International Journal of Information and Communication Technology Research

http://www.esjournals.org

Voltage Disturbances Improvement of Gird-Connected Wind Turbines in Distribution System Using STATCOM at Weak-Grid Connection Point

[1]Mansour Hosseini Firouz, [2]Behrouz Alefy, [3]M.Montazeri
[1,2]Department of Electrical Engineering, College of Engineering, Ardabil Branch, Islamic Azad University, Ardabil, Iran
[3]Department of Electrical Engineering, College of Engineering, Borujerd Branch, Islamic Azad University, Borujerd, Iran

ABSTRACT

The connection of wind turbines to power system could lead to drop power quality especially in weak point of system. So power system planner investigated this as a main problem and tried to mitigate this effect using new technologies. FACT devises are main solution for this kind of problem in power system. This paper focuses on the utilizing STATCOM for power quality improvement due to connection of wind turbines as a main source of renewable energy to distribution system for meet demand side of system.

This situation can be improved using some of custom power devices technology. In this paper STATCOM is connected at point of common coupling to improve the power quality.

Keywords: *Wind turbine, Power quality, Facts device, STATCOM*

1. INTRODUCTION

Induction generators require reactive power for magnetization [1-2]. Added to the random variations, periodic fluctuations of power can appear in the delivered wind turbine power [3-5]. Hendri Masdi and et.al presents the construction of a prototype DSTATCOM for voltage sag mitigation [6]. The D-STATCOM protects the utility transmission or distribution system from voltage sag and/or flicker caused by rapidly varying reactive current demand. During the transient conditions the D-STATCOM provides leading or lagging reactive power to active system stability, power factor correction and load balancing and /or harmonic compensation of a particular load [7-8]. In [9] the static compensator for maintaining voltage stability of wind farm integration to a distribution network is simulated and analyzed. In [10] advanced control of FACTS devices for improving power quality regarding to wind farm is investigated. Authors of [10] showed that because of enlarging wind generation, growing non-liner loads and competitive electricity markets the operation mechanism of power systems are facing some problems like voltage regulation, damping of power oscillation, etc. Also they concluded that in shunt FACTS devices STATCOM and SVC have been identified as a good device and perfect compensators to solve these troubles.

In case of temporary stability, in [11], the STATCOM effects were examined in the wind plants that have induction generators. In [12] the effects of voltage and reactive power characteristics in fixed speed wind plants by were examined using STATCOM [12]. Authors in [13] were made active–reactive power, voltage variations, the rotor angle, oscillation damping and power flow control of wind plant in power system which has many generators by using STATCOM and SSSC. In [14], authors were found in their study were observed slide-moment characteristic in low power wind plant which has induction generator by using STATCOM and SVC. The effects of load changes by the STATCOM in the power system with infinte power bus were examined by [15] and the voltage and reactive power variation in the bus were compared with proportional integral (PI) and fuzzy logic (FL) control methods.

2. VOLTAGE DISTURBANCES

2.1 Sag

Voltage drop as indicated in Fig.1 is defined as reduction of AC voltage at a given frequency for the duration of 0.5 cycles to 1 minute’s time. Sags are usually caused by system faults, and are also often the result of switching on loads with heavy startup currents.

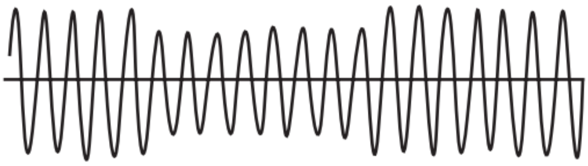

Fig.1.Voltage sag of the system

2.2 Under Voltage

Under voltages as shown in Fig.2 are the results of long-term problems that create sags. The term “brownout” has been commonly used to describe this problem, and has been superseded by the term under voltage.

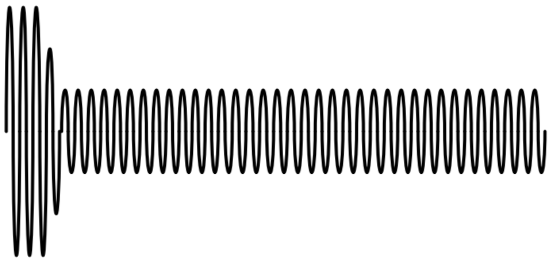

Fig.2.Undervoltage of the system

2.3 Swell

Power line conditioners, UPS systems, and ferro-resonant "control" transformers are common solutions. It is shown in Fig.3.

Volume 4 No. 6, June 2014 ISSN 2223-4985

International Journal of Information and Communication Technology Research

http://www.esjournals.org

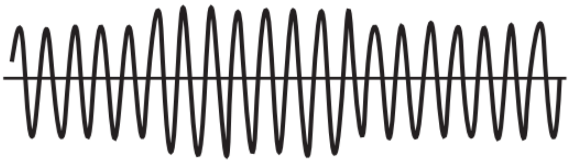

Fig.3.Voltage swell of the system

2.4 Overvoltage

Over voltages as presented in Fig.4 can be the result of long-term problems that create swells. An over-voltage can be thought of as an extended swell. Over-voltages are also common in areas where supply transformer tap settings are set incorrectly and loads have been reduced.

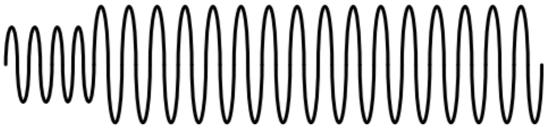

Fig.4.Overvoltage of the system

2.5 Voltage fluctuations

A voltage fluctuation as indicated in Fig.5 is a systematic variation of the voltage waveform or a series of random voltage changes, of small dimensions, namely 95 to 105% of nominal at a low frequency, generally below 25 Hz.

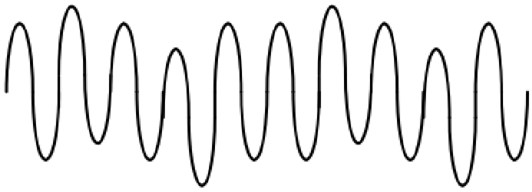

Fig.5.Voltage flicker of the system due to load variation

3. FACTS DEVICE FOR VOLTAGE DISTURBANCES MITIGATION

3.1 Dynamic Voltage Restorer

A DVR is a device that injects a dynamically controlled voltage ***Vinj(t)*** in series to the bus voltage by means of a booster transformer as depicted in Fig.6.

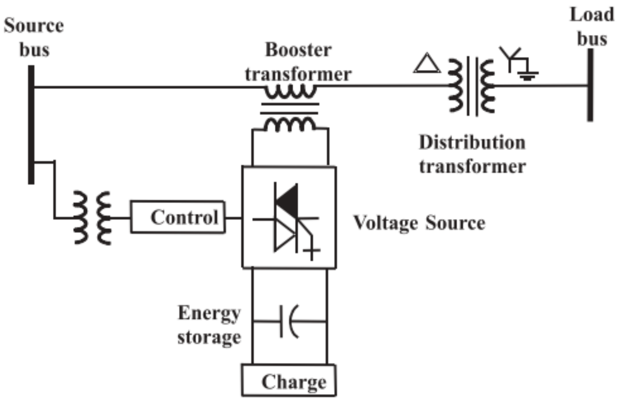

Fig.6.Basic structure of DVR

3.2 Unified Power Flow Controller (UPFC)

This FACT device is consisted of two converters. As presented in Fig.7 the converter-1 is to supply or absorb the real power demanded by converter-2 at the common dc link to support the real power exchange resulting from the series voltage injection. Converter-1 can generate or absorb controllable reactive power if desired, and thereby provide independent shunt reactive compensation for the line. The superior operating characteristic of UPFCConverter-2 provides the main function the UPFC by injecting a voltage Vpq with controllable magnitude and phase angle ρ in series with the line via an insertion transformer.

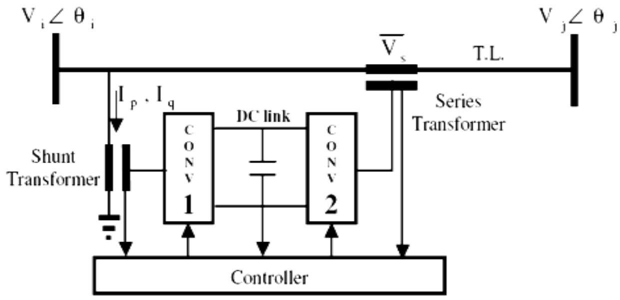

Fig.7.Basic structure of UPFC

3.3 Static synchronous Compensator (Statcom)

A general scheme of a STATCOM connected to an AC system has been presented in Fig.8.

If the primary voltage of the inverter side becomes larger than the system side, the current passes the AC power system through the leakage reactance (X) of the transformer, and inverter generates reactive power for the power system (capacitive case).

If the secondary voltage of the inverter side becomes larger than the system side, the reactive current passes from AC system to the inverter and inverter observes reactive power.

The proposed grid connected system is implemented for power quality improvement at point of common coupling (PCC), as shown in Fig.8. The grid connected system in Fig.8, consists of wind energy generation system and battery energy storage system with STATCOM.

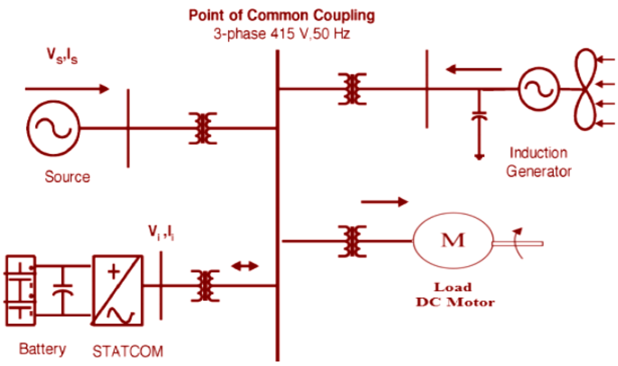

Fig.8.Basic structure of STATCOM at grid connected wind turbines

International Journal of Information and Communication Technology Research

http://www.esjournals.org

4. MATLAB-SIMULINK BASED SIMULATION AND DISCUSSION

The proposed strategy based STATCOM for power quality improvement of grid connected wind turbines is implemented on distribution test system as shown in Fig.9.

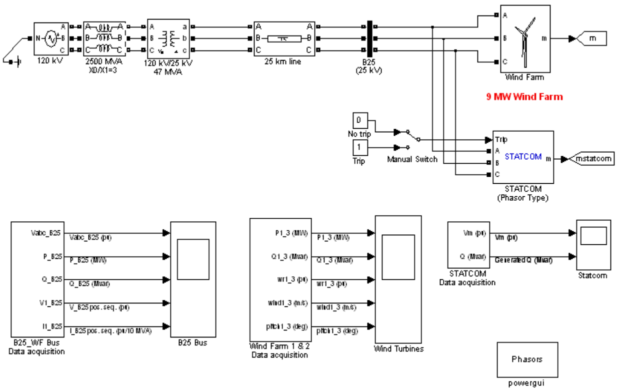

Fig.9.MATLAB/SIMULINK diagram of grid connected wind farm

The subsystem of simulated system discussed in this paper for data acquisition of analyzed bus and wind turbine is presented as Figs 10-11.

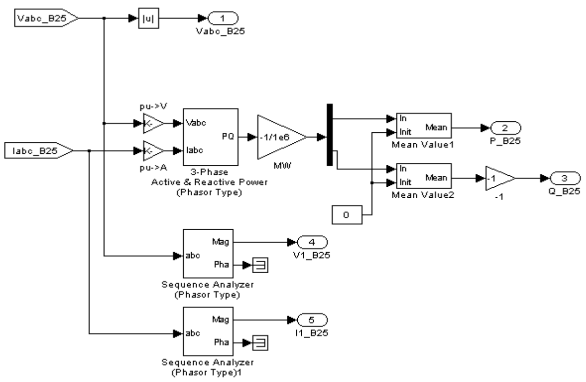

Fig.10.The subsystem of simulated system for data acquisition of analyzed bus

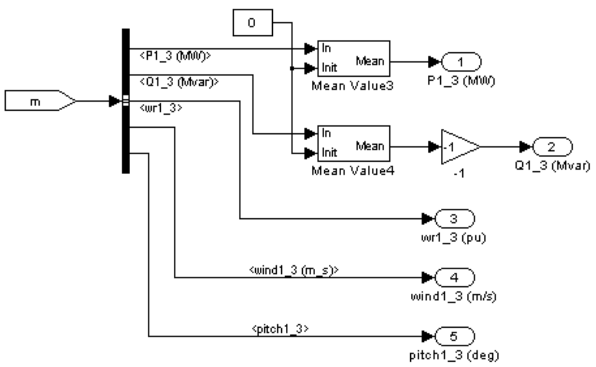

Fig.11.The subsystem of simulated system for data acquisition of wind turbines

All wind turbines use squirrel-cage induction generators (IG). The parameters setting of each of three wind turbines which implanted in this study is shown in Fig.12.

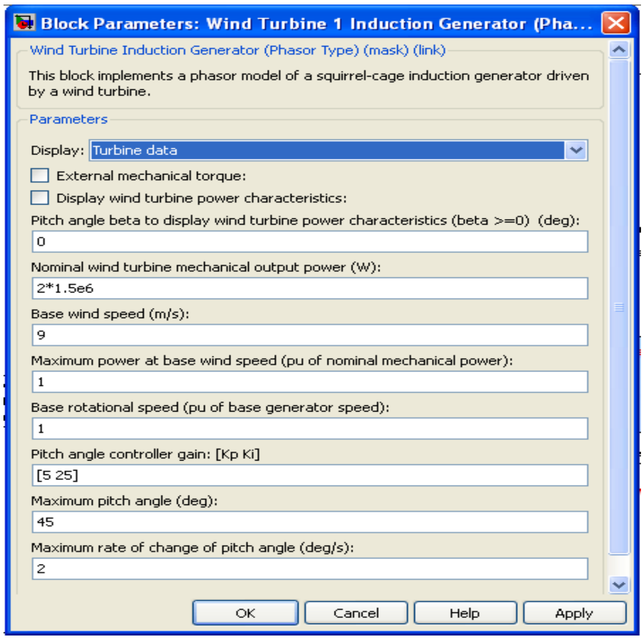

Fig.12. Setting of wind turbine parameters

As shown in Fig.13, due to presence of wind turbines at t=9.2 s, the voltage bus 25 drops to 0.923 pu, due to insufficient reactive power.

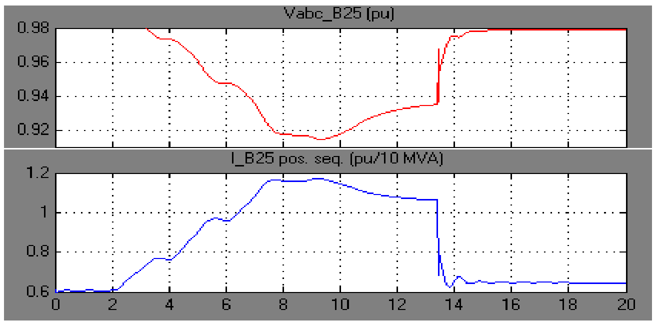

Fig.13.The voltage drop and current variation of analyzed bus 25 of system under wind turbine operation without STATCOM

The variation of active and reactive power at Bus 25 of test system under wind turbine operation without connection of STATCOM to system is presented as shown in Fig.14.

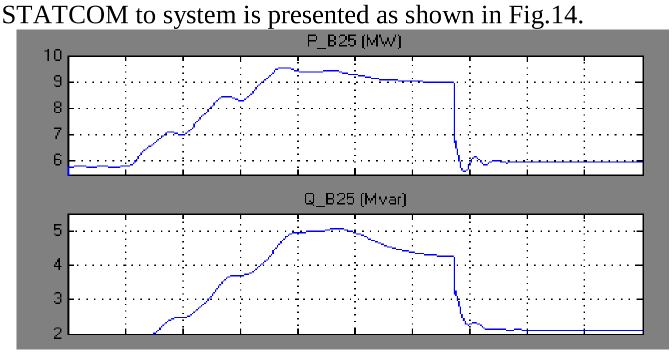

Fig.14.The variation of active and reactive power at bus 25 of test system

 ISSN 2223-4985

International Journal of Information and Communication Technology Research

http://www.esjournals.org

Due to wind turbine operation the voltage bus 25 drops and consequently the protection circuit of wind turbine 1 disconnects it due to under voltage. After turbine 1 has tripped, turbines 2 and 3 continue to generate 3 MW. The simulation results with STACOM are and variation of active and reactive power of Bus 25 is shown in Fig.15.

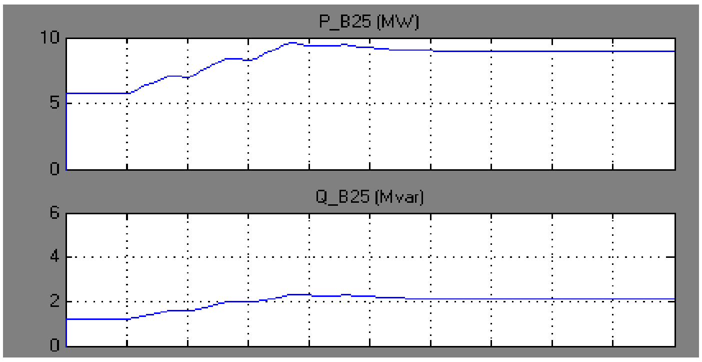

Fig.15.The variation of active and reactive power at Bus 25 of test system with presence of STATCOM

The injected voltage and reactive power by STATCOM is depicted in Fig.16.

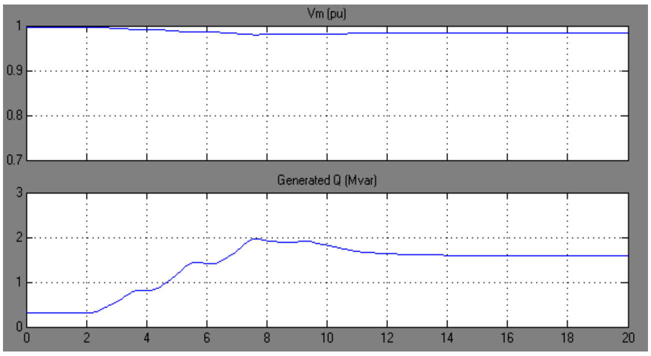

Fig.16.The injected voltage and reactive power by STATCOM for improvement of wind turbines operation

The improvement of PCC parameters under operation of both wind turbines and STATCOM are presented in Fig.17.

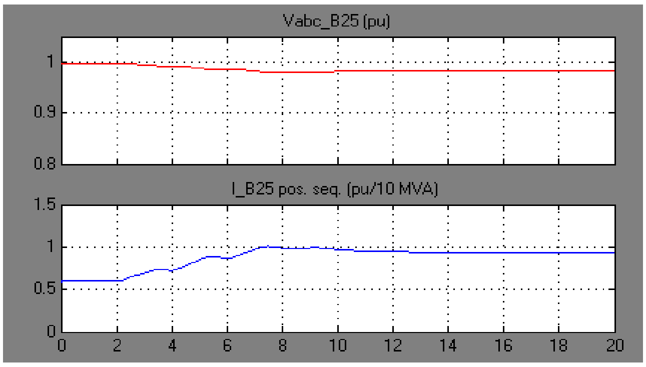

Fig.17.The improvement voltage and current of analyzed bus 25 under wind turbine operation with STATCOM

5. CONCLUSION

In this research the effects of connection of wind turbines on power quality is analyzed and finally as a solution to power quality improvement the effect of static compensator is investigated.

Results are presented to show that the voltage at bus 25 drops to very low value of 0.923 pu due to insufficient reactive power but this bus voltage gets improved to 0.978 when STATCOM is incorporated in the system.

REFERENCES

[1] *T. Thiringerm*. Power quality measurements performed on a low-voltage grid equipped with two wind turbines. IEEE Trans. Energy Conversion, vol. 11, pp. 601–606, June 1996.

[2] T. Thiringer and J.A. Dahlberg. Periodic power pulsations from a three-bladed wind turbine. IEEE Trans. Energy Conversion, vol. 16, pp. 128–133, June 2001.

[3] IEC 61400-21:2001 - Wind turbine generator systems. Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines.

[4] IEC 61000-4-15: Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 15: Flickermeter - Functional and design specifications.

[5] Ferando Soares dos Reis, Using PFC for Hanonic Mitigation in Wind Turbine Energy Conversion Systems, The 30th Annual Conference of the IEEE Industrial Electronics Society, Novembr 2 - 6, 2004, Busan, Korea.

[6] Hendri Masdi, Norman Mariun, S.M. Bashi, Azah Mohamed, Construction of a Prototype D-Statcom for Voltage Sag Mitigation, European Journal of Scientific Research, Vol.30 No.1 (2009), pp.112-127.

[7] IEEE PES working group FACTS Applications, IEEE press. Pub. No. 96-TP-116, 1996.

[8] N.G. Hingorani and L. Gyugyi, Understanding FACTS, concepts and technology of Flexible AC Transmission systems, piscatway, NJ: IEEE press, 2000.

[9] J.Olamaei, et.al., Advanced Control of FACTS Devices for Improving Power Quality Regarding to Wind Farms, Energy Procedia 14 (2012) 298 – 303.

[9] Du W,Wang HF,Dunn R.Power system oscillation stability and control by FACTS and ESS –asurvey .In: Sustainable power generation and supply,SUPERGEN '09.International conference on,6–7April 2009.p.1–13.

[10] Zhang X-P,Rehtanz C,Pal B.Flexible AC transmission systems:modelling and control. Berlin (Heidelberg) :Springer;2006.

ISSN 2223-4985
International Journal of Information and Communication Technology Research

http://www.esjournals.org

[11] Al-Alawi SM,Ellithy KA.Tuning of SVC damping controllers over awide range of load models using an artificialneural network.Int JElectr Power Energy Syst 2000;22(6):405–20.

[12] Dash PK,Mishra S,Panda G.Aradial basis function neural network controller forUPFC.IEEE Trans Power Syst 2000;15(4):1293–9.

[14] Ray S,Venayagamoorthy GK.Wide-area signal-based optimal neuro controller for a UPFC.IEEE Trans Power Deliv 2008;23(3):1597–605.

[15] Chia-Chi C,Hung-Chi T.Application of lyapunov-based adaptive neural network UPFC damping controllers for transient stability enhancement.In:Power and energy society general meeting conversion and delivery of electrical energy in the 21st century,IEEE,20–24July 2008.p.1–6.