STATCOM CONTROL SCHEME FOR POWER QUALITY IMPROVEMENT IN WIND FARM

[1]Rohit Sengar, [2]Devendra Tiwari

[1]PG Scholar, [2]Assistant Professor,
Electrical Engineering Department
[1]Samrat ashok technological institute, vidisha, India

Abstract— **The Wind energy sources, which have been required to be a promising option energy source, can bring new difficulties when it is associated with the power network. Be that as it may, the created power from renewable energy source is continually fluctuating because of ecological condition. Similarly Wind power infusion into an electric grid influences the power quality because of the wind direction and the relatively new sorts of its generators. On the premise of estimations and standards took after as per the rules indicated in IEC-61400 (International Electro-technical Commission) standard, the execution of the wind turbine and there by power quality are resolved. The power emerging out of the wind turbine when it associated with power system concerning the power quality estimations are-the active power, reactive power and electrical nature of switching operation and these are measured by global rules. The paper obviously demonstrates the presence of power quality issue because of establishment of wind turbine with the grid. In this proposed plan a FACTS device that is STATIC COMPENSATOR (STATCOM) is associated at appoint of coupling with a battery energy storage system (BESS) to dimish the power quality issues. The battery energy storage system is coordinated to boost the genuine power source under oscillating wind power. The FACTS Device control plan for the grid associated wind energy system to enhance the power quality is recreated utilizing MATLAB as a part of power system. The expected consequence of the proposed plan remembers the fundamental supply source from the reactive power demand of the load and the induction generator.**

Index Terms— **Battery energy storage system , IEC-61400, STATCOM.**

I. INTRODUCTION

To have practical development and social advancement, it is nec-essary to meet the energy need by using the conventional energy sources like wind, biomass, hydro, co-generation, and so on In practical , energy protection and the utilization of renewable source are the key worldview. The need to incorporate the renewable energy like wind energy into power system is to make it conceivable to minimize the ecological effect on customary plant. The addition of wind energy into existing power system exhibits a specialized difficulties and that requires thought of voltage regulation, dependability, power quality issues. The power quality is a crucial customer-centered measure and is incredibly influenced by the distribution and transmission system. The issue of power quality is of incredible significance to the wind turbine.

There has been a broad development and fast improvement in the area of wind energy. The individual units can be of extensive limit up to 2 MW, sustaining into distri-bution system, especially with clients associated in closeness. Today, more than 28 000 wind producing turbine are effectively working everywhere throughout the world. In the fixed speed wind turbine operation, all the fluctuation in the wind speed are transmitted as changes in the mechanical torque, electrical power on the system and prompts vast voltage variations.In the typical operation, wind turbine delivers a interruptions into induction generator. These power variations are commonly brought about by the impact of turbulence, wind shear, and tower-shadow and of control system in the power system. In this manner, the system needs to oversee for such changes. The power quality issues can be seen as for the wind era, transmission and distribution system, for example, voltage sag, swells, harmonics, flicker and so forth. However the wind generator brings disturbances into the appropriation system. One of the basic techniques for running a wind creating framework is to utilize the induction generator associated specifically to the network. The induction gen-erator has natural preferences of cost effectiveness and strong ness. In any case; induction generators require reactive power for magnetization. At the point when the created active power of an induction generator is differed because of wind, consumed responsive power and terminal voltage of an induction generator can be essentially influenced. An appropriate control plan in wind energy is required under typical working condition to permit the best possible control over the active power generation. In case of expanding grid unsettling influence, a battery energy storage system for wind energy producing framework is for the most part required to compensate the variation created by wind turbine.STATCOM control innovation has been proposed for enhancing the power quality. The proposed STATCOM control scheme for power quality improvement in wind farm has some objectives.

- Unity power variable at the source side.
- Reactive power support just from STATCOM to wind Generator and Load.
- Simple bang bang controller for STATCOM to accomplish quick dynamic reaction.

The paper is sorted out as fallows. The Section II presents the force quality models, issues and its results of wind turbine. The Section III presents the grid quality points. The Section IV depicts the topology for power quality change. The Sections V, VI, VII says the control plan, system execution and conclusion separately.

II. POWER QUALITY STANDARDS, ISSUES

FURTHERMORE, ITS CONSEQUNCES

A. INTERNATIONAL ELECTRO TECHNICAL COMMISSION GUIDELINES

THE RULES ARE GIVEN TO ESTIMATION OF POWER NATURE OF WIND TURBINE. THE INTERNATIONAL GUIDELINES ARE DEVELOPED BY THE WORKING GATHERING OF TECHNICAL COMMITTEE-88 OF THE INTERNATIONAL ELECTRO-SPECIALIZED COMMISSION (IEC), IEC STANDARD 61400-21, DEPICTS THE SYSTEM FOR DECIDING THE FORCE QUALITY ATTRIBUTES OF THE WIND TURBINE .

THE STANDARD STANDARDS ARE INDICATED.

1)IEC 61400-21: WIND TURBINE PRODUCING FRAMEWORK, SECTION 21. ESTIMATION AND ASSESSMENT OF POWER QUALITY CHARACTERISTIC OF GRID ASSOCIATED WIND TURBINE

2)IEC 61400-13: WIND TURBINE—MEASURING SYSTEM IN DECIDING THE POWER BEHAVIOR.

3)IEC 61400-3-7: ASSESSMENT OF OUTFLOW BREAKING POINT FOR FLUCTUATING LOAD IEC 61400-12: WIND TURBINE EXECUTION.

THE INFORMATION SHEET WITH ELECTRICAL NORMAL FOR WIND TURBINE GIVES THE BASE TO THE UTILITY APPRAISAL IN REGARDS TO A GRID ASSOCIATION.

.

3 POWER QUALITY ISSUES

Power quality issues are related to a broad number of electromagnetic marvels in power network with an expansive scope of time. Case in point, it incorporates transients' drifts and additionally current deviations. The reason for this segment is to present these main disturbances that will be focused along the thesis, as well as their time range. A comprehensive description of the classifications and attributes of power systems electromagnetic phenomena associated to variations in the voltage magnitude is available in. For the sake of convenience, according to the cases studied in this thesis, it is feasible to classify them based on the duration. The classification takes the voltage into account, as the quality of the voltage is the tended to issue in the greater part of the cases. In any case, it is outstanding that there is dependably a good relationship amongst voltages and streams in a power system. Specifications with respect to are connected to dimensioning a device or on account of harmonics.

The power quality issues is commonly classified as under:

- Voltage Sag.
- Voltage Swells.
- Short term Interruptions.
- Long duration voltage variation.

The voltage flicker issue depicts dynamic varieties in the system brought about by wind turbine or by differing loads. In this manner the power disturbances from wind turbine happens. The amplitude of voltage fluctuation relies on upon grid quality, system impedance and phase angle and power variable of the wind turbines. It is characterized as a change of voltage in a frequency 10–35 Hz. The IEC 61400-4-15 indicates a flicker meter that can be utilized to quantify flicker specifically

- **HARMONICS**: THE HARMONIC RESULTS BECAUSE OF THE OPERATION OF POWER ELECTRONIC CONVERTER TO THE SATISFACTORY LEVEL AT THE PURPOSE OF WIND TURBINE ASSOCIATION WITH THE SYSTEM. TO GUARANTEE THE HARMONIC VOLTAGE WITH IN LIMIT, EVERY SOURCE OF HARMONIC CURRENT CAN PERMIT JUST A RESTRICTED COMMITMENT, ACCORDING TO THE IEC-61400-36 RULE. THE QUICK SWITICHING GIVES A SUBSTANTIAL DIMINISHMENT IN LOWER ORDER HARMONIC CURRENT CONTRASTED WITH THE LINE COMMUTATED CONVERTER, HOWEVER THE OUTPOT CURRENT WILL HAVE HIGH FREQUENCY CURRENT AND CAN BE EFFORTLESSLY FILTER OUT.

- **WIND TURBINE LOCATION IN POWER SYSTEM**: THE METHOD FOR ASSOCIATING THE WIND PRODUCING FRAMEWORK INTO THE POWER NETWORK IMPACTS THE POWER QUALITY. IN THIS MANNER THE OPERATION AND ITS IMPACT ON POWER FRAMEWORK RELY ON UPON THE STRUCTURE OF THE ADJOINING POWER SYSTEM.

- **SELF EXCITATION OF WIND TURBINE GENERATING SYSTEM:** THE SELF EXCITATION OF WIND TURBINE GENERATING SYSTEM (WTGS) WITH AN ASYNCHRONOUS GENERATOR HAPPENS AFTER SEPARATION OF WIND TURBINE GENERATING SYSTEM (WTGS) WITH NEARBY LOAD. THE DANGER OF SELF EXCITATION EMERGES PARTICULARLY WHEN WTGS IS FURNISHED WITH COMPENSATING CAPACITOR. THE CAPACITOR ASSOCIATED WITH INDUCTION GENERATOR GIVES REACTIVE POWER. HOWEVER THE VOLTAGE AND FREQUNCY ARE CONTROLLED BY THE ADJUSTING OF THE SYSTEM. THE WEAKNESSES OF SELF EXCITATION ARE THE SAFETY ASPECT AND BALANCE AMONGST REAL AND REACTIVE POWER.

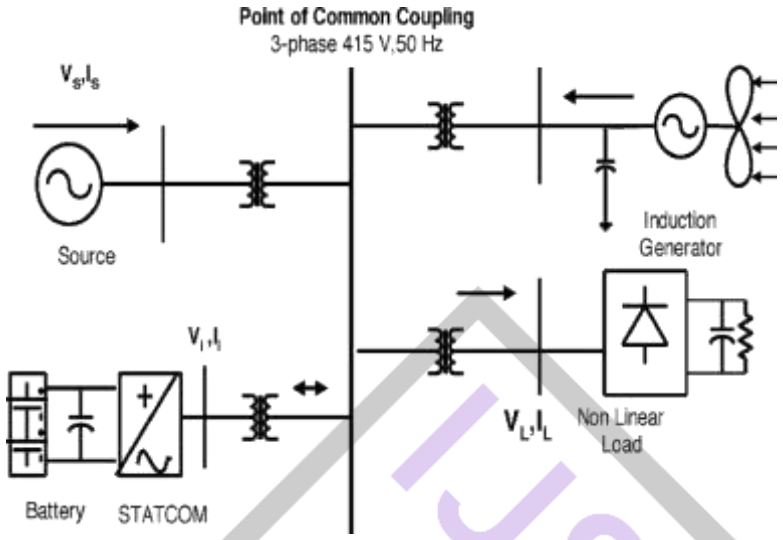


Fig. 1: Grid connected system for power quality improvement

4 Grid Coordination Rule: The grid quality attributes and points of confinement are given for references that the consumer and the utility system may anticipate. As indicated by Energy-Economic Law, the administrator of transmissiongrid is in charge of the association and operation of interconnected framework.

- Voltage Rise
- Voltage Dips
- flicker
- harmonics
- grid Frequency

5 Topology for Power Quality Improvement: The STATCOM based current control voltage source converter infuses the current into the grid in a manner that the source current are without harmonic and their phase angle as for source voltage has a sought worth. The infused current will cancel the reactive part and harmonics part of the load and induction generator current, in this way it enhances the power factor and the force quality. To fulfill these objectives, the network voltages are detected and are synchronized in creating the present charge for the inverter. The proposed grid associated framework is actualized for power quality change at point of common coupling (PCC).

6 Wind Energy Generating System: In this design, wind eras depend on steady speed topologies with pitch control turbine. The induction generator is utilized as a part of the proposed plan in view of its straightforwardness does not require a different field circuit, it can acknowledge steady and variable load and has regular security against short circuit.

7 BESS-STATCOM: The battery energy storage system (BESS) is utilized as a energy storage component with the end goal of voltage direction. The BESS will actually keep up dc capacitor voltage consistent and is most appropriate in STATCOM since it quickly infuses or retained reactive power to settle the grid system. It likewise control the distribution and transmission framework in a quick rate. At the point when power fluctuations happens in the electric system, the BESS can be utilized to level the power variable by charging and releasing operation. The battery is associated in parallel to the dc capacitor of STATCOM. The STATCOM is a three-phase voltage source converter having the capacitance on its DC interface and associated at the purpose of regular coupling. The STATCOM infuses a compensating current of variable magnitude andfrequency component at the bus of common coupling.

8 System Operation: The shunt integrated STATCOM with battery energy storage is associated with the interface of the induction generator and non-direct load at the PCC in the grid network. The STATCOM compensator output is changed by controlled methodology, in order to keep up the power quality standards in the system. The present control procedure is

incorporated into the control conspire that characterizes the practical operation of the STATCOM compensator in the power system. A solitary STATCOM utilizing insulated gate bipolar transistor(IGBT) is proposed to have a reactive power support, to the induction generator and to the nonlinear load in the grid system.
The main block diagram of the system operational scheme is shown in Fig. 2.

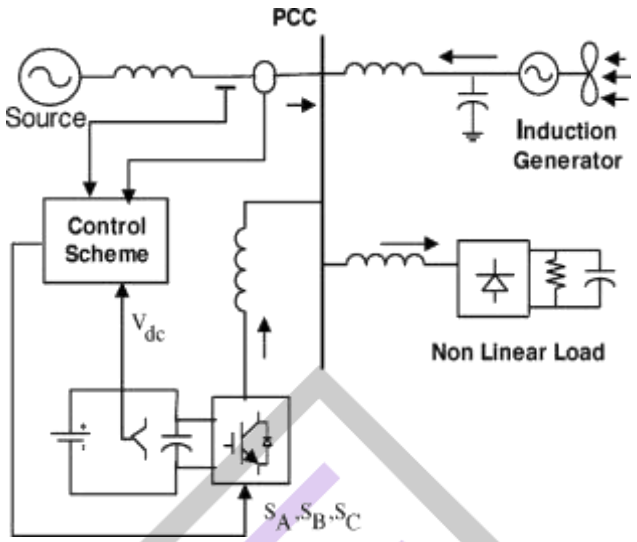


Fig. 2. System operational scheme in grid system

9 Control Scheme: The control plan methodology depends on infusing the current into the grid utilizing "bang bang controller." The controller utilizes a hysteresis current controlled system. Utilizing such procedure, the controller keeps the control system variable between limits of hysteresis range and gives right exchanging signals for STATCOM operation.

The proposed control plan is utilizing SIMULINK as a part of power system . The system execution of proposed framework under dynamic condition is likewise introduced
The control system scheme for generating the switching sig-nals to the STATCOM is shown in Fig. 3.

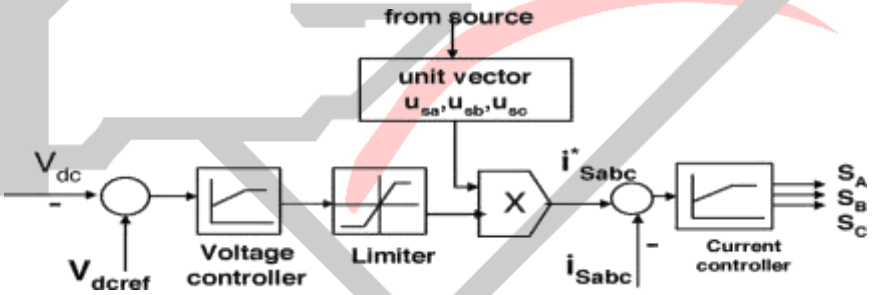


Fig. 3. Control system scheme

10. **Voltage Source Current Control—Inverter Operation**

The three phase infused current into the system from STATCOM will offset the distortion brought on by the non-linear load and wind generator. The IGBT based three phase inverter is associated with grid through the transformer. The generation of switiching from reference current is simulated inside hysteresis band of 0.8. The decision of restricted hysteresis band switiching in the system enhances the current quality. The control sign of switiching frequency inside its working band, as appeared in Fig. 4.

The decision of the current band relies on upon the working voltage and the interfacing transformer impedance. The compensated current for the nonlinear load and requested receptive power is given by the inverter. The real power transfer from the batteries is also supported by the controller. In the three phase inverter injected current is shown in fig 5.

S.N.	Parameters	Ratings
1	Grid Voltage	3-phase ,415V,50 Hz
2	Induction Motor/Generator	3.35 kVA,415V, 50 Hz, P = 4, Speed = 1440 rpm, Rs = 0.01Ω, Rr=0.015Ω,Ls =0.06H,Lr=0.06H
3	Line Series Inductance	0.05mH
4	Inverter Parameters	DC Link Voltage = 800V, DC link Capacitance = 100 μF. Switching frequency = 2 kHz,
5	IGBT Rating	Collector Voltage =1200V, Forward Current =50A,Gate voltage =20V, Power dissipation = 310W
6	Load Parameter	Non-linear Load 25kW.

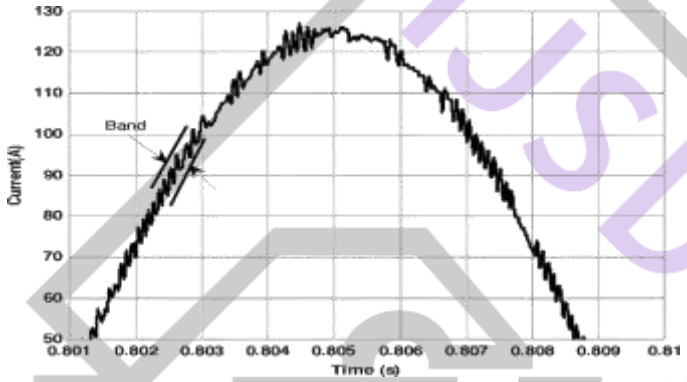


Fig. 4. Switching signal within a control hysteresis band

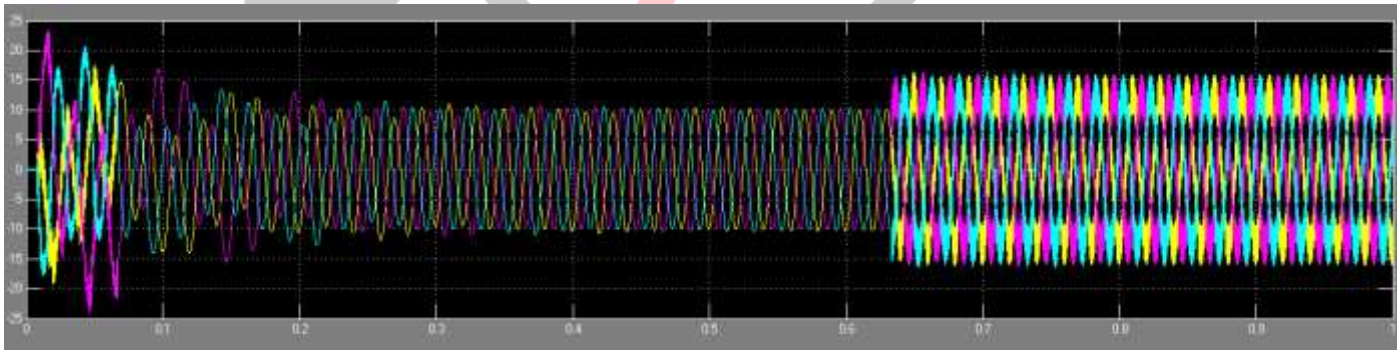


Fig. 5. Three phase injected inverter Current

11 STATCOM—Performance Under Load Variations

The wind energy producing system is associated with grid having the nonlinear load. The execution of the network is measured by switiching the STATCOM at time s in the system and how the STATCOM reacts to the progression change summon for increment in extra load at 1.0 s is appeared . At the point when STATCOM controller is made ON, without change in some other load condition parameters, it begins to relieve for reactive demand and also harmonic current. The dynamic execution is additionally done by step change in a load, when connected at 1.0 s. This extra request is satisfy by STATCOM compensator. In this way, STATCOM can direct the accessible genuine force from source. The consequence of source current, load current are

appeared in Fig. 6(a) and (b) individually. While the aftereffect of infused current from STATCOM are appeared in Fig. 6(c) and the produced current from wind generator at PCC are delineated in Fig. 6(d).

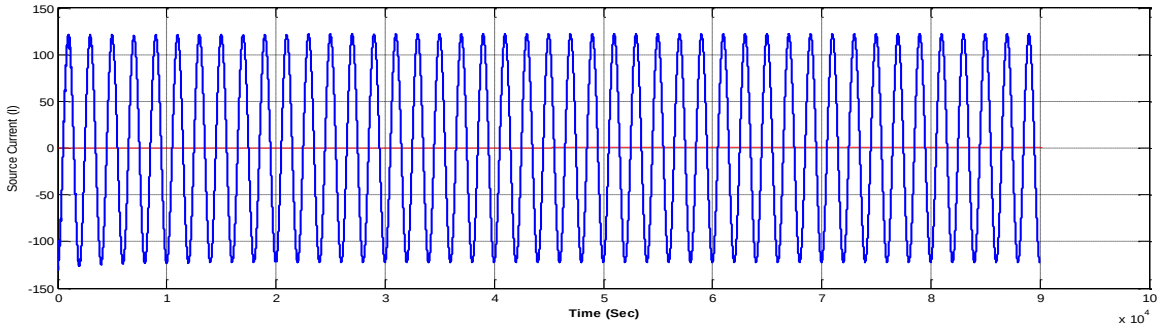


Fig. 6. (a) Source Current

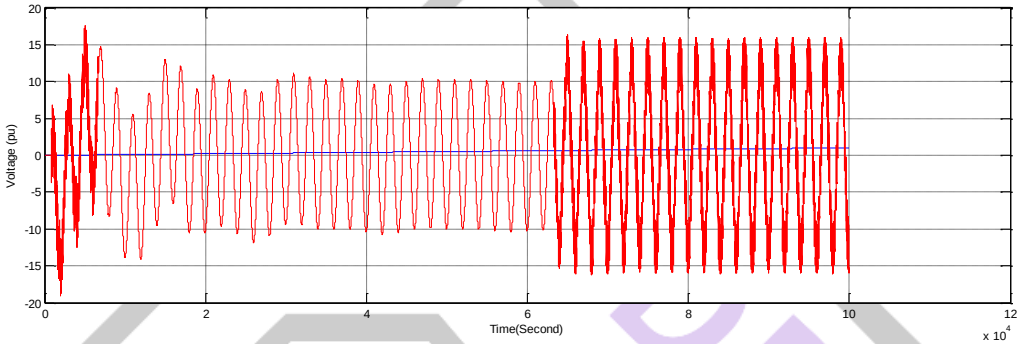


Fig. 6. (b) Load Current

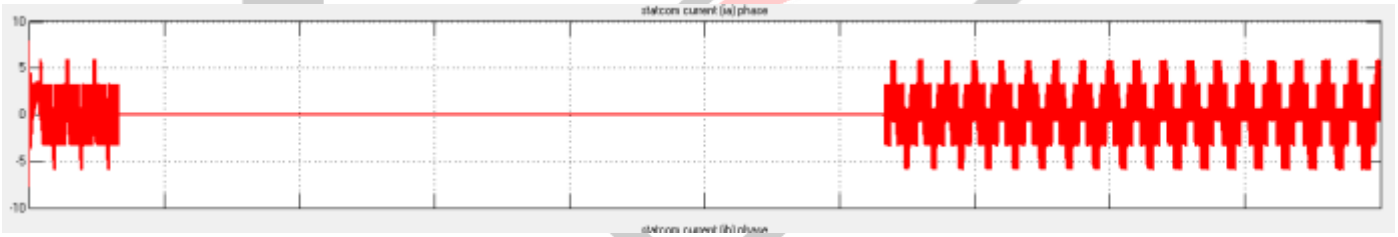


Fig-6(c) Inverter injected current

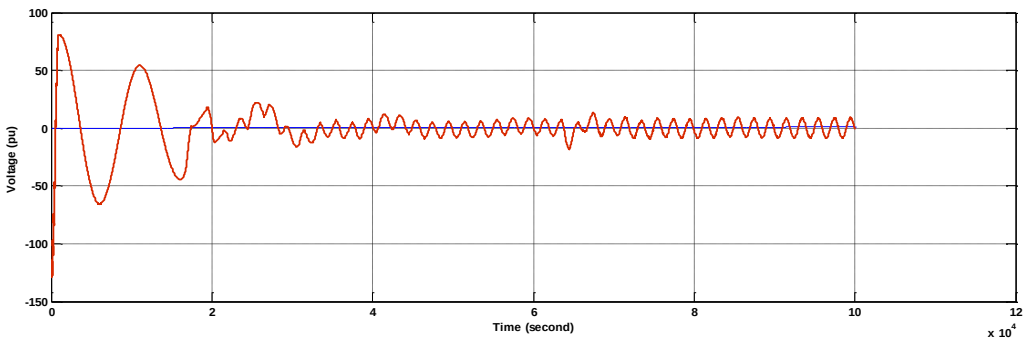


Fig6(d) wind turbine generator current

The DC link voltage controls the source current in the grid syatem, so the DC link voltage is kept up consistent over the capacitor as appeared in Fig. 7(a). The current through the dc link capacitor demonstrating the charging and releasing operation as appeared in Fig. 7(b)

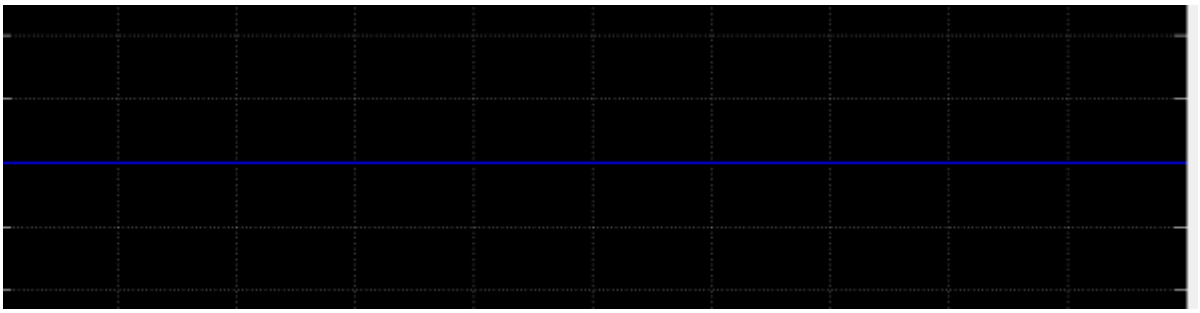
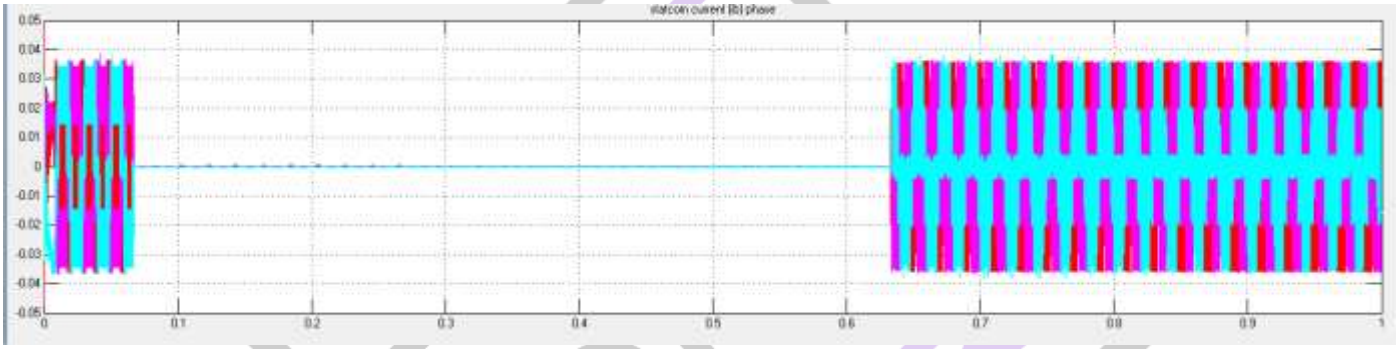


Fig. 7. (a) DC link voltage



.**fig7 (b)** Current through Capacitor

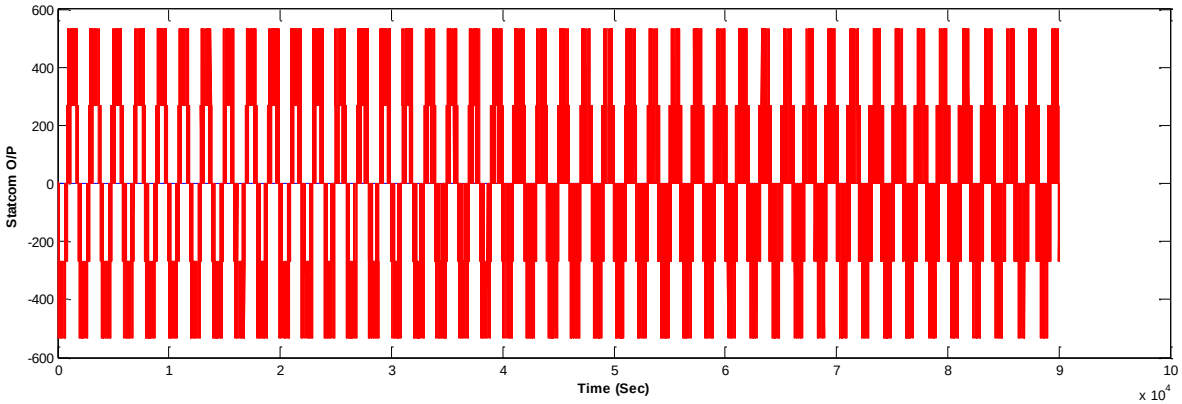


Fig 8 Statcom output voltage

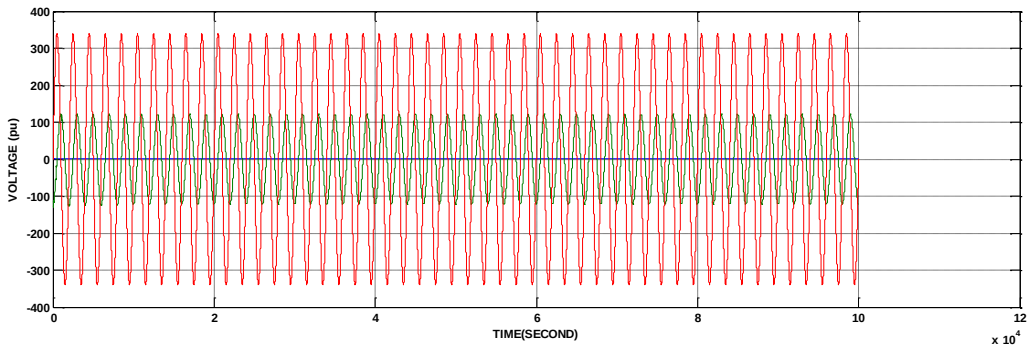


Fig 9 Supply voltage and current

12. Power Quality Improvement

it is observed that the source current on the grid is influenced because of the impacts of nonlinear load and wind generator, in this manner waveform might be lost on both sides in the system. The inverter output voltage under STATCOM operation with load variation is appeared in Fig. 8. The dynamic load affects the inverter output voltage. The source current with and without STATCOM operation is appeared in Fig. 9. This demonstrates the unity power factor is kept up for the source power when the STATCOM is in operation. The present waveform previously, then after the fact the STATCOM operation is dissected. The Fourier examination of this waveform is communicated and the THD of this source current at PCC without STATCOM is 4.71%, as appeared in Fig. 10.

The power quality improvement is seen at purpose of regular coupling, when the controller is in ON condition. The STATCOM is set in the operation at 0.67 s and source current waveform is appeared in Fig. 11 with its FFT. It is demonstrated that the THD has been enhanced significantly and inside the standard.

The above tests with proposed plan has power quality improvement highlight as well as has manage ability to support the load with the energy storage through the batteries

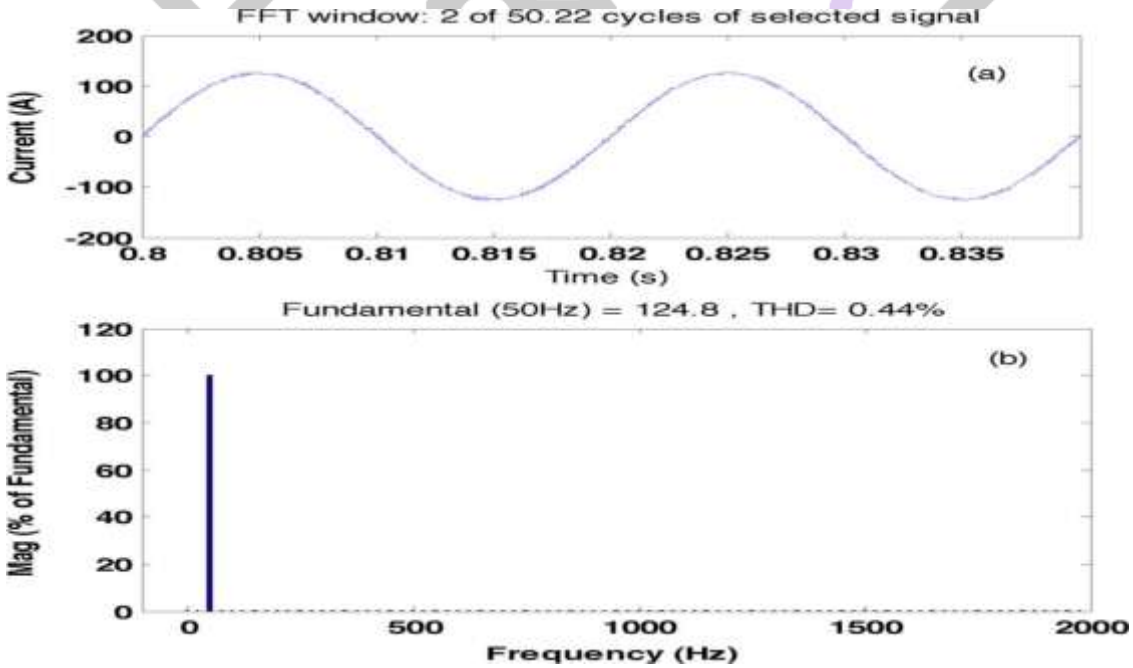


Fig. 10. (a) Source Current. (b) FFT of source current

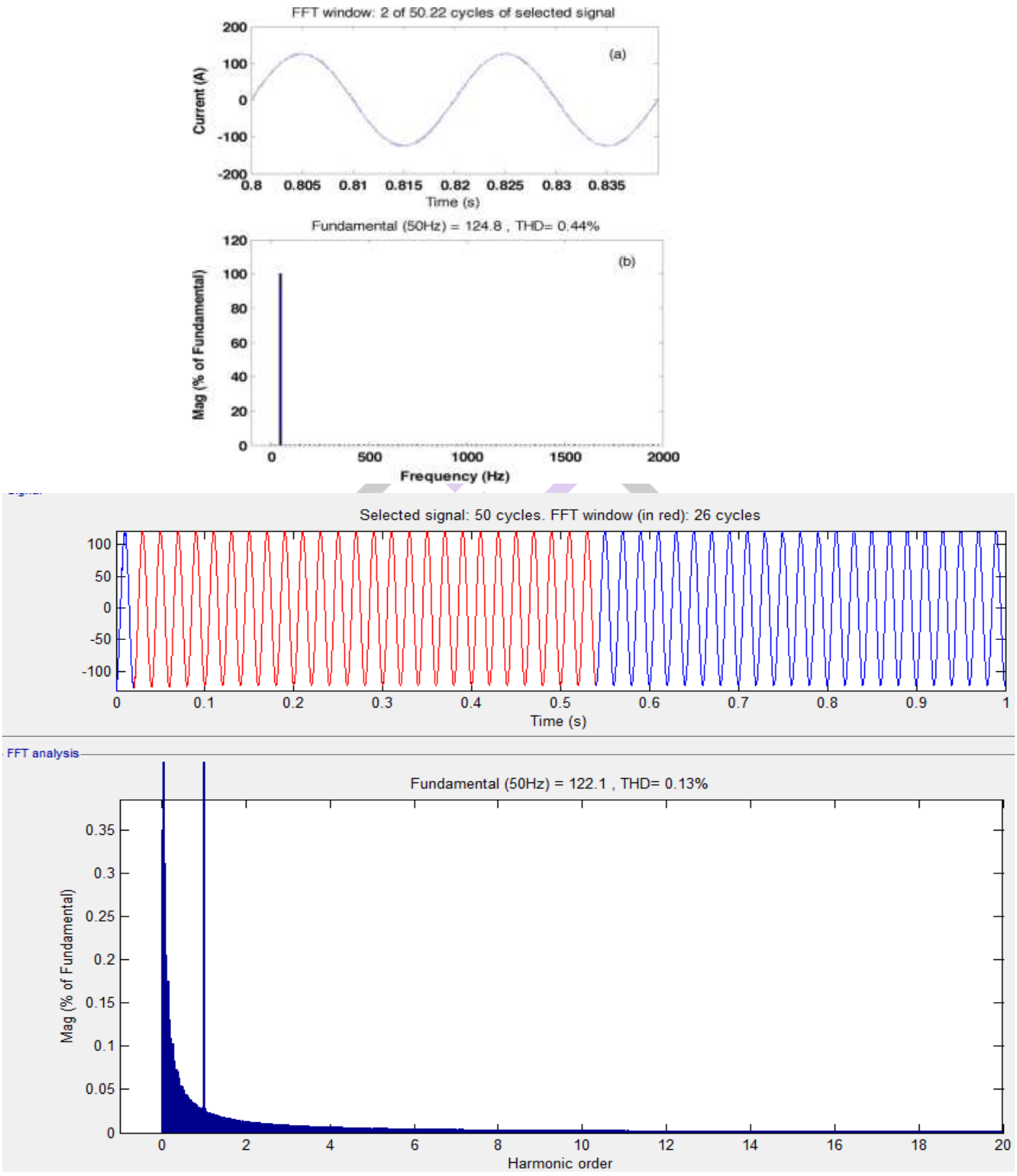


Fig. 11. (a) Source Current. (b) FFT of source current.

Conclusion

The paper presents the statcom control schemes for power quality improvement in wind farm with non linear load. The power quality issues and its consequences on the consumer utility are presented. The operation of the control scheme is developed for the statcom bess in MATLAB SIMULINK FOR maintaining the power quality at the source side is presented. It has the capability to cancel out the harmonic part of the load current. It maintains the source voltage and current in phase and support the reactive power

demand of wind turbine generator. Thus it gives the opportunity to enhance the utilization factor of the transmission line. Thus the proposed scheme in the grid connected system fulfills the power quality norms as per the IEC standard 61400-21. We have reduce the harmonics from 0.44% to 0.13%.

REFERENCES

[1] A. Sannino, "Global power systems for sustainable development," in *IEEE General Meeting*, Denver, CO, Jun. 2004.

[2] K. S. Hook, Y. Liu, and S. Atcitty, "Mitigation of the wind generation integration related power quality issues by energy storage," *EPQU J.*, vol. XII, no. 2, 2006.

[3] R. Billinton and Y. Gao, "Energy conversion system models for ade-quacy assessment of generating systems incorporating wind energy," *IEEE Trans. on E. Conv.*, vol. 23, no. 1, pp. 163–169, 2008, Multistate.

[4] Wind Turbine Generating System—Part 21, International standard-IEC 61400-21, 2001.

[5] J. Manel, "Power electronic system for grid integration of renewable energy source: A survey," *IEEE Trans. Ind. Electron.*, vol. 53, no. 4,
pp.1002–1014, 2006, Carrasco.

[6] M. Tsili and S. Papathanassiou, "A review of grid code technology requirements for wind turbine," *Proc. IET Renew.power gen.*, vol. 3,
pp.308–332, 2009.

[7] S. Heier, *Grid Integration of Wind Energy Conversions*. Hoboken, NJ: Wiley, 2007, pp. 256–259.

[8] J. J. Gutierrez, J. Ruiz, L. Leturiondo, and A. Lazkano, "Flicker mea-surement system for wind turbine certification," *IEEE Trans. Instrum. Meas.*, vol. 58, no. 2, pp. 375–382, Feb. 2009.

[9] Indian Wind Grid Code Draft report on, Jul. 2009, pp. 15–18, C-NET.

[10] C. Han, A. Q. Huang, M. Baran, S. Bhattacharya, and W. Litzenberger, "STATCOM impact study on the integration of a large wind farm into
a weak loop power system," *IEEE Trans. Energy Conv.*, vol. 23, no. 1,
pp.226–232, Mar. 2008.

[11] D. L. Yao, S. S. Choi, K. J. Tseng, and T. T. Lie, "A statistical approach to the design of a dispatchable wind power—Battery energy storage system," *IEEE Trans. Energy Conv.*, vol. 24, no. 4, Dec. 2009.

[12] F. Zhou, G. Joos, and C. Abhey, "Voltage stability in weak connection wind farm," in *IEEE PES Gen. Meeting*, 2005, vol. 2, pp. 1483–1488.

[13] T. Kinjo and T. Senjyu, "Output leveling of renewable energy by elec-tric double layer capacitor applied for energy storage system," *IEEE Trans. Energy Conv.*, vol. 21, no. 1, Mar. 2006.

[14] 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 Drives System*, Jan. 2006, vol. 1, pp. 501–506.

[15] S. W. Mohod and M. V. Aware, "Grid power quality with variable speed wind energy conversion," in *Proc. IEEE Int. Conf. Power Elec-tronic Drives and Energy System (PEDES)*, Delhi, Dec. 2006.

[16] Fu. S. Pai and S.-I. Hung, "Design and operation of power converter for microturbine powered distributed generator with capacity expansion capability," *IEEE Trans. Energy Conv.*, vol. 3, no. 1, pp. 110–116, Mar. 2008.