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Power Quality Improvement in Grid Connected Wind Energy System Using STATCOM

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ABSTRACT

Wind energy conversion system has gained importance in recent years as a prime source of distributed generation in which variable speed wind turbine with direct driver, PMSG and power electronic interface is the most commonly used system exhibiting variability in the output power as a result of change in the prime mover(wind speed).When such a configuration is interconnected to the grid it introduces various challenges to the network in terms of power quality issues, voltage fluctuations etc. Our project proposes the enhancement of power quality in the wind energy system using STATCOM. It aims to present in a thorough and coherent way the aspects of power quality in terms of the reduction of total harmonic distortion (THD).The simulation is carried out in MATLAB/Simulink.

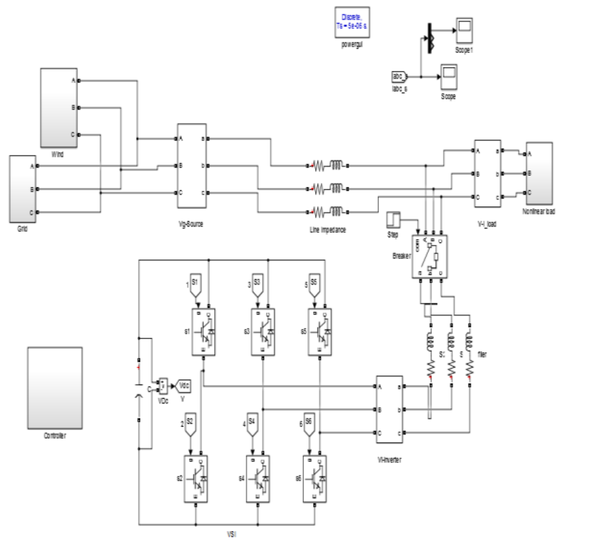
Keywords: Power quality, Wind generating System, STATCOM, Non linear load, Synchronous generator

I. INTRODUCTION

With increase in the demand for Electricity due to increase in population and industrialization, the Generation of power was really a challenge now a day. If we want to increase the power generated in the conventional way i.e., by means of non-renewable energy sources like coal, diesel, natural gases and similar fossil fuels, the pollution increases which degrades the Environment and human life style. In this paper we consider Wind power that can be utilized for generation of electrical power using with FACTS device STATCOM to compensate the disturbances that occur due to the fluctuating nature of the wind. This nature of wind also affects the current and voltage in the grid to which wind turbine Is connected.

The causes of power quality problems are generally complex and difficult to detect when we integrate a wind turbine to the grid. Technically speaking, the ideal AC line supply by the utility system should be a pure sine wave of fundamental frequency (50/60Hz). We can therefore conclude that the lack of quality power can cause loss of production, damage of equipment. It is therefore imperative that a high standard of power quality is maintained. This project demonstrates that the power electronic based power conditioning using custom power devices like STATCOM can be effectively utilized to improve the quality of power supplied to the customers.

The aim of the project is to implement Wind turbine connected to a Grid and STATCOM in the MATLAB/ Simulink using Simpower systems tool box and to verify the results through various case studies applying Non-linear loads and study them in detail.



Figuer1: Block Diagram

II. DESCRIPTION

Power quality and reliability cost the industry large amounts due to mainly sags and short-term interruptions. Distorted and unwanted voltage wave forms, too. And the main concern for the consumers of electricity was the reliability of supply. Here we define the reliability as the continuity of supply. As shown in fig.2.1, the problem of distribution lines is divided into two major categories. First group is power quality, second is power reliability. First group consists of harmonic distortions, impulses and swells. Second group consists of voltage sags and outages. Voltage sags is much more serious and can cause a large amount of damage. If exceeds a few cycle, motors, robots, servo drives and machine tools cannot maintain control of process.

Both the reliability and quality of supply are equally important. For example, a consumer that is connected to the same bus that supplies a large motor load may have to face a severe dip in his supply voltage every time the motor load is switched on. In some extreme cases even we have to bear the black outs which is not acceptable to the consumers. There are also sensitive loads such as hospitals (life support, operation theatre, and patient database system), processing plants, air traffic control, financial institutions and numerous other data processing and service providers that require clean and uninterrupted power. In processing plants, a batch of product can be ruined by voltage dip of very short duration. Such customers are very wary of such dips since each dip can cost them a substantial amount of money. Even short dips are sufficient to cause contactors on motor drives to drop out. Stoppage in a portion of process can destroy the conditions for quality control of product and require restarting of production. Thus in this scenario in which consumers increasingly demand the quality power, the term power quality (PQ) attains increased significance.

A. About STATCOM :

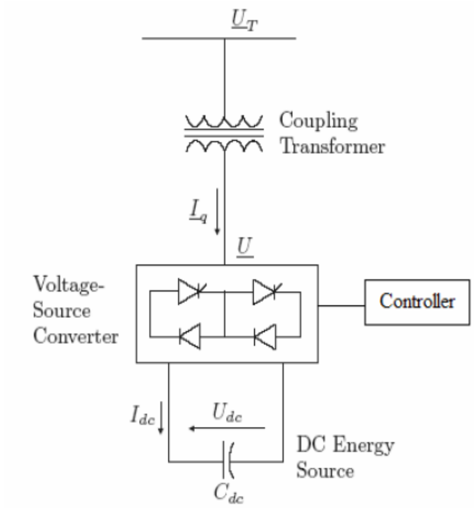


Figure 2: STATCOM

Operation:

The STATCOM is a solid-state-based power converter version of the SVC. Operating as a shunt-connected SVC, its capacitive or inductive output currents can be controlled independently from its terminal AC bus voltage. Because of the fast-switching characteristic of power converters, STATCOM provides much faster response as compared to the SVC. In addition, in the event of a rapid change in system voltage, the capacitor voltage does not change instantaneously; therefore, STATCOM effectively reacts for the desired responses. For example, if the system voltage drops for any reason, there is a tendency for STATCOM to inject capacitive power to support the dipped voltages.

STATCOM is capable of high dynamic performance and its compensation does not depend on the common coupling voltage. Therefore, STATCOM is very effective during the power system disturbances. Moreover, much research confirms several advantages of STATCOM. These advantages compared to other shunt compensators include:

- Size, weight, and cost reduction
- Equality of lagging and leading output
- Precise and continuous reactive power control with fast response
- Possible active harmonic filter capability.

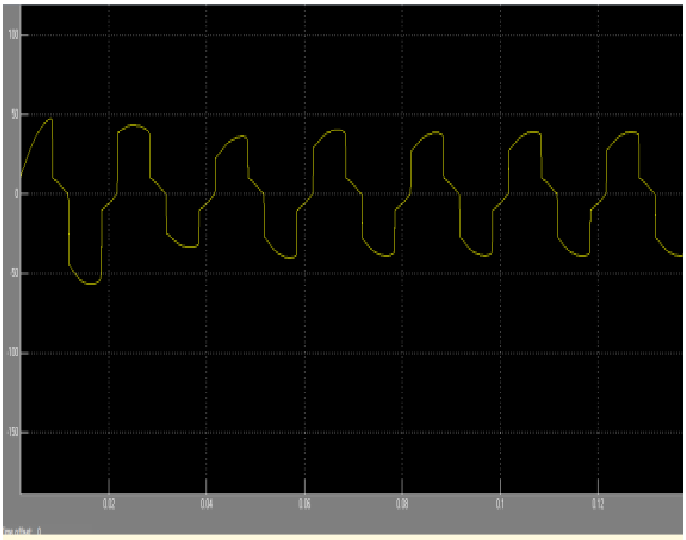


Figure 3: Single phase waveform without STATCOM

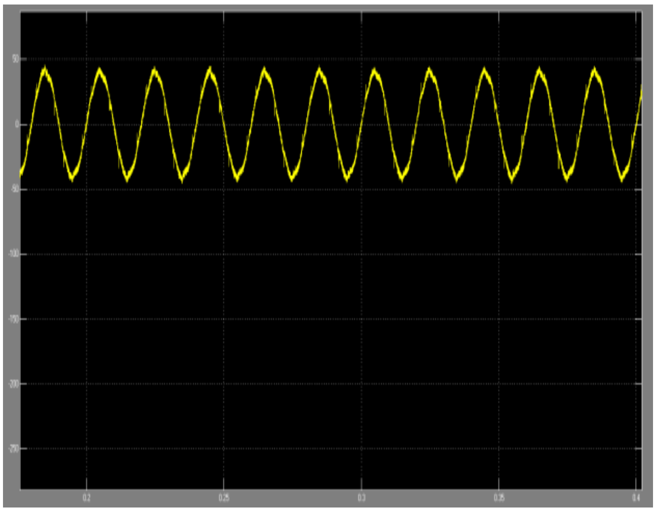


Figure 4: Single phase waveform with STATCOM

B.Modes of operation:

Circuit diagram:

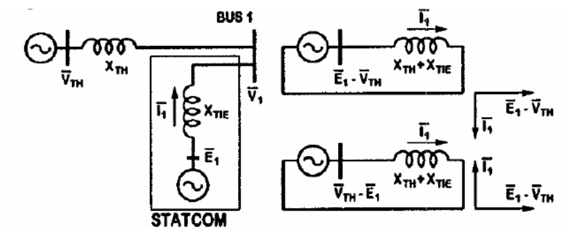


Figure 5: STATCOM operating in inductive or capacitive modes.

Operation:

There are two modes of operation for a STATCOM,

- Inductive mode
- Capacitive mode.

The STATCOM regards an inductive reactance connected at its terminal when the converter voltage is higher than the transmission line voltage. Hence, from the system's point of view, it regards the STATCOM as a capacitive reactance and the STATCOM is considered to be operating in a capacitive mode. Similarly, when the system voltage is higher than the converter voltage, the system regards an inductive reactance connected at its terminal. Hence, the STATCOM regards the system as a capacitive reactance and the STATCOM is considered to be operating in an inductive mode

In other words, looking at the phasor diagrams on the right of Figure 3.4, when1*I*, the reactive current component of the STATCOM, leads (*THVE*–1) by 90º, it is in inductive mode and when it lags by 90º, it is in capacitive mode.

This dual mode capability enables the STATCOM to provide inductive compensation as well as capacitive compensation to a system. Inductive compensation of the STATCOM makes it unique. This inductive compensation is to provide inductive reactance when overcompensation due to capacitors banks occurs. This happens during the night, when a typical inductive load is about 20% of the full load, and the capacitor banks along the transmission line provide with excessive capacitive reactance due to the lower load. Basically the control system for a STATCOM consists of a current control and a voltage control.

III SYSTEM PERFORMANCES

Grid voltage: *400v, 50 Hz*
Lagging reactive load: 400v, 6KVA
A.Non –linear load:
Inductance: 0.1 H.
Capacitance: 500 microfarad.
Resistance: 20 ohm.
B. Voltage source converter:
IGBT rating:
Internal resistance: 1milli ohm
Rs: 0.1 micro ohms
Cs: INF
Capacitor: 1000 micro farad

IV. RESULTS

This is used to improve the power quality in grid connected wind energy system by reducing harmonics. The harmonics produced in the current and voltage source has been reduced by this method. In this we are using a STATCOM. It is used for us when there is any harmonics distortions in the line the reactive power will less and supplying power at consumers end will be a problem. By using STATCOM we are reducing harmonics and supplying the power that shows improvement of power quality in the system.

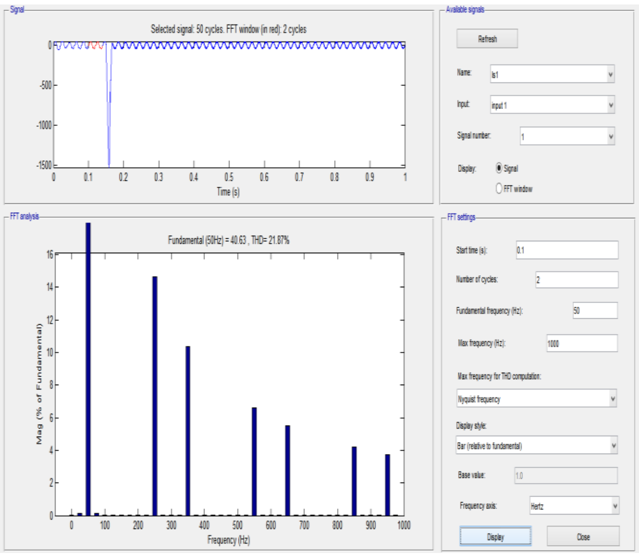


Fig 6: Reduction of harmonics by with and without STATCOM

V. CONCLUSION

Thus we present the FACTS device (STATCOM) - based control scheme for power quality improvement in grid connected wind generating system and with nonlinear load. The power quality issues and its consequences on the consumer and electric utility are presented. The operation of the control system developed for the STATCOM in MATLAB/SIMULINK for maintaining the power quality is to be simulated. It has a capability to cancel out the harmonic parts of the load current. It maintains the source voltage and current in-phase and support the reactive power demand for the wind generator and load at PCC in the grid system, thus it gives an opportunity to enhance the utilization factor of transmission line. Thus the integrated wind generation and FACTS device with BESS have shown the outstanding performance in maintaining the voltage profile as per requirement. Thus the proposed scheme in the grid connected system fulfils the power quality requirements and maintains the grid voltage free from distortion and harmonics.

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