER QUALITY ISSUES AND ITS CONSEQUENCES

Even a few years back, the main concern of consumers of electricity was the realiablity of supply.Here we define reliability as the continuity of electric supply.Even through the power generation in most advanced countries is fairely reliable, the distribution is not always so. The various power quality problems are voltage sag, swell,interruption, voltage unbalance,flicker, and harmonics etc which are discussed briefly.

2.1 VOLTAGE SAG

It is defined as decrease in voltage between 10 to 90% of its nominal rms voltage at the rated power frequency i.e. 50 Hz. Voltage sag consequences are tripping of motor etc.

2.2 VOLTAGE SWELL

Voltage swell is an increase in RMS voltage in range of 10% to 80% for duration greater than half cycle and less than 1 minute. A swell can occur due to a single line-to-ground fault on the system which can result temporary voltage rise on the other unfaulted phases. Swells can also be caused by switching off a large load or switching on a large capacitor bank.

2.3 VOLTAGE INTERRUPTION

Voltage interruption is nothing but the supply voltage goes close to zero that means lower than 10% of its nominal voltage. Interruptions can results the power system faults,equipment failure, control system malfunction.

2.4 VOLTAGE UNBALANCE

Voltage unbalance is deviation in the magnitude and phase of one or more of the phases, of a three phase supply, with respect to the magnitude of the other phase and the normal phase angle. Voltage unbalance can cause temperature rise in motors and can even cause a large motor to trip.

2.5 FLICKER

Flicker comes due to frequent on-off or switching regularly of large loads connected to grid. It results in rapid variation in voltage and changing brightness of incandescent and fluorescent lamps at consumer end.

2.6 HARMONICS

It is a sinusoidal component of a periodic wave having a frequency that is an intergral multiple of the fundamental frequency. A non-Linear element in power systems such as power electronic devices, static power converters, arc discharge devices etc creates harmonics in system. Harmonics cause communication interference, heating, and malfunction of equipments.

3 TOPOLOGY FOR POWER QUALITY IMPROVEMENT

The basic block diagram of the scheme is:

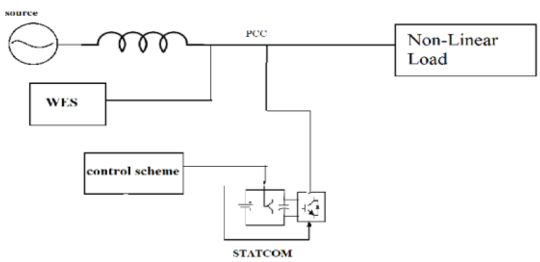

Figure 1 system operational scheme in grid system

The STATCOM with capacitance at DC side is a three phase voltage source inverter. The basic principle of STATCOM installed inpower system is to generate controllable ac voltage source by a VSI connected to dc capacitor. Here the shunt connected STATCOM is opearated in current control mode and is connected with wind turbine induction generator and non-linear load at the point of common coupling(PCC) in the grid system. The current controlled voltage source inverter based STATCOM injects the current into the grid in such a way that the source current are harmonic free and they are in phase-angle with respect to source voltage. The injected current will cancel out there active part and harmonic part of the induction generator current and load current, thus it improves the system power quality.

3.1 WIND GENERATING SYSTEM

In the proposed system induction generator is used since separate field circuit in not required, it accepts constant and variable load. Induction generator and energy storage system are interface at point of common coupling. STATCOM is connected to the system in parallel. This system has natural protection against short ciruit.

The wind power available is given by

$$P_{air}=0.5\rho A V_{wind}^{2} \qquad (1)$$

Where ρ=air density(Kg/m^3),A=Area swept out by turbine blade(m), V_{wind}=wind speed(m/s).

It is not possible to extract all kinectic energy of wind. Thus extracts a fraction of the power called power coefficient 'C_p' of the wind turbine, and is given by :

$$P_{mech}=C_p P_{wind} \qquad (2)$$

The mechanical power produced by wind turbine is given by:

$$P_{mech}=1/2\pi R^2 V_{wind}{}^{3} C_p \qquad (3)$$

Where R= Radius of the blade(m).

3.2 BESS-STATCOM

The battery energy storage system(BESS) is used as an energy storage element for the purpose of voltage regulation.

The BESS will naturally maintain dc capacitor voltage constant and is best suited in STATCOM since it rapidly injects or absorbs reactive power to stabilize the grid system.

When power fluctuation occurs in the system,the BESS is used to level the power fluctuation by charging and discharging operation. The battery is connected in parallel to the dc capacitor of STATCOM.

3.3 SYSTEM OPERATION

The shunt connected STATCOM with battery energy storage is connected at the interface of the induction generator and non-linear load at the pcc. The Fig.1 shows the system operational scheme in grid system. The STATCOM output is varied according to the control strategy, so as to maintain the power quality norms in the grid system. The current control strategies for STATCOM is Bang-Bang controller.A single STATCOM using insulated gate bipolar transistors is proposed to have a reactive power support to the induction generator and to the nonlinear load in the grid system.

3.4 CONTROL SCHEME

The control scheme is based on injecting the currents into the grid using Bang-Bang controller. The controller uses a hysteresis current controlled technique as shown in fig 2. Using such a technique, the controller keeps the control system variable between the boundaries of hysteresis area and gives correct switching signals for STATCOM operation. The current controller block receives reference current and actual current as inputs and are subtracted so as to activate the operation of STATCOM in current control mode.

3.5 GRID SYNCHRONISATION

In the three-phase balance system, the RMS source voltage amplitude is calculated from the source phase voltages (Vsa, Vsb, Vsc) and is expressed as sample template (sampled peak voltage),V sm :

$$Vsm = \sqrt{2/3(Vsa^2+Vsb^2+Vsc^2)} \quad (4)$$

The in-phase unit vectors are obtained from source voltage in each phases and the RMS value of unit vector is shown below.

$$Usa = Vsa/Vsm$$
$$Usb = Vsb/Vsm \quad (5)$$
$$Usc = Vsc/Vsm$$

The in-phase reference currents generated are derived using in-phase unit voltage template as shown below.

$$isa^* = I^*\ Usa,\ isb^* = I^* Usb,\ isc^* = I^*\ Usc \quad (6)$$

Where 'I' is proportional to magnitude of filtered source voltage for respective phases. This ensures that the source current is controlled to be sinusoidal.

3.6 BANG-BANG CURRENT CONTROLLER

It is implemented in the current control scheme. The reference current is generated as in equation (6) and actual current are detected by current sensors and are subtracted for obtaining a current error for a hysteresis based bang-bang Controller. Thus the ON/OFF switching signals for IGBTs of STATCOM are derived from hysteresis controller .The switching function SA for phase 'a' is expressed as:

$$(i_{sa} - i_{sa}^*) < HB = S_A = 1$$
$$(i_{sa} - i_{sa}^*) > HB = S_A = 0 \quad (7)$$

This is same for phases 'b' and 'c'.

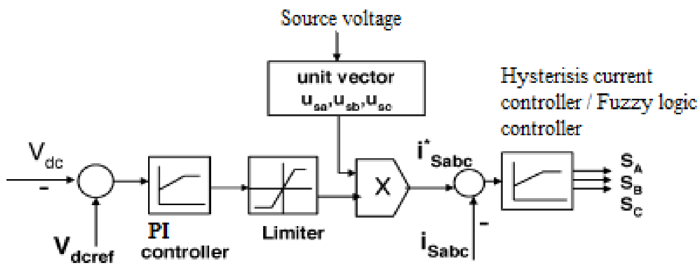

Figure 2 Control scheme

4 SIMULATION RESULTS

The proposed STATCOM control scheme with wind farm and non linear load is simulated using MATLAB SIMULINK in power system blocks. Figure 3 shows the MATLAB simulation model along with STATCOM. The power circuit and control circuit are incorporated in simulink block sets. The three phase AC source is connected to grid along with three phase non linear load wind generator wind turbine. The STATCOM os connected in shunt at PCC and it consists of Hysteresis control technique for pulse generation for JGBT and DC capacitor of STATCOM.

They are two cases in this scheme. They are simulation with STATCOM and simulation WITHOUT STATCOM.

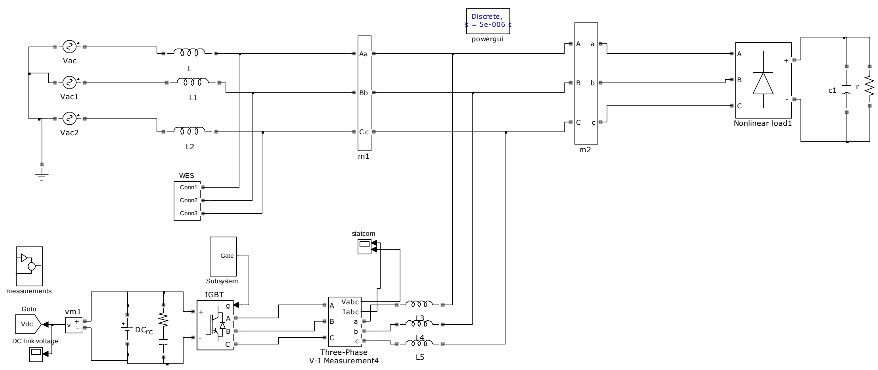

Figure 3 MATLAB simulation model (with STATCOM).

4.1 SYSTEM PERFORMANCE

The table 1 shows the system parameters

Table:1

Parameters	Ratings
1)Grid voltage	3-phase,415V,50Hz
2)Asynchronous generator	3.350KVA,415V,R_s=20Ω, R_r=20Ω,L_s=0.06H, L_r=0.06H
3)Inverter Parameter	DC Link voltage-800V,DC link Capacitance=100μF, switching frequency=2KHz
4)Line series inductances	0.05e-3H
5)IGBT Rating	Collector voltage=1200V, forward current=50A, gate voltage=20V
6)Critical Load parameters	3-Phase 415V, non linear load, R=100Ω, c=1μF

Simlation diagram of generating of control scheme is shown in figure 4

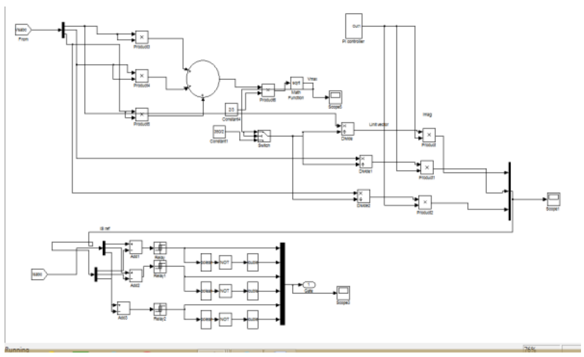

Figure 4 control scheme in MATLAB

STATCOM Inverter pulses are shown in figure 5

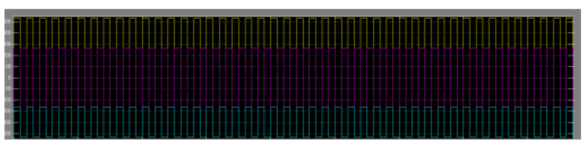

Figure 5 STATCOM Inverter pulses

The total harmonic distortion of source current without STATCOM is shown in figure 6

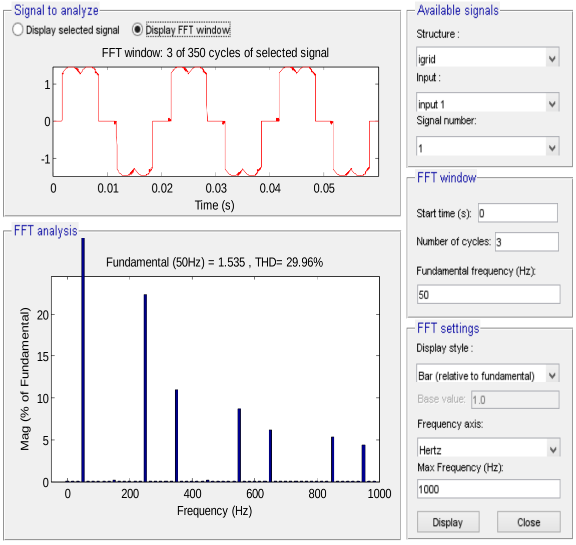

Figure 6. THD without STATCOM

The THD with STATCOM is shown in figure 7

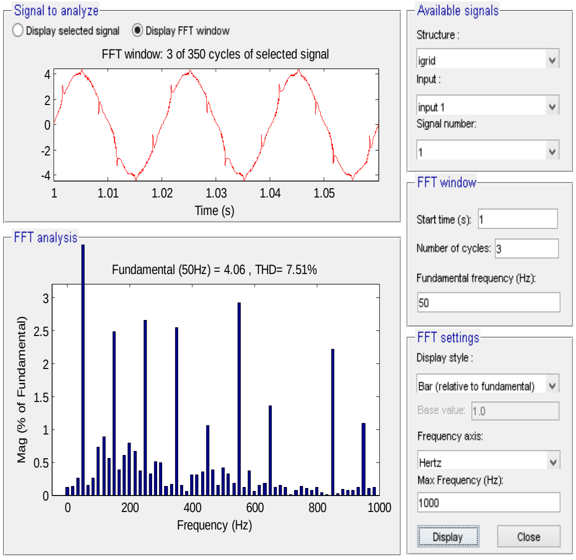

Figure 7. THD with STATCOM

5 CONCLUSION

The paper presents the STATCOM-based control scheme for power quality improvement in grid connected wind generating system with non linear load.

The operation of STATCOM is simulated using Bang-Bang current controller. STATCOM injects current to the grid and it cancel out the reactive and harmonic parts of the induction generator current and load current.

The THD analysis reveals that Bang Bang controller gives satisfactory results to improve the power quality. In order to get better improvement in power quality fuzzy logic controller can be used.

REFERENCES

1) Sharad W. Mohod, Mohan V.Aware "A STATCOM control scheme for grid connected wind energy system for power quality improvement" IEEESYSTEMS JOURNAL, VOL. 4, No.3, September 2010.

2) S.W.mohod and M.V. Aware, "power quality issues & its mitigation technique in wind energy conversion",in proc.of IEEE int.conf.Quality power & harmonic, Wollongong,Australia,2008.

3) Hamdy Mohamed soliman, S.M.EL.Hakim: Improved Hysteresis Current controller to drive permanent magnet synchronous motors through th efirld oriented control", in IJSCE, volume-2, Issue-4, September 2012.

4) "Power Quality enhancement using custom power devices" by Arindham Ghosh and Gerard ledwich, Springer International Edition.

5)" Understanding FACTS Concepts and technology of flexible AC transmission systems" by Narain.G.Hingorani and Laszlo gyugyi, wiley india(p) ltd.

6) T.Kinjo and T.senjyu,:output levelling of renewable energy by electric double layer capacitor applied for energy storage system",IEEE Trans.Energy Conv.,Vol.21,no.1,mar 2006.

7) R.S.Bhatia, S.P. Jain, D.K.Jain, and B.Singh,:Battery energy storage system for power conditioning of renewable energy sources",in proc.int.conf.power electron drive system,jan 2006, vol. 1,pp 501-506.