To Investigate Power Quality's Issue of Hybrid System Using DVR and STATCOM

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ABSTRACT: A high power Quality is one of the major part in power system which is nothing but a distribution and transmission sector. In the renewable energy generation side (wind, solar, hydro energy) etc to created various type of problem in the grid. The source of a power quality problem often cause a disturbance or power quality variation .Need for solving these power quality disturbance .To mitigate these problem with the help of passive filter and active filter are used. The FACTS (Flexible AC Transmission systems) device like Static Synchronous Compensator (STATCOM) and Dynamic Voltage Restorer (DVR) are used for the system. With the help of DVR to compensate voltage drop by injecting active and reactive power. STATCOM is a device to regulate the reactive power in the system. In this paper will design the STATCOM and DVR for voltage control and harmonics filter out. Separately control technique used for the STATCOM and DVR.The simulation has been made by MATLAB/SIMULINK and the result of these system are combine.

Keywords:*STATCOM, DVR, Harmonics, Power quality, FACTS.*

INTRODUCTION

Flexible AC Transmission systems (FACTS) are a new technology. It has the principal role of the enhancing controllability and power transfer capability in a AC systems. With the increasing demand of power, the power system networks are becoming more complex from the point of view of operation and control. The existing networks are mostly mechanically controlled. Microelectronics, computers and high speed communication are widely used for protection and control of transmission system. A number of control devices were developing under the term FACTS technology. FACTS technology opens up new opportunities for controlling power and enhancing the usable capacity of existing and new line. Power quality as anything that affects the voltage, current and frequency of the power being supplied to the end user. The power quality problem solved is very essential these affect the entire system. Now a day there are many techniques to solve this problem. The ability to define and understand the various types of the power quality problems the necessary background needed to prevent and solved those problems. The power quality characteristic, of the disturbance identifies the type of power quality problem. The nature of variation in the basic components of the sine wave distortion. The most common problem are voltage sag, swell, voltage fluctuation problem is voltage unbalance is rapid change in voltage within the allowable limits.

A. POWER QUALITY

1. Power Quality Standards

The organization responsible for developing power quality standards in the United States include the following Institute of Electrical and Electronics Engineer (IEEE), American National Standards Institute (ANSI), National Fire Protection Association (NFPA) etc.

1) International Electro technical Commission (IEC)

It has since evolved into an organization with membership from 43 countries. The IEC council heads the IEC and oversees 200 technical committees, subcommittees and working groups. They refer to power quality standards as so called electromagnetic compatibility (EMC) standards. When wind turbine is involved for determine power quality characteristics [12].

2) American National Standards Institute (ANSI)

Five engineering societies and three government agencies founded ANSI .It is a private nonprofit organization with member organizations form the private and public sectors.

2. Purpose of power quality standards

The purpose of power quality standards is to protect utility and end user equipment from failing or misoperating when the voltage, current and frequency deviates from normal. Power quality standards provide this protection by setting measurable limits as to how far the voltage, current or frequency can deviate from normal. By setting these limits power quality standards helps utility and their customers gain agreement as to what are acceptable level of service.

3.Harmonics

Mostly harmonics are created due to the device of power electronic switching in the system and increase the use of nonlinear equipment. The harmonics standard for the United States, IEEE 519-1992 recommended practice and requirements for Harmonics control in electrical power system Recognizes that the primary source of harmonics current is non liner load located on the end user side of meter.IEEE - 519-1992 set current limit at the point of common coupling (PCC) .Due to the Harmonics created electronic equipment to malfunction.

4. Voltage variation

Generally change in the voltage variation which affected on the active and reactive power. Mostly voltage variation problem are voltage sag, swell, voltage dip, unbalance, Interruption (complete loss of power) .In wind frame voltage variation occurs due to torque of induction generator and wind speed. The nature of voltage variation are sine wave distortion that is voltage, current and frequency. The nonlinear load include all the type of power electronics equipment that use switch mode power supplies, rectifiers converting ac to dc ,arc welders ,adjustable speed drive etc.

B. WIND TURBINE INDUCTION GENERATOR

A large amount of reactive power is need for its operation. The power must be feed for operation of wind turbine induction generator whether from capacitor bank or synchronous grid. When the wind turbine initially connect to a grid it need some reactive power for generation of energy in that case the voltage to be drop at pcc.

C.STATIC SYNCHRONOUS COMPENSATOR (STATCOM)

1. Function of STATCOM

The primary objective of STATCOM are used to improve the power quality issue which is nothing but to removed Harmonics in the desired system and also maintain the reactive power. To improve the system voltage as a shunt compensator for the combination of WTIG. This device which is nothing but a capacitor are shunted connect across voltage source converter (VSC). With the help of STATCOM to mitigate the harmonics and uses a Hysteresis current control method to inject a current in the system to measure a harmonics created by the nonlinear load connect in the system.

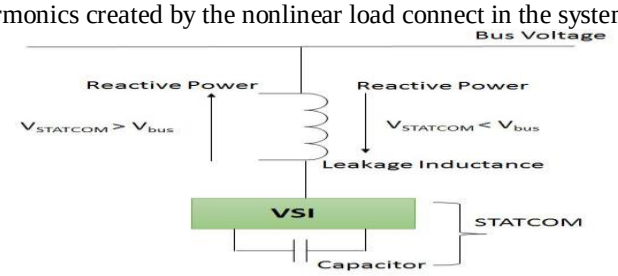

Figure 1. STATCOM Model

2. Hysteresis current controller

Hysteresis controller is used as it is simple; it has fast transient Response and good accuracy. Hysteresis current controller is used for producing switching signal by comparing the error present in the current in a fixed tolerance band. Here comparison is done between the actual current & reference current within a fixed tolerance band. It is different for different phases. Hysteresis current controller is used to compare current so to generate switching signals. This error is compared by a relay that gives a signal for the IGBT if the error is higher or lower.

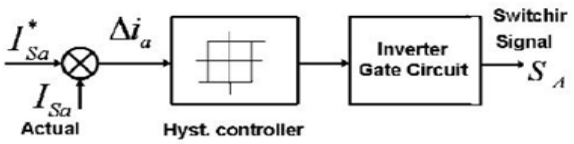

Figure 1 Hysteresis Controller

For phase A we have the following switching operation.

- If Isa - $Is*_a$<−hb , then we need to inject a current and Sa =1.
- If Isa - $Is*_a$>hb , then we need to absorb current then Sa=0.

Where **hb** = hysteresis band.

Phase B and phase C work in the same way for this switching logic. If smaller the hysteresis band then less the error and hysteresis band is the high then large the error.

D. Dynamic Voltage Regulator (DVR)

1. Basic DVR operation

The power quality problem is occurring generally in transmission and distribution side to overcome this problem by using custom power devices. In the family of FACTS device DVR is the most efficient and effective modern device used in the power system.DVR are connected between the critical load feeder and the supply side at a point of common coupling (PCC).Due to the fault in the system the voltage variation problem occurred in the system with the help of that device to mitigate the effect in the system and stable the voltage. In basic construction of DVR is connecting to an injection transformer that is mounted in series with the three phase nonlinear load in which an inverter connect itself. The depth of voltage sag (dip) DVR can compensate this voltage by injecting active and reactive power which is depending upon the system requirement.

2. DVR control method

Various control strategy used in DVR device but in these paper to choose (Pulse with Modulation Technique) PWM with Synchronous Reference Frame Theory .In these by using park or dqo transformation to make this algorithm. With the help of these transformation to convert current or voltage in rotating component into phase component or vice versa.

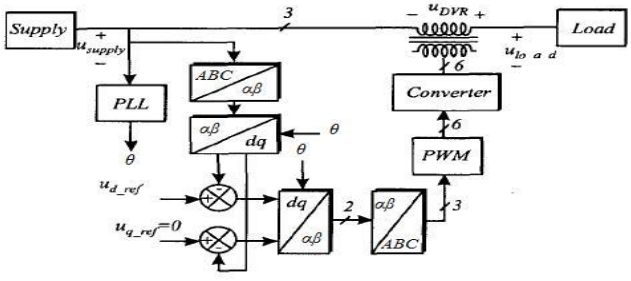

Fig 3. Control Algorithm of DVR

In the above figure shows the complete control of DVR, in which to control this device using PLL .When the reference voltage compared with the actual one in that operation of DVR control the PLL. PLL circuit provides the rotation speed of the rotating reference frame these are open loop controller [1].

Consider the following equation

$$\begin{bmatrix} V_{so} \\ V_{sd} \\ V_{sq} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \sin(wt) & \sin(wt-\frac{2\pi}{3}) & \sin(wt+\frac{2\pi}{3}) \\ \cos(wt) & \cos(wt-\frac{2\pi}{3}) & \cos(wt+\frac{2\pi}{3}) \end{bmatrix}\begin{bmatrix} V_{sa} \\ V_{sb} \\ V_{sc} \end{bmatrix} \quad (1)$$

Fundamental quantities become d-q quantities which can be separated easily and filtering. The Fundamental component become a Constant which can be low pass filter to leave the high frequency component. Low pass filter of DC component does not cause any phase error in a signal if the issue occur then high pass filter are used.

$$\begin{bmatrix} V^*_{La} \\ V^*_{Lb} \\ V^*_{Lc} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \sin(wt) & \cos(wt) & 1 \\ \sin(wt-\frac{2\pi}{3}) & \cos(wt-\frac{2\pi}{3}) & 1 \\ \sin(wt+\frac{2\pi}{3}) & \cos(wt+\frac{2\pi}{3}) & 1 \end{bmatrix}\begin{bmatrix} V_{Sd} \\ 0 \\ 0 \end{bmatrix} \quad (2)$$

Where V*L is the reference value of amplitude of load terminal voltage. The load voltages (VLa, VLb, VLc) are converted into the rotating reference frame using the abc-dq0 conversion using the Park's transformation with unit vectors (sin θ, cos θ) derived using a PLL (phase locked loop) .

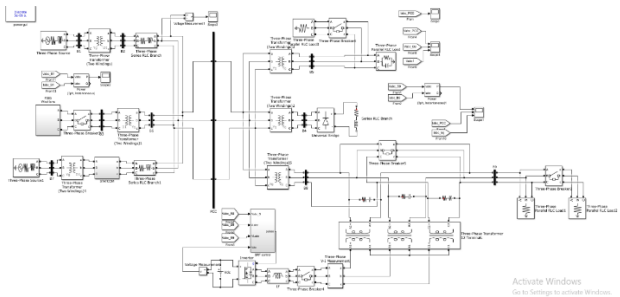

Fig. 4 MATLAB / SIMULINK modeled system

MATLAB SIMULATION AND RESULTS

1) DVR Operation

When wind mill is initially connected to the system it need reactive power for the induction generator to start producing electric power to cause the voltage drop at PCC. At this instant the DVR should start its operation and compensate these voltage drop. Fig. 5a shows the voltage drop at PCC when turbine is starting; Fig. 5b shows the voltage at critical load and its shows the DVR compensation; Fig. 5c shows theInjected voltage by the DVR.

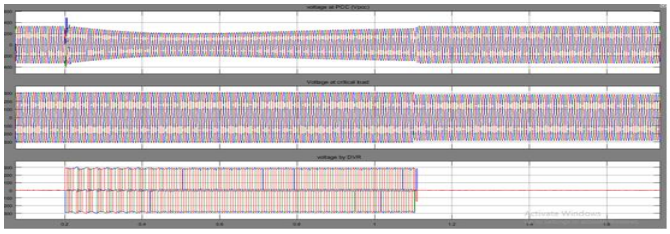

Fig. 5 a) voltage drop at PCC when turbine is starting; b) voltage at critical load bus (with DVR compensation); C) Injected voltage by the DVR.

Here the STATCOM (Active filter) is activated and will inject the exact current into the system needed to cancel the effect of the harmonics. This reference injected current is generated by the hysteresis control technique. STATCOM is capable to the injected current which is highly distorted current that cancels the effect of the harmonics present at the PCC.

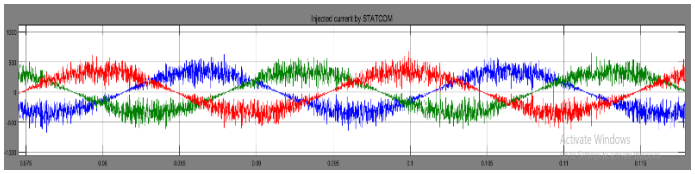

Fig. 6 Injected current by STATCOM

The THD of current before compensation shown below, in the below figure the THD of the source current is found to be 10.38% before operation of STATCOM which indicate presence of several harmonic component

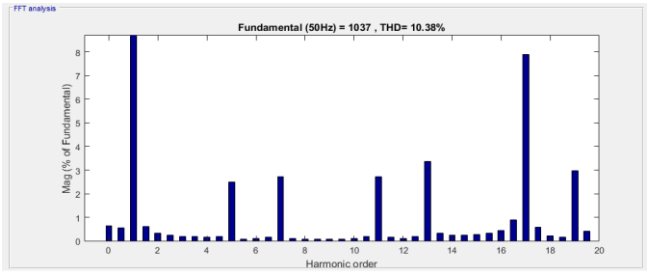

Fig. 7 THD of Current before STATCOM

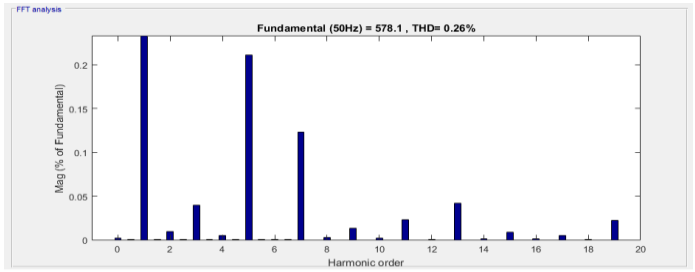

Fig. 8 THD of Current after STATCOM

THD of current is reduced and it is 0.26 % which is very less as compared to the THD of uncompensated current. Also the magnitude of harmonic components are reduced with the help of STATCOM .The detail comparison of magnitude of harmonic component in current before and after the application of STATCOM is shown as above which is analyzed with help of FFT window of Simulink.

REFERENCES

[1] D.P.Kothri, Bhimsingh, ''Control of Reduced-Rating Dynamic Voltage Restorer with a Battery Energy Storage System" IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 50, NO. 2, MARCH/APRIL 2014.

[2] S.G.Kulkarni , ''Synchronous Reference Frame Theory for nonlinear load using Mat-lab simulink" volume3, June 2016

[3] Sanjay chaudhary , ''Analysis ,Modeling and simulation of DVR for compensation of voltage for sag-swell disturbance" volume 9,IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) May 2014

[4] S. Mohod and M. Aware, 'A STATCOM-Control Scheme for Grid Connected Wind Energy System for Power Quality Improvement', *IEEE Systems Journal*, vol. 4, no. 3, pp. 346-352, 2010.

[5] S. W. Mohod and M. V. Aware, 'Grid Power Quality with Variable Speed Wind Energy Conversion', *2006 International Conference onPower Electronic, Drives and Energy Systems*, pp. 1–5, 2006.

[6] C. Zhan, V. K. Ramachandaramurthy, A. Arulampalam, C. Fitzer, S. Kromlidis, N. Bames, and M. Jenkins, 'Dynamic voltage restorer based on voltage-space-vector PWM control', *IEEE Transactions onIndustry Applications*, vol. 37, no. 6, pp. 1855–1863, 2001.

[7] N. Hingorani, "Introducing Custom Power," IEEE Spectrum, Vol.32, no. 6, June 1995, pp. 41-48.

[8] R. C. Dugan, M. F. McGranaghan, and H. W. Beaty, Electrical Power Systems Quality. New York: McGraw-Hill, 1996.

[9] Chellalibenachaiba,"Voltage Quality Improvement using DVR"

[10] Electrical power Quality and Utilisation, Journal vol .XIV,No 1,2008.

[11] Bhimsingh ," Application of UPQC for power quality improvement" 16th NATIONAL POWER SYSTEM CONFERENCE ,15th -17th DECEMBER ,2010.

[12] Barry W. Kennedy,"PowerQualityPrimer,"McGraw-Hill DOI: 10.1036/0071344160.