Comparison of Power Quality Issue in STATCOM and DVR

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Abstract: — ***A renewable energy has made a stunning entrance to the market..The integration of this hydro energy, solar power etc.) created different kinds of problems in the grid. Whether system stability problems or Power Quality issues, these issues need to be solved. Classically passive filters were used but nowadays active filters such as Static Synchronous Compensator (STATCOM) and Dynamic Voltage Restorer (DVR) are chosen for the task. STATCOM is a device that regulates the voltage level or the reactive power in the system. It is used to maintain voltage stability, enlargement of critical clearing time. DVR is a voltage restorer that can solve the voltage power quality issues. This paper will integrate the STATCOM and the DVR for voltage control and harmonics filtering. The simulation has been done by MATLAB/SIMULINK and shows the work of the STATCOM and the DVR combined.***

Keywords—Wind Turbine, STATCOM, Active Filters, DVR, Harmonics, Power Quality

1. Introduction

In the last couple of decades, the creation, implementation and perfection of renewable energy has occurred. It has progressed through time with increasing reliability. The integration of renewable energy such as wind, photovoltaic, fuel cell, and tidal to the grid solved many problems and replenished the exceeding and ascending need for electrical energy but created plenty more. The issue of power quality is of great importance to the wind turbine. There's a need to find solutions to these problems, using different technologies such as smart meters, monitoring system, controllers, remote ability. The integration of wind energy into a weak system is a challenge; voltage fluctuation, voltage dips, swells and swags are created due to the uncontrollable resource and the nature of the DWIG (Distributed Wind Induction Generators) on the already weak system. This causes stability issues, reliability and power quality issues which need to be solved.

A Power Quality

(1)International Electro Technical Commission Guidelines: The International Electro-technical Commission (IEC) gives the procedures for determining the power quality characteristics when a wind turbine is involved .

(2) Voltage Variation: Wind speed and induction generator torque are the main cause of voltage variations. These voltage variations are directly related to real and reactive power variations. Voltage Sag/Dips/Swell, Short Interruptions and Long duration voltage variation are common voltage variation issues. The amplitude of voltage fluctuation depends on grid strength, network impedance, phase-angle and power factor of the wind turbines.

(3) Harmonics

Harmonics are created due to power electronic switching devices in the system. The harmonic content in a voltage or current should be under the limit at the Point of Common Coupling (PCC). The IEC-61400-21 establishes a guideline to base the study of harmonics on. The filtering by rapid switching largely reduces the lower order harmonic current, but the remaining current will have higher order frequency content which can be easily filtered-out.

(4) Consequences of the Issues

The power quality issues damage equipment such as Microprocessors, Programmable Logic Controllers (PLC's),Variable Speed Drives (VSD's) and delicate control systems. It may cause the tripping of Contactors and protection devices. It can lead to stopping sensitive equipment such as PC's, and even stop the process of plants.

B Wind Turbine Induction Generator

The wind turbine needs a relatively large amount of reactive power to operate. This power must be fed externally whether from a capacitor bank, or a controlled inverter, or from the electrical synchronous grid. The reactive power absorbed by the WTIG causes the voltage on the bus where the generator is connected to drop, and the system build up will raise the voltage again to the nominal voltage of the grid.

C Static Synchronous Compensator (STATCOM)

(1)STATCOM Model

The STATCOM has been reported to improve the power quality in power systems with DG integration of wind type . STATCOM can be implemented to regulate the voltage as a shunt compensator for the WTIG. It is a Battery Energy

Storage System (BESS) connected to a DC link capacitor which itself connected to a Voltage Source Converter (VSC).The STATCOM is shunt connected and uses in this paper a Hysteresis current control method to inject a current in the system to counter the harmonics created by the non-linear load and the WTIG. The basic STATCOM model is shown in below figure.

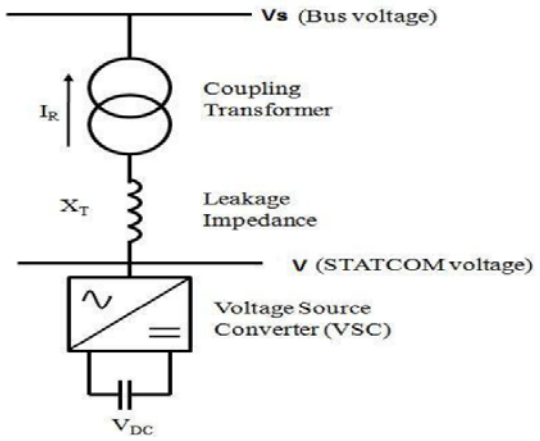

Figure 1 : Basic statcom model

(2) Reference current generation

To get a reference current to use in the STATCOM control we need a topology for grid coordination. This paper uses these formulas to synchronize the reference currents to the grid voltage of the infinite bus, which is a bus withtheoretical voltage of 1 per unit (p.u.) with infinite stability. If we take the 3 phase RMS voltages (V*sa*,V*sb*,V*sc*) and is expressed, as sample template *Vsm*, sampled peak voltage, as in (1).

$$V_{\mathrm{sm}} = \left\{ \frac{2}{3} \left(V_{\mathrm{sa}}^2 + V_{\mathrm{sb}}^2 + V_{\mathrm{sc}}^2 \right) \right\}^{1/2}$$

Then the unit vectors are generated from the source—are shown in (2).

$$u_{\mathrm{sa}} = \frac{V_{\mathrm{Sa}}}{V_{\mathrm{sm}}}, \quad u_{\mathrm{sb}} = \frac{V_{\mathrm{Sb}}}{V_{\mathrm{sm}}}, \quad u_{\mathrm{sc}} = \frac{V_{\mathrm{Sc}}}{V_{\mathrm{sm}}}$$

Then the reference currents will be as in (3):

$$i_{\mathrm{Sa}}^* = I.u_{\mathrm{Sa}}, \quad i_{\mathrm{Sb}}^* = I.u_{\mathrm{Sb}}, \quad i_{\mathrm{Sc}}^* = I.u_{\mathrm{Sc}}$$

This creates a fixed sinusoidal reference current synchronized with the grid without using a Phase Locked Loop (PLL). This method is simple, robust and favorable as compared with other methods.

D Dynamic Voltage Regulator (DVR)
(1)DVR Model

The DVR is used to protect critical or sensitive loads by mitigating the effects of voltage sags or swells on the distribution feeder due to faults in the system by maintaining constant voltage magnitude. It is basically a BESS connected to an inverter which itself is connected to an injection transformer that is mounted in series with the 3 phase sensitive load.

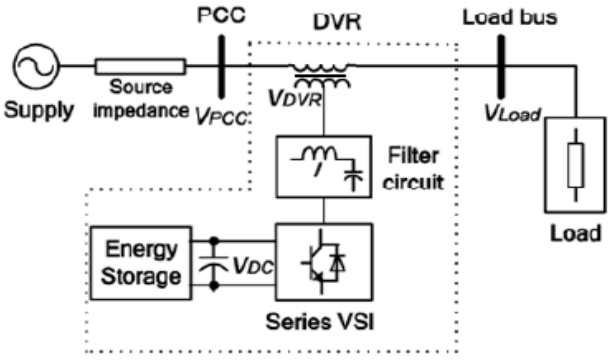

Figure 2 : basic DVR topology

The DVR can compensate voltage sags by injecting reactive power or real and reactive power. This depends on the depth and width of the sag or swell.

(2) DVR control*:* As for the control of the DVR many techniques exist to control the voltage injection, the chosen one is the Space Vector Pulse Width Modulation (SVPWM) which is proven very effective and gives a better result than conventional PWM in terms of THD and power quality. The reference phasor consists of: phase, frequency and magnitude components. All will vary to some point during normal network operation [15].The block diagram of the control system used is shown in Fig. 4. The control system of a DVR plays an important role, with the requirements of fast response in the face of voltage sags and variations in the connected load. This paper uses an open loop control for the DVR system using PLL. The PLL is to synchronize the DVR with the power system by generating a reference voltage to be compared with the actual one.

2. System in Study

The system of study is shown in Fig.3

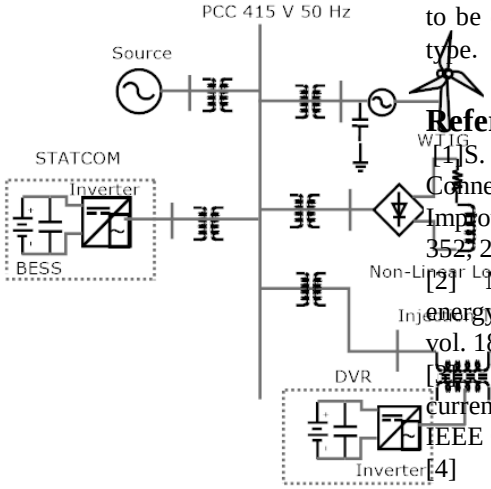

Figure 3 : Proposed system in study

We have to study our system at the PCC, which is the interest of this kind of research. Studying at the PCC will give an idea of the system behavior at any other Bus. Fig. 3 shows the grid or the infinite bus connected to the PCC, it shows the WTIG, a non-linear load for harmonics generation. The DVR and STATCOM are used for Active filtering. They cancel the effect of voltage sags and swells by injecting a voltage into the system, and remove the harmonics by injecting a current into the system.

3. System operation

(A)DVR operation

When a wind turbine is initially connected to the grid, it needs reactive power for the induction generator to start producing electric power. This causes the voltage to drop at the PCC. At this instant the DVR should start its operation and compensate for the voltage drop at the critical load.

(B)STATCOM operation

After the wind turbine is initialized and running and after the Non-Linear load is connected to the system, the voltage and current at the PCC will be distorted and need to be filtered. 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.

4. Conclusion

This paper examined the STATCOM hysteresis control technique for harmonic cancelation with load tracking in a system where a wind turbine is present and it examined the work of the SVPWM operated DVR when connected to a critical load from the same system. It used a separate control for the STATCOM and the DVR interchanging their roles. This gives room to the subject of combining the two without having overlapping problems. This paper used as non-linear loads simple AC to DC rectifiers, another subject to be examined in the future is changing the non-linear load type.

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