Mitigation of Power Quality Problems in Wind Power Generation using UPQC

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Abstract— **Wind Farms (WF) employing squirrel cage induction generator (SCIG) directly connected to the grid, represent a large percentage of the wind energy conversion systems around the world. In facilities with moderated power generation, the WF are connected through medium voltage (MV) distribution headlines. This case is known as Wind Farm to Weak Grid Connection, and its main problem is the poor voltage regulation at the point of common coupling (PCC).Thus, the combination of weak grids, wind power fluctuation and system load changes produce disturbances in the PCC voltage, worsening the Power Quality and WF stability. This situation can be improved using control methods at generator level, or compensation techniques at PCC. In case of wind farms based on SCIG directly connected to the grid, is necessary to employ the last alternative. Custom power devices technology (CUPS) result very useful for this kind of application. In this paper is proposed a compensation strategy based on a particular CUPS device, the Unified Power Quality Compensator (UPQC). A customized internal control scheme of the UPQC device was developed to regulate the voltage in the WF terminals, and to mitigate voltage fluctuations at grid side. The internal control strategy is based on the management of active and reactive power in the series and shunt converters of the UPQC, and the exchange of power between converters through UPQC DC-Link. This approach increases the compensation capability of the UPQC with respect to other custom strategies that use reactive power only. Simulations results show the effectiveness of the proposed compensation strategy for the enhancement of Power Quality and Wind Farm stability.**

I. INTRODUCTION

The location of generation facilities for wind energy is determined by wind energy resource availability, often far from high voltage (HV) power transmission grids and major consumption centers In case of facilities with medium power ratings, the WF is connected through medium voltage (MV) distribution headlines. A situation commonly found in such scheme is that the power generated is comparable to the transport power capacity of the power grid to which the WF is connected, also known as *weak grid connection*. The main feature of this type of connections, is the increased voltage regulation sensitivity to Wherefi=a,b,c represents either phase voltage or currents, and fi=d,q,0 represents that magnitudes transformed to the dqo space. This transformation allows the alignment of a rotating reference frame with the positive sequence of the PCC voltages space vector. To accomplish this, a reference angle synchronized with the PCC positive sequence fundamental voltage space vector is calculated using a Phase Locked Loop (PLL) system. In this work, an "instantaneous power theory" based PLL has been implemented.

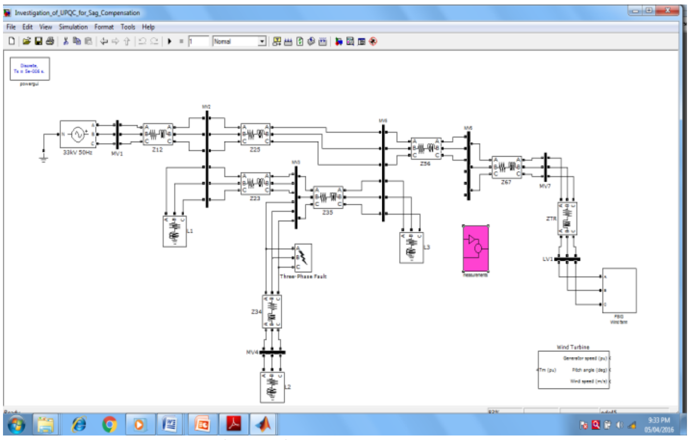

Fig. 1.1 Block diagram of wind farm to weak grid connection without UPQC

This is main block diagram of wind farm connected to grid. Wind farm and grid is connected at the point of common coupling. If fault is occurred at grid side the effect is found on turbine terminal voltage and phase angle jump. Also speed of turbine is reducing.

The result is describe in the following paper and compare the result with the using UPQC. It will compensate power quality problems and increase stability of the wind turbine.

II. EASE OF USE

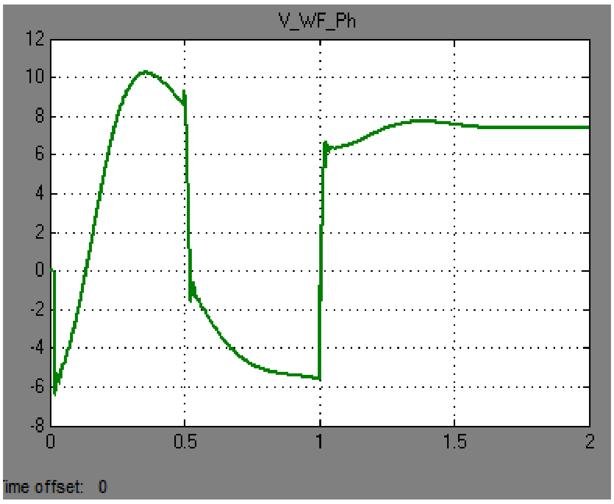

Fig.1.2. a. Result of simulation for sag without UPQC

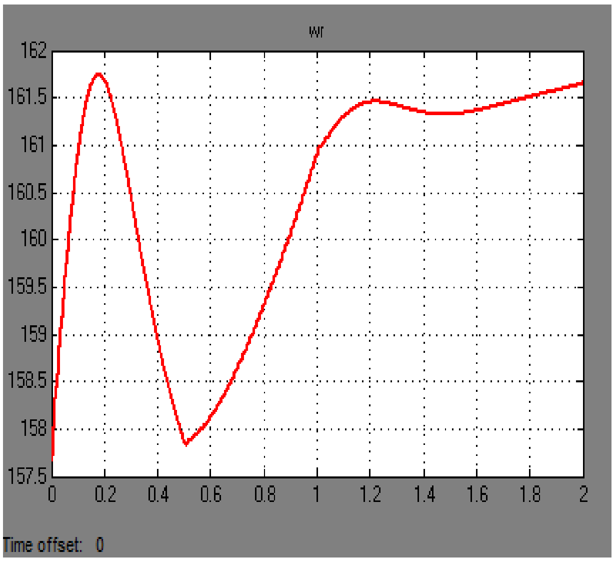

Fig. 1.2. b Result of simulation for speed of turbine without UPQC

In this result the sag problem is created in this paper and the torque is not smooth . There is phase jump problems is also found

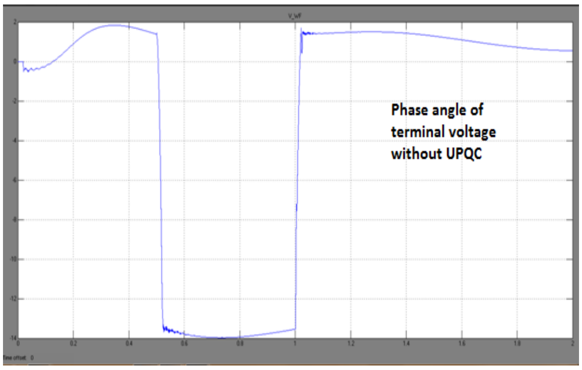

Fig shows the phase angle jumpwithout UPQC

III. USING UPQC

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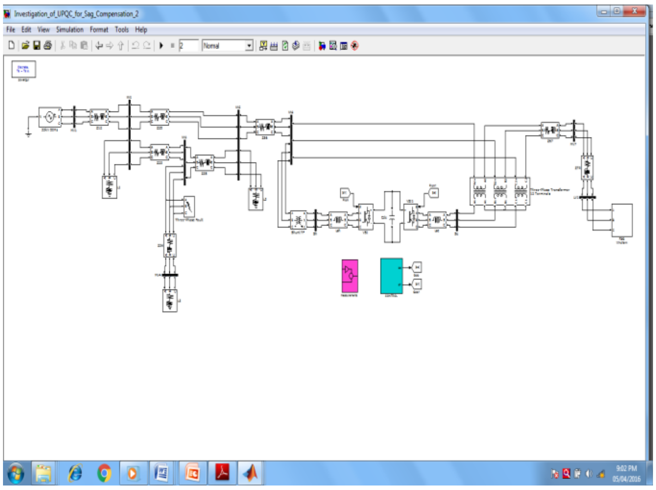
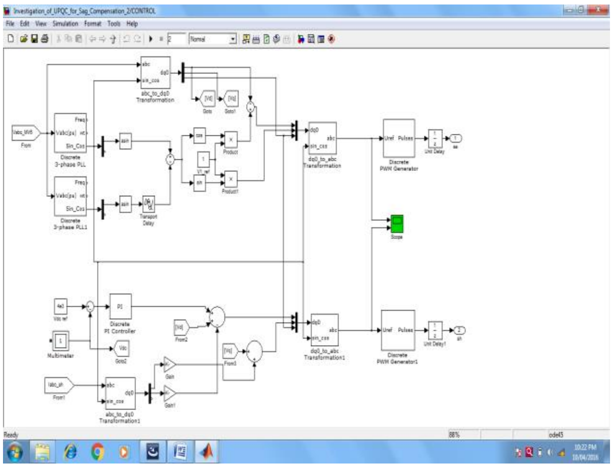


COMPENSATION OF VOLTAGE FLUCTUATION Simulation results for 0 < t < 6 are shown. At t = 0.5 ″Begins the cyclical power pulsation produced by the tower shadow effect. As was mentioned, the tower shadow produces variation in torque, and hence in the active and reactive WF generated power. For nominal wind speed condition, the power fluctuation frequency is f = 3.4Hz, and the amplitude of the resulting voltage variation at PCC, expressed as a percentage is: dU/ Urated = 1.50% .

IV. UPQC CONTROL STRATEGE



Control strategy plays the most significant role in any powerelectronics based system. It is the control strategy which decides the behavior and desired operation of a particular system. The effectiveness of a UPQC system solely depends upon its control algorithm. The UPQC control strategy determines the reference signals (current and voltage) and, thus, decides the switching instants of inverter switches, such that the desired performance can be achieved. There are several control strategies/algorithm/techniques available in the existing literature those have successfully applied to UPQC systems. Frequency domain methods, such as, based on the fast Fourier transformer (FFT), are not popular due to large computation time and delay in calculating the FFT. Control methods for UPQC in the time domain are based on instantaneous derivation of compensating commands in the form of either voltage or current signals.

There are a large number of control methods in the time domain. Two most widely used time-domain control techniques for UPQC are the instantaneous active and reactive power or three phase *pq* theory [10] and synchronous reference frame method or three-phase *dq* theory [10].

These methods transfer the voltage and current signals in ABC frame to stationary reference frame (*pq* theory) or synchronously rotating frame (*dq* theory) to separate the fundamental and harmonic quantities. In *pq* theory, instantaneous active and reactive powers are computed, while, the *d*-*q* theory deals with the current independent of the supply voltage. The interesting feature of these theories is that the real and reactive powers associated with fundamental components (*pq* theory), and the fundamental component in distorted voltage or current (*dq* theory), are dc quantities.

These quantities can easily be extracted using an LPF or a high-pass filter (HPF). Due to the dc signal extraction, filtering of signals in the *αβ* reference frame is insensitive to any phase shift errors introduced by LPF.

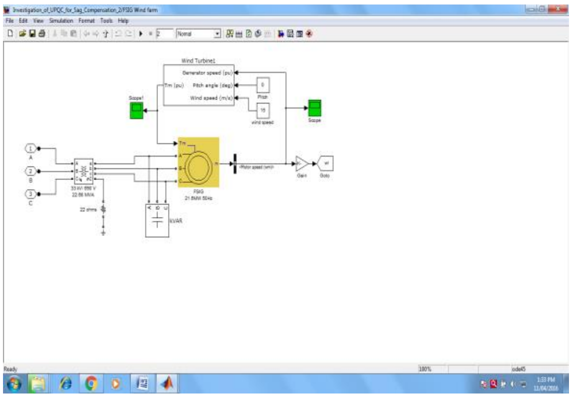
However, the cutoff frequency of these LPF or HPF can affect the dynamic performance of the controller The UPQC serial converter is controlled to maintain the WF terminal voltage at nominal value, thus compensating the PCC voltage variations. In this way, the voltage disturbances coming from the grid cannot spread to the WF facilities.

As a side effect, this control action may increase the low voltage ride–through (LVRT) capability in the occurrence of voltage sags in the WF terminals. Fig. 2. Shows a block diagram of the series converter controller. The injected voltage is obtained subtracting the PCC voltage from the reference voltage, and is phase–aligned with the PCC voltage. On the other hand, the shunt converter of UPQC is used to filter the active and reactive power pulsations generated by the WF. Thus, the power injected into the grid from the WF compensator set will be free from pulsations, which are the origin of voltage fluctuation that can propagate into the system. This task is achieved by appropriate electrical currents injection in PCC. Also, the regulation of the DC bus voltage has been assigned to this converter. This controller generates both voltages commands.

The powers PshuC and QshuC are calculated in the rotating reference frame, as follows:

$$\mathrm{PshuC}(t) = 3/2\,.V^{\mathrm{PCC}}{}_{d}\,(t)\,.I^{\mathrm{shuC}}{}_{d\,(t)}$$

$$\mathrm{QshuC}(t) = -3/2\,.V^{\mathrm{PCC}}{}_{d}\,(t)\,.I^{\mathrm{shuC}}{}_{q}\,(t)$$


Investigation_of_UPQC_for_Sag_Compensation_2/FSIG Wind farm

Model of induction generator

For the squirrel cage induction generator the model available in MATLAB/ Simulink Sim Power Systems libraries is used. It consists of a fourth order state space electrical model and a second order mechanical model

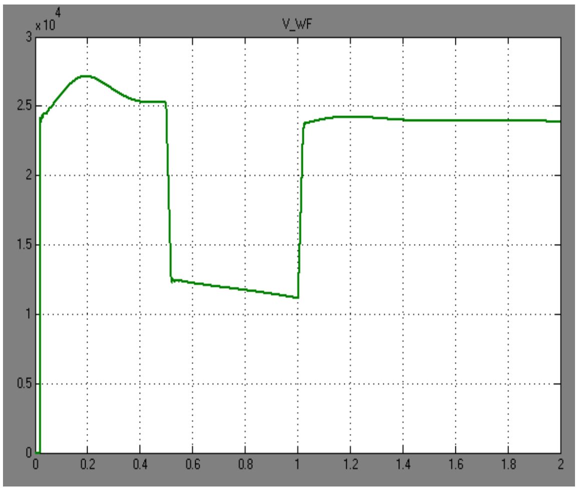
$$= 2/3\begin{bmatrix} \sin\theta & \sin\left(\theta-\frac{2\pi}{3}\right) & \sin\left(\theta+\frac{2\pi}{3}\right) \\ \cos\theta & \cos\left(\theta-\frac{2\pi}{3}\right) & \cos\left(\theta+\frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix}$$

$$\begin{bmatrix} fd \\ fq \\ fo \end{bmatrix} = T.\begin{bmatrix} fa \\ fb \\ fc \end{bmatrix}$$

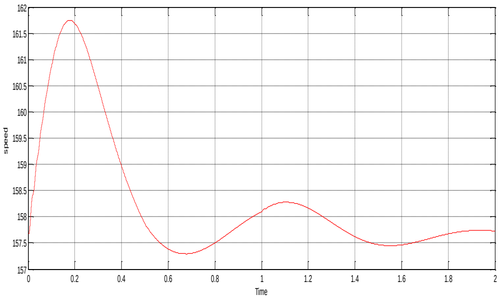
Where fi=a,b,c represents either phase voltage or currents, and fi=d,q,0 represents that magnitudes transformed to the dqo space. This transformation allows the alignment of a rotating reference frame with the positive sequence of the PCC voltages space vector. To accomplish this, a reference angle _ synchronized with the PCC positive sequence fundamental voltage space vector is calculated using a Phase Locked Loop (PLL) system. In this work, an "instantaneous power theory" based PLL has been implemented. Under balance steady-state conditions, voltage and currents vectors in this synchronous reference frame are constant quantities

A. *Simulation result of terminal voltage*

The voltage sag problem is compensated by using UPQC device



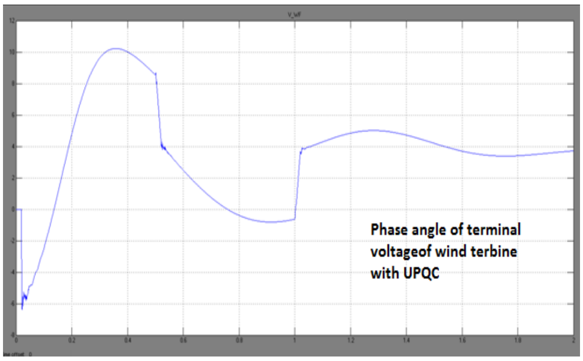
B. *Simulation result of speed means smooth torque*



As we seen that the torque of wind terbine is smooth with UPQC.The custom power devices compensate the power quality problems .

1) Maintain Stability of the system and regulate voltage,Improve power factor and also mitigate power quality problems. This feature is useful for analysis and decoupled control. Ed shuC and Eq shuC based on power fluctuations _P and Q, respectively. Such deviations are calculated subtracting the mean power from the instantaneous power measured in PCC Ed shu C also contains the control action for the DC–bus voltage loop.

C. *Simulation result of phase jump*



V. VOLTAGE REGULATION

As stated in Sec. I, the UPQC is also operated to maintain the WF terminal voltage constant, rejecting PCC voltage variations, due to events like sudden connection/ disconnection of loads, power system faults, etc. A sudden connection of load is performed at t = 6″, by closing L3 switch (SW). As can be observed in the upper curve, the series converter requires negligible power to operate, while the shunt converter demands a high instantaneous power level from the capacitor when compensating active power fluctuation. Compensation of reactive powers has no influence on the DC side power. The DC-bus has voltage level limitations in accordance with the VSI's operational characteristics. As the fluctuating active power is handled by the capacitor, its value needs to be selected so that the "ripple" in the DC voltage is kept within a narrow range. In this case, I have considered a capacitor size C = 0.42 F. This high value can be easily obtained by using emerging technologies based capacitors, such as double–layer capacitors, also known as ultra capacitors.

VI CONCLUSION

. The model of the power system scheme illustrated in Fig.1, including the controllers with the control strategy detailed in II, was implemented using MATLAB/ Simulink software. Numerical simulations were performed to determine and then compensate voltage fluctuation due to wind power variation, and voltage regulation problems due to a sudden load connection. The simulation was conducted with the following chronology. In this paper, a new compensation strategy implemented using an UPQC type compensator was presented, to connect SCIG based wind farms to weak distribution power grid. The proposed compensation scheme enhances the system power quality, exploiting fully DC–bus energy storage and active power sharing between UPQC converters, features not present in DVR and D–Statcom compensators. The simulation results show a good performance in the rejection of power fluctuation due to "tower shadow effect" and the regulation of So, the effectiveness of the proposed compensation approach is demonstrated in the study case. There are two important types of APF, namely, shunt APF and series APF [8]–[10]. The shunt APF is the most promising to tackle the current-related problems, whereas, the series APF is the most suitable to overcome the voltage-related problems Since the modern distribution system demands a better quality of voltage being supplied and current drawn, installation of these APFs has great scope in actual practical implementation.

REFERENCES

[1] Farias, M.F.; Battaiotto, P.E.; Cendoya, M.G., "Investigation of UPQC for sag compensation in wind farms to weak grid connections," in *Industrial Technology (ICIT), 2010 IEEE International Conference on* , vol., no., pp.937-942, 14-17 March 2010)

[2] Khadkikar, V., "Enhancing Electric Power Quality Using UPQC: A Comprehensive Overview," in *Power Electronics, IEEE Transactions on* , vol.27, no.5, pp.2284-2297, May

[3] Han, B.; Bae, B.; Baek, S.; Jang, G., "New configuration of UPQC for medium-voltage application," in *Power Delivery, IEEE Transactions on* , vol.21, no.3, pp.1438-1444, July 2006 [4] Peng Li; Qian Bai; Gengyin Li, "Coordinated control strategy for UPQC and its verification," in *Power Engineering Society General Meeting, 2006. IEEE* , vol., no., pp.8

[4] Khadkikar, V.; Chandra, A.; Barry, A.O.; Nguyen, T.D., "Conceptual Study of Unified Power Quality Conditioner (UPQC)," in *Industrial Electronics, 2006 IEEE International Symposium on* , vol.2, no., pp.1088-1093, 9-13 July 2006

[5] Aryanezhad, M.; Ostadaghaee, E.; Joorabian, M., "Voltage dip mitigation in wind farms by UPQC based on Cuckoo Search Neuro Fuzzy Controller," in *Fuzzy Systems (IFSC), 2013 13th Iranian Conference on*, vol., no., pp.1-6, 27-29 Aug. 2013

[6] Khadkikar, V.; Chandra, A., "UPQC-S: A Novel Concept of Simultaneous Voltage Sag/Swell and Load Reactive Power Compensations Utilizing Series Inverter of UPQC," in *Power Electronics, IEEE Transactions on* , vol.26, no.9, pp.2414-2425, Sept. 2011

[7] S. Moran, "A line voltage regulator/conditioner for harmonic-sensitive load isolation," in *Proc. Ind. Appl. Soc. Annu. Meet. Conf.*, Oct. 1–5, 1989, pp. 947–951

[8] S. Moran, "A line voltage regulator/conditioner for harmonic-sensitive load isolation," in *Proc. Ind. Appl. Soc. Annu. Meet. Conf.*, Oct. 1–5, 1989, pp. 947–951

[9] H. Fujita and H. Akagi, "The unified power quality conditioner: The integration of series and shunt-active filters," *IEEE Trans. Power Electron.*,

[10] vol. 13, no. 2, pp. 315–322, Mar. 1998

[11] Mr.R.G.Shriwastava,Dr. M.B.Daigavane,Dr. S.R.Vaishnav "*Application Characteristics of Permanent Magnet Synchronous Motors", (*Case Study) International Journal of Computer Information Systems (IJCIS)*Vol. 3, No. 3, 2011.*

[12] Mr.R.G.Shriwastava,DrM.B.Daigavane,Dr.S.R.Vaishna*v" Literature Review of Permanent Magnet AC Motors DriveforAutomotiveApplication",*BuletinTeknikElektrodanInformatika (Bulletin of Electrical Engineering and Informatics) *Vol.1, No.1, March 2012, pp. 7~14*

[13] Mr.R.G.Shriwastava,Dr. M.B.Daigavane,Dr. S.R.Vaishnav*"Torque Analysis of Permanent Magnet Synchronous Motor Used in Automotive Industry",* International joint journal of electrical &electronics engineering (IJJEE-2011)*Vol. 05, No. 02, Mar 2011(ACEEE DOI:01.IJRTET.05.02.85)*