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Wind Farm to Weakgrid Without using UPQC Custom Device

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***Abstract*— The Unified Power Quality Conditioner (UPQC) is used to improve the power quality and is based on the union of a series active filter and a shunt active filter. The resulting topology has the characteristics of both filters and can compensate voltage and currents disturbances and improve the customer's power quality. The topology based on current source converters (CSC-UPQC) has a good dynamic behavior to mitigate voltage disturbances as it uses a first order filter in the series stage. This allows a rapid response while using low switching frequencies without the problems associated with the resonance of the second order filter as required in the voltage source topology. This work develops a control scheme based on an on-linear control scheme for load current harmonic compensation by the shunt stage. The proposed control scheme regulates the load voltage under fast PCC voltage disturbances mean while the load currents harmonics are mitigated.**

Index Terms*— Static Synchronous compensator (statcom), Custom power, FACTS devices.

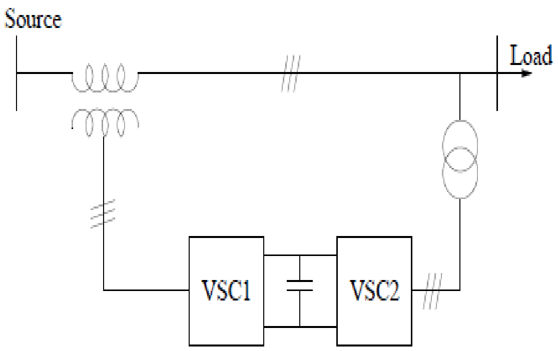
I. INTRODUCTION

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 changes in load. So, the system's ability to regulate voltage at the point of common coupling (PCC) to the electrical system is a key factor for the successful operation of the WF. Also, is well known that given the random nature of wind resources, the WF generates *fluctuating electric power*. These fluctuations have a negative impact on stability and power quality in electric power systems. Moreover, in exploitation of wind resources, turbines employing *squirrel cage induction generators* (SCIG) have been used since the beginnings. The operation of SCIG demands reactive power, usually provided from the mains and/or by local generation in capacitor banks. In the event that changes occur in its mechanical speed, i.e due to wind disturbances, so will the WF active (reactive) power injected(demanded) into the power grid, leading to variations of WF terminal voltage because of system impedance. This power disturbances propagate into the power system, and can produce a phenomenon known as "flicker", which consists of fluctuations in the illumination level caused by voltage variations. Also, the normal operation of WF is impaired due to such disturbances. In particular for the case of "weak grids", the impact is even greater. In order to reduce the voltage fluctuations that may cause "flicker", and improve WF terminal voltage regulation, several solutions have been posed. The most common one is to upgrade the power grid, increasing the short circuit power level at the point of common coupling PCC, thus reducing the impact of power fluctuations and voltage regulation problems. In recent years, the technological development of high power electronics devices has led to implementation of electronic equipment suited for electric power systems, with fast response compared to the line frequency. These *active compensators* allow great flexibility in: a) controlling the power flow in transmission systems using Flexible AC Transmission System (FACTS) devices, and b) enhancing the power quality in distribution systems employing Custom Power System CUPS) devices. The use of these active compensators to improve integration of wind energy in weak grids is the approach adopted in this work. In this paper we propose and analyze a compensation strategy using an UPQC, for the case of SCIG–based WF, Connected to a weak distribution power grid. This system is taken from a real case. The UPQC is controlled to regulate the WF terminal voltage, and to mitigate voltage fluctuations at the point of common coupling (PCC), caused by system load changes and pulsating WF generated power, respectively. The voltage regulation at WF terminal is conducted using the UPQC series converter, by voltage injection "in phase" with PCC voltage. On the other hand, the shunt converter is used to filter the WF generated power to prevent voltage fluctuations, requiring active and reactive power handling capability. The sharing of active power between converters, is managed through the common DC link. Simulations were carried out to demonstrate the effectiveness of the proposed compensation approach.

II. UNIFIED POWER QUALITY CONDITIONER

The provision of both DSTATCOM and DVR can control the power quality of the source current and the load bus voltage. In addition, if the DVR and STATCOM are connected on the DC side, the DC bus voltage can be regulated by the shunt connected DSTATCOM while the DVR supplies the required energy to the load in case of the transient disturbances in source voltage. The configuration of such a device (termed as

Unified Power Quality Conditioner (UPQC)) is shown in Fig. 14.15. This is a versatile device similar to a UPFC. However, the control objectives of a UPQC are quite different from that of a UPFC.



III. CONTROL OBJECTIVES OF UPQC

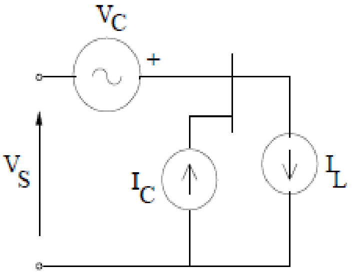
The shunt connected converter has the following control objectives

1. To balance the source currents by injecting negative and zero sequence components required by the load
2. The compensate for the harmonics in the load current by injecting the required harmonic currents
3. To control the power factor by injecting the required reactive current (at fundamental frequency)
4. To regulate the DC bus voltage.

The series connected converter has the following control objectives

1. To balance the voltages at the load bus by injecting negative and zero sequence voltages to compensate for those present in the source.
2. To isolate the load bus from harmonics present in the source voltages, by injecting the harmonic voltages
3. To regulate the magnitude of the load bus voltage by injecting the required active and reactive components (at fundamental frequency) depending on the power factor on the source side
4. To control the power factor at the input port of the UPQC (where the source is connected. Note that the power factor at the output port of the UPQC (connected to the load) is controlled by the shunt converter.

IV. OPERATION OF UPQC



Figs

The operation of a UPQC can be explained from the analysis of the idealized equivalent circuit shown in Fig. 14.16. Here, the series converter is represented by a voltage source VC and the shunt converter is represented by a current source IC. Note that all the currents and voltages are 3 dimensional vectors with phase coordinates. Unlike in the case of a UPFC (discussed in chapter 8), the voltages and currents may contain negative and zero sequence components in addition to harmonics. Neglecting losses in the converters, we get the relation

$$\langle V_L, I_C\rangle + \langle V_C, I_S\rangle = 0$$

Where X,Y denote the inner product of two vectors, defined by

$$\langle X, Y\rangle = \frac{1}{T}\int_0^T X^t(\tau)Y(\tau)d\tau.$$

Let the load current IL and the source voltage VS be decomposed into two
Components given by

$$I_L = I_L^{1p} + I_L^r$$

$$V_S = V_S^{1p} + V_S^r$$

Where I1p L contains only positive sequence, fundamental frequency components Similar comments apply to V 1pS. IrL and V rS contain rest of the load current and the source voltage including harmonics. I1pL is not unique and depends on the power factor at the load bus. However, the following relation applies for I1p L.

$$P_L = \langle V_L, I_L\rangle = \langle V_L, I_L^{1p}\rangle$$

This implies that hIrL; VLi = 0. Thus, the fundamental frequency, positive sequence component in IrL does not contribute to the active power in the load. To meet the control objectives, the desired load voltages and source currents must contain only positive sequence, fundamental frequency components and

$$P_L = |V_L^* I_S^*|\cos\phi_l = |V_S^{1p} I_S^*|\cos\phi_s$$

Where V ¤ L and I¤S are the reference quantities for the load bus voltage and the source current respectively. Ál is the power factor angle at the load bus while Ás is the power factor angle at the source bus (input port of UPQC). Note that V ¤ L(t) and I¤S (t) are sinusoidal and balanced. If the reference current (I¤C) of the shunt converter and the reference voltage (V ¤ C) of the series converter are chosen as

$$I_C^* = I_L^*, \quad V_C^* = -V_S^r + V_C^{1p}$$

With the constraint

$$\langle V_C^{1p}, I_S^*\rangle = 0$$

We have,

$$I_S^* = I_L^{1p}, \quad V_L^* = V_S^{1p} + V_C^{1p}$$

Note that the constraint (14.30) implies that V 1p C is the reactive voltage in quadrature with the desired source current, I¤S . It is easy to derive that

$\langle V_C^*, I_S^*\rangle = 0 = \langle I_C^*, V_L^*\rangle$ .The above equation shows that for the operating conditions assumed, a UPQC can be viewed as a inaction of a DVR and a STATCOM with no active power °ow through the DC link. However, if the magnitude of V ¤ L is to be controlled, it may not be feasible to achieve this by injecting only reactive voltage. The situation gets complicated if V 1p S is not constant, but changes due to system disturbances or fault. To ensure the regulation of the load bus voltage it may be necessary to inject variable active voltage (in phase with the source current).

If we express

$$V_C = V_C^* + \Delta V_C, I_C = I_C^* + \Delta I_C$$

$$I_S = I_S^* - \Delta I_C, V_L = V_S^{1p} + V_C^{1p} + \Delta V_C$$

$$\langle I_S, \Delta V_C \rangle + \langle V_L, \Delta I_C \rangle = 0$$

In deriving the above, we assume that

$$\langle I_S, V_C^* \rangle = 0 = \langle V_L, I_C^* \rangle$$

This implies that both ¢VC and ¢IC are perturbations involving positive sequence, fundamental frequency quantities (say, resulting from symmetric voltage sags). the power balance on the DC side of the shunt and series converter. The perturbation in VC is initiated to ensure that

$$|V_C^* + \Delta V_C + V_S| = |V_L| = \text{constant.}$$

Thus, the objective of the voltage regulation at the load bus may require exchange of power between the shunt and series converters.

V. REMARKS:

1. The unbalance and harmonics in the source voltage can arise due to uncompensated nonlinear and unbalanced loads in the upstream of the UPQC.
2. The injection of capacitive reactive voltage by the series converter has the advantage of raising the source voltage magnitude.

VI. WEAK GRID

The term 'weak grid' is used in many connections both with and without the inclusion of wind energy. It is used without any rigour definition usually just taken to mean the voltage level is not as constant as in a 'stiff grid'. Put this way the definition of a weak grid is a grid where it is necessary to take voltage level and fluctuations into account because there is a probability that the values might exceed the requirements in the standards when load and production cases are considered. In other words, the grid impedance is significant and has to be taken into account in order to have valid conclusions. Weak grids are usually found in more remote places where the feeders are long and operated at a medium voltage level. The grids in these places are usually designed for relatively small loads. When the design load is exceeded the voltage level will be below the allowed minimum and/or the thermal capacity of the grid will be exceeded. One of the consequences of this is that development in the region with this weak feeder is limited due to the limitation in the maximum power that is available for industry etc. The problem with weak grids in connection with wind energy is the opposite. Due to the impedance of the grid the amount of wind energy that can be absorbed by the grid at the point of connection is limited because of the upper voltage level limit. So in connection with wind energy a weak grid is a power supply system where the amount of wind energy that can be absorbed is limited by the grid capacity and not e.g. by operating limits of the conventional generation.

A. Basic power control idea

The basic power control idea investigated in the current project is to buffer wind energy in situations where the grid voltage would otherwise exceed the limit and then release at a later time when the voltage of the grid is lower. The main idea is to combine a wind farm with an energy storage and a control system and then be able to connect a larger amount of wind capacity without exceeding the voltage limits and without grid re-enforcement and still have a profitable wind energy system.

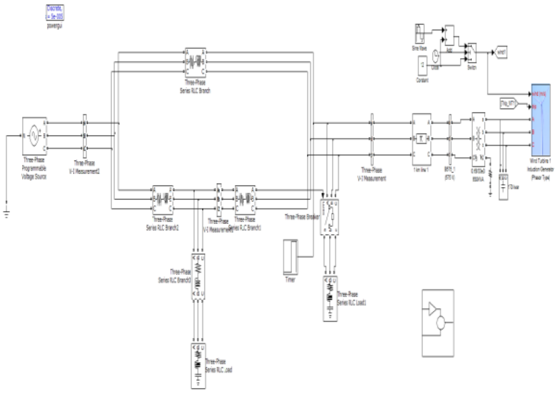
VII. BASIC PROBLEMS WITH WIND TURBINES IN WEAK GRIDS VOLTAGE LEVEL

The main problem with wind energy in weak grids is the quasi-static voltage level. In a grid without wind turbines connected the main concern by the utility is the minimum voltage level at the far end of th profile for a feeder without wind energy is that the highest voltage is at the bus bar at the substation and that it drops to reach the minimum at the far end.

The settings of the transformers by the utility are usually so, that the voltage at the consumer closest to the transformer will experience a voltage, that is close to the maximum value especially when the load is low and that the voltage is close to the minimum value at the far end when the load is high. This operation ensures that the capacity of the feeder is utilised to its maximum. When wind turbines are connected to the same feeder as consumers which often will be the case in sparsely populated areas the voltage profile of the feeder will be much different from the no wind case. Due to the power production at the wind turbine the voltage level can and in most cases will be higher than in the no wind case.

As is seen on the figure the voltage level can exceed the maximum allowed when the consumer load is low and the power output from the wind turbines is high. This is what limits the capacity of the feeder. The voltage profile of the feeder depends on the line impedance, the point of connection of the wind turbines.

- SIMULATION DESIGN



- RESULT OF WITHOUT UPQC:

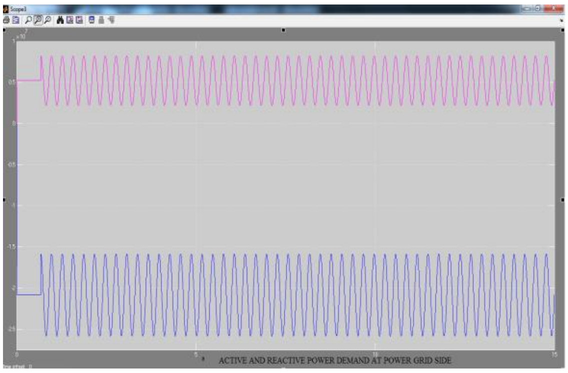


Fig1.Active And Reactive Power Demand At Power Grid Side

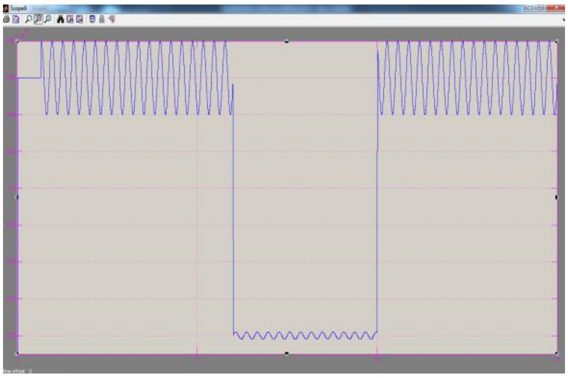


Fig2. Middle curve pcc voltage

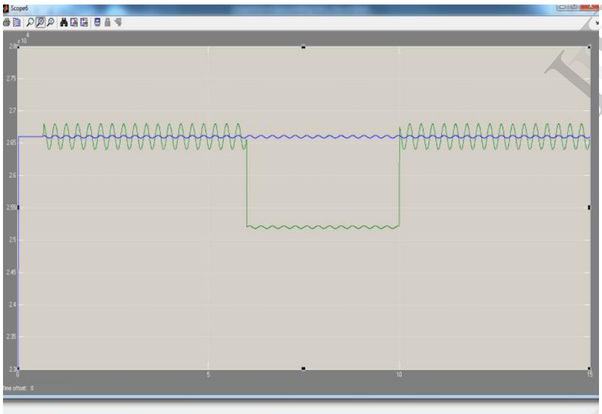
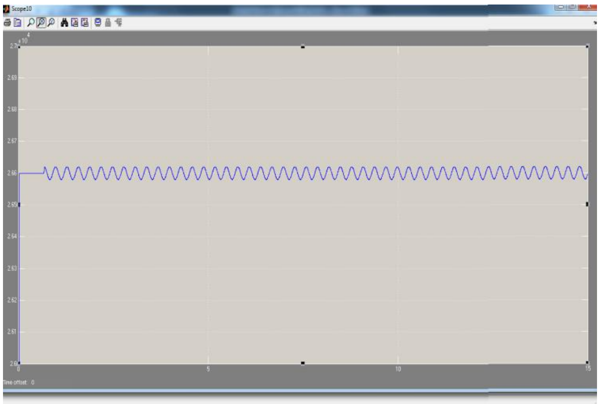
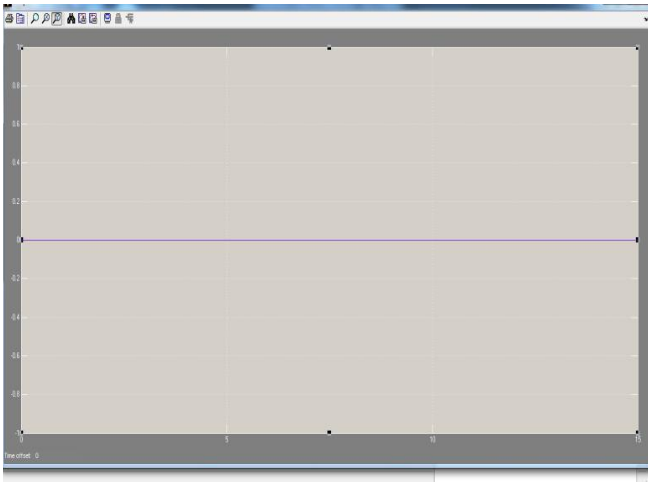
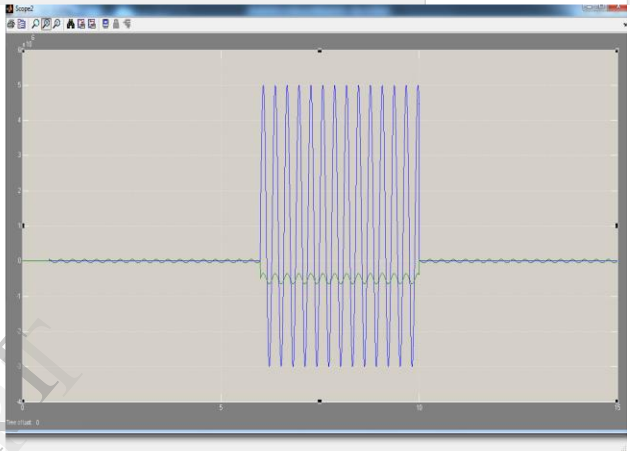


Fig3. Lower curve : WF terminal voltages







Fig;Power and voltage

VIII. CONCLUSION

In this paper, a new compensation strategy implemented Without 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.*

REFERENCES

[1] V. Khadkikar and A. Chandra, "UPQC-S: A novel concept of simultaneous voltage sag/swell and load reactive power compensations utilizing series inverter of UPQC," IEEE Trans. Power Electon., vol. 99, pp. 2414–2425. Jan. 2011.

[2] I. Axente, J. N. Ganesh, M. Basu, M. F. Conlon, and K. Gaughan, A 12-kVA DSP-controlled laboratory prototype UPQC capable of mitigating unbalance in source voltage and load current,‖ IEEE Trans. Power Electron., vol. 25, no. 6, pp. 1471–1479, Jun. 2010

[3] C. N. Ho and H. S. Chung, ―Implementation and performance evaluation of a fast dynamic control scheme for capacitor-supported interline DVR,‖ IEEE Trans. Power Electron., vol. 25, no. 8, pp. 1975–1988, Aug. 2010.

[4] Y. Chen, C. Lin, J. Chen, and P. Cheng, ―An inrush mitigation technique of load transformers for the series voltage sag compensator,‖ IEEE Trans. Power Electron., vol. 25, no. 8, pp. 2211–2221, Aug. 2010.

[5] S. Subramanian and M. K. Mishra, ―Interphase AC–AC topology for voltage sag supporter,‖ IEEE Trans. Power Electron., vol. 25, no. 2, pp. 514–518, Feb. 2010

[6] Doncker, C. Meyer, R. W. De, W. L. Yun, and F. Blaabjerg, ―Optimized control strategy for a medium-voltage DVR—Theoretical investigations and experimental results,‖ IEEE Trans. Power Electron., vol. 23, no. 6, pp. 2746–2754, Nov. 2008.

[7] H. Akagi, E. H. Watanabe, M. Aredes “Instantaneous power theory an applications to power conditioning”, John Wiley & Sons, 2007. ISBN 978-0-470-10761-4.

[8] B. Han, B. Bae, H. Kim, and S. Baek, ―Combined operation of unified power-quality conditioner with distributed generation,‖ IEEE Trans. Power Del., vol. 21, no. 1, pp. 330–338, Jan. 2006.

[9] H. R. Mohammadi, A. Y. Varjani, and H. Mokhtari, Multiconverter unified power-quality conditioning system:MC-UPQC,‖ IEEE Trans. Power Del., vol. 24, no. 3, pp. 1679–1686, Jul. 2009.

[10] I. Axente, J. N. Ganesh, M. Basu, M. F. Conlon, and K. Gaughan, ―A 12-kVA DSP-controlled laboratory prototype UPQC capable of mitigating unbalance in source voltage and load current,‖ IEEE Trans. Power Electron., vol. 25, no. 6, pp. 1471–1479, Jun. 2010.

[11] M. Basu, S. P. Das, and G. K. Dubey, ―Investigation on the performance of UPQC-Q for voltage sag mitigation and power quality improvement at a critical load point,‖ IET Generat., Transmiss.Distrib., vol. 2, no. 3, pp. 414–423, May 2008.

[12] V. Khadkikar and A. Chandra, ―A novel control approach for unified power quality conditioner Q without active power injection for voltage sag compensation,‖ in Proc. IEEE Int. Conf. Ind. Technol. (ICIT), Dec. 15–17, 2006, pp. 779–784.

[13] Y.Y.Kolhatkar and S. P. Das, ―Experimental investigation of a singlephase UPQC with minimum VA loading,‖ IEEE Trans. Power Del., vol. 22, no. 1, pp. 373–380, Jan. 2007.

[14] D. O. Kisck, V. Navrapescu, and M. Kisck, ―Single-phase unified power quality conditioner with optimum voltage angle injection for minimum VA requirement,‖ in Proc. IEEE Power Electron. Spec. Conf. (PESC), Jun. 17–21, 2007, pp. 574–579.

[15] G. S. Kumar, P. H. Vardhana, B. K. Kumar, and M. K. Mishra, ―Minimization of VA loading of unified power quality conditioner (UPQC),‖ in Proc. IEEE Powereng, Mar. 18–20, 2009, pp. 552–557.

[16] M Hosseinpour, A Yazdian, M Hohamadian, J Kazempour, “Desing andSimulation of UPQC to Improve Power Quality and Transfer Wind Energy toGrid”, Jour of Applied Sciences, 2008, vol. 8(21), pp. 3770 – 3782.

[17] M. Basu, S. P. Das, and G. K. Dubey, “Comparative evaluation of two models of UPQC for suitable interface to enhance power quality,” Elect. Power Syst. Res., vol. 77, pp. 821–830, 2007.

[18] P. Ledesma, J. Usaola, J.L. Rodriguez “Transient stability of a fixed speed wind farm” Renewable Energy 28, 2003 pp.1341–1355

[19] P. Rosas “Dynamic influences of wind power on the power system”. Technical report RISØR-1408. Ørsted Institute. March 2003.

[20] R.C. Dugan, M.F. McGranahan, S. Santoso, H.W. Beaty “Electrical Power Systems Quality” 2nd Edition McGraw–Hill, 2002. ISBN 0-07-138622-X