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A Review on Reactive Power Compensation Techniques Using Power Filter

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ABSTRACT : The intent of this paper is to present an analysis of reactive power control and voltage stability in power systems. It identifies a new model used to enhance voltage stability and exposes several key issues that had remained as research challenges in this area. The steady state voltage and reactive power control in distribution systems can be properly controlled by coordinating the available voltage and reactive power control equipment, such as on-load tap-changers, substation shunt capacitors and feeder shunt capacitors. It explains the need to improve the voltage stability of Power system, as well as the increasing requirements for energy quality and security.Reactive power management and voltage control of large transmission system using STATCOM. The role of transmission network in the power system is to transmit the power generated in power plant to the load centres and the interconnected power system.The genuine investigation was completed in MATLAB and its scientific outflow was inferred utilizing diverse routines for calculation.

KEYWORDS*:* STATCOM, Reactive Compensation, Shunt Compensation and Series Compensation, Voltage Stability, Power filter.

I. INTRODUCTION

When integrated to the power system, large wind farms pose stability and control issues. A through study is needed to identify the potential problems and to develop. This thesis investigates the use of a Static Synchronous Compensator (STATCOM) along with wind farms for the purpose of stabilizing the grid voltage after grid-side disturbances such as a three phase short circuit fault, temporary trip of a wind turbine and sudden load changes. The strategy focuses on a fundamental grid operational requirement to maintain proper voltages at the point of common coupling by regulating voltage. The DC voltage at individual wind turbine (WT) inverters is also stabilized to facilitate continuous operation of wind turbines during disturbances.

From the past towards the future the supply of electrical energy developed from separated utilities to large interconnected systems. In former times distributed power generation supplied load centers within a limited supply area. These smaller systems were operated at lower voltage levels. Nowadays there is increased power exchange over larger distances at highest system voltages allowing reserve sharing

Stored temporarily in inductive and capacitive elements, which results in the periodic reversal of the direction of flow of energy between the source and the load.

Explanation for reactive power says that in an alternating current system, when the voltage and current go up and down at the same time, only real power is transmitted and when there is a time shift between voltage and current both active and reactive power are transmitted. But, when the average in time is calculated, the average active power exists causing a net flow of energy from one point to another, whereas average reactive power is zero, irrespective of the network

State of the system. In the case of reactive power, the amount of energy flowing in one direction is equal to the amount of energy flowing in the opposite direction .That means reactive power is neither produced nor consumed. But, in reality we measure reactive power losses, introduce so many equipment's for reactive power compensation to reduce electricity consumption and cost. Capacitors are said to generate reactive power, because they store energy in the form of an electric field.

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Therefore when current passes through the capacitor, a charge is built up to produce the full voltage difference over a certain period of time. Thus in an AC network the voltage across the capacitor is always charging. Since, the capacitor tends oppose this change; it causes the voltage to lag behind current in phase. In an inductive circuit, we know the instantaneous power to be:

$$P= \frac{Vmax1max}{2} \cos\theta\,(1+\cos\omega t) + \frac{Vmax1max}{2} \sin\theta.\sin2\omega t$$

Where,

P = instantaneous power

V_{max} = Peak value of the voltage waveform

ω = Angular frequency

ω = 2πf

F = frequency of the waveform.

t = Time period.

θ = Angle by which the current lags the voltage in phase.

1.2 ***Need for Reactive power compensation***

The main reason for reactive power compensation in a system is;

1) The voltage Regulation.
2) Increased system stability.
3) Better utilization of machines connected to the system.
4) Reducing losses associated with the system.

The impedance of transmission lines and the need for lagging VAR by most machines in a generating system results in the consumption of reactive power, thus affecting the stability limits of the system as well as transmission lines.

Unnecessary voltage drops lead to increased losses which needs to be supplied by the source and in turn leading to outages in the line due to increased stress on the system to carry this imaginary power. Thus we can infer that the compensation of reactive power not only mitigates all these effects but also helps in better transient response to faults and disturbances. In recent times there has been an increased focus on the techniques used for the compensation and with better devices included in the technology, the compensation is made more effective. It is very much required that the lines be relieved of the obligation to carry the reactive power, which is better provided near the generators or the loads. Shunt compensation can be installed near the load, in a distribution substation or transmission substation.

II. MODELLING OFACTIVE POWER FILTER

In active filter is a type of analog circuit implementing and electronic filter using active components, typically an amplifier. Amplifiers included in a filter design can be used to improve the cost, performance and predictability of a filter. An amplifier prevents the load impedance of the following stage from affecting the characteristics of the filter. An active filter can have complex poles and zeros without using a bulky or expensive inductor. The shape of the response, the Q (quality factor), and the tuned frequency can often be set with inexpensive variable resistors. In some active filter circuits, one parameter can be adjusted without affecting the others.

2.1 Series Active Power Filter

It is well known that series active power filters compensate current system distortion caused by non-linear loads by imposing a high impedance path to the current harmonics which forces the high frequency currents to flow through the LC passive filter connected in parallel to the load . The high impedance imposed by the series active power filter is created by generating a voltage of the same frequency that the current harmonic component that needs to be eliminated. Voltage unbalance is corrected by compensating the fundamental frequency negative and zero sequence voltage components of the system.

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2.2 *Shunt Active Power Filter*

Shunt active power filter compensate current harmonics by injecting equal-but-opposite harmonic compensating current. In this case the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase shifted by180o. This principle is applicable to any type of load considered a harmonic source. Moreover, with an appropriate control scheme, the active power filter can also compensate the load power factor. In this way, thepower distribution system sees the non linear load and the active power filter as an ideal resistor.

IV. SYSTEM IMPLEMENTATION USING STATCOM

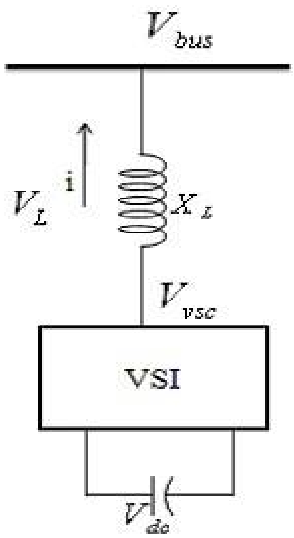

Figure 3.1: Single line Diagram of STACOM

A STATCOM is a regulating device which can be used to regulate the flow of reactive power in the system independent of other system parameters. STATCOM has no long term energy support on the d.c side and it cannot exchange real power with the a.c system. In the transmission systems, STATCOMs primarily handle only fundamental reactive power exchange and provide voltage support to buses by modulating bus voltages during dynamic disturbances in order to provide better transient characteristics, improve the transient stability margins and to damp out the system oscillations due to these disturbances. So it is necessary to invest in power plants and transmission facilities. Therefore, the control for reactive power is essential in order to stabilize system voltage. With the progress of power electronics, FACTS (flexible a.c. transmission system) devices make it possible to maximize the transmission efficiency and can be widely applied for the voltage control. In Korea, beginning with the installation of FACTS devices has been expanding into other areas. STATCOM (Static Synchronous Compensator) can perform voltage regulation function in a robust manner because it generates or absorbs reactive power at a fast rate. The control of reactive power with FACTS devices can greatly contribute to stabilizing the voltage. The FACTS devices are very effective to maintain the voltage stability during systematic accident and the proper voltage level for both heavy and light load.

3 .1 Static Compensator (STATCOM)

The concept of STATCOM is proposed in [2]. A STATCOM is mainly consists of a voltage source controller and the corresponding shunt-connected transformer. Although it acts like a static part of the rotating synchronous device, its absence of moving parts makes it owns faster speed than the older dynamic compensators. The basic structure of the STATCOM is shown in the Figure 2.4. The STATCOM performs the same voltage regulation function as the SVC introduced before and it is also a shunt connected device.

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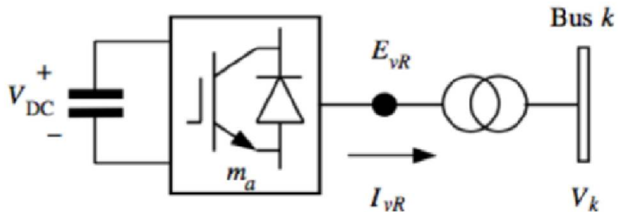

Figure 3.1.1: Basic Structure of the STATCOM

3.2 Reactive Power Compensation Techniques

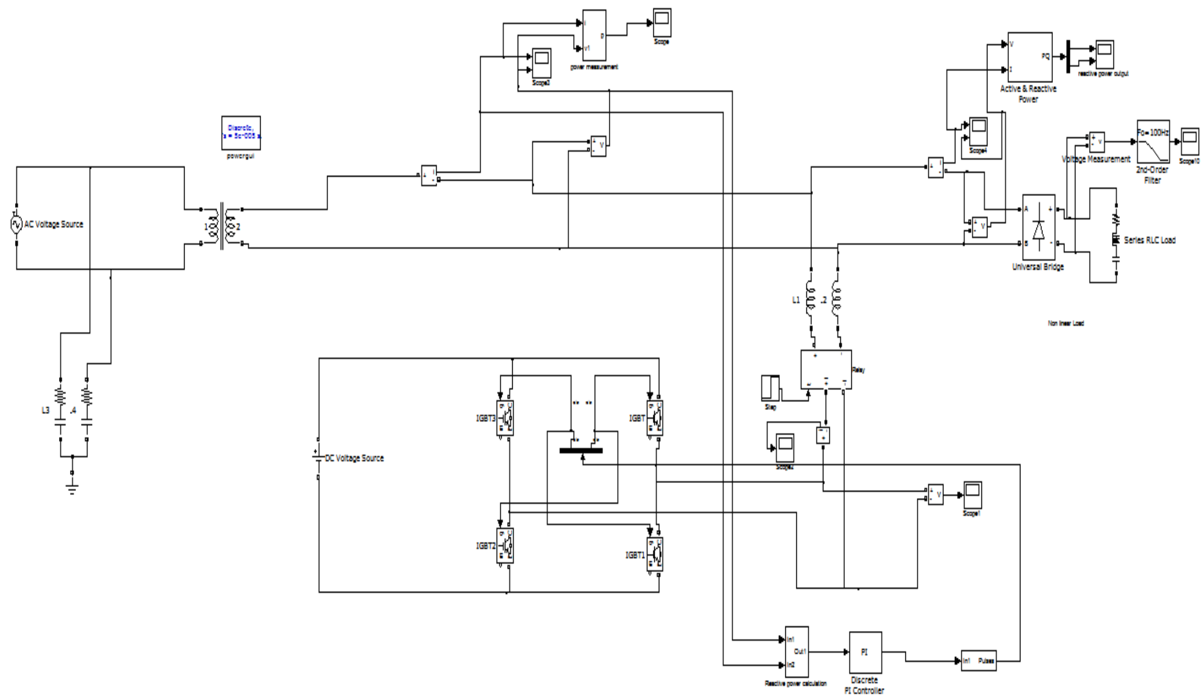

Figure 3.2 Reactive power compensation

Above figure 3.2 shows the system without any type of compensation. It includes the voltage source V_1 with an inductive load and a power line. Here the active current I_p is in phase with a load voltage V_2. As the load is an inductive therefore it requires reactive power for suitable operation. Thus, by increasing the current from the generator side and thus through power lines, it is desirable to regulate the reactive power that can be supplied near the load, the line current can be minimized, reducing the power losses and improving the voltage regulation at the load terminals. This can be done in three ways: 1) A voltage source. 2) A current source. 3) A capacitor. Therefore we can see that, a current source or a voltage source can be used for both leading and lagging shunt compensation, the main advantages being the reactive power generated is independent of the voltage at the point of connection.

ii)Series Compensation

Below figure 4 shows the series compensation which can be implemented like the shunt compensations, i.e.; with a current or a voltage source. However, series compensation techniques are different from the shunt compensation technique as here capacitors are used mostly in the series compensation technique.

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3.3 Reactive power Tabulation

Step input	**Reactive Power Compensation**	
	Before	**After**
0.1	0.5mV	-0.1mV
0.3	0.6mV	-0.2mV
0.5	0.7mV	-0.3mV
0.7	0.9mV	-0.4mV

Table 3.3.1 Reactive Power Filter

3.4 *Simulation and result discussion*

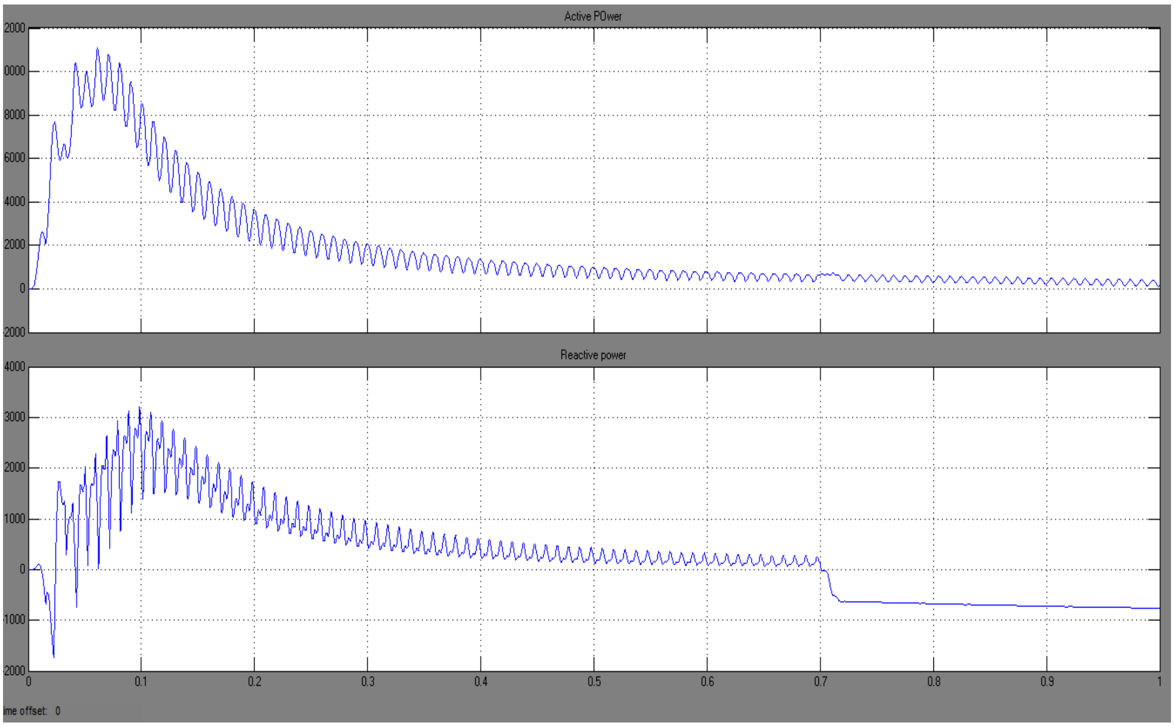

Figure 3.4.1 Active and Reactive Power Waveform

IV. CONCLUSION

Power distribution system is turning out to be very defenseless against various power quality issues as the microscope renewable energy penetration is emerging vitally towards consumer end. This reconciliation of DERs in

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power system has further forced new difficulties like power quality compensation to the industry. To keep up the controlled power quality regulations, providing compensation at all the power levels is turning into a typical practice. In this regard, a distributed generation based micro grid consisting of a WECS, solar PV, and stand-alone AC loads has been considered in this paper to analyze its performance under various operating conditions. It is found that when the wind velocities are changing or partial shadowing occurs, it would cause huge disturbances in the source, apart from load variations imparting their own perturbances in the form of power quality disturbances. Due to this unpredictable nature, it is almost impossible to maintain an accurate AC power balance between the source and load. Subsequently, maintaining nominal voltage is essential in micro grid which requires reactive power balance. Various control techniques, algorithms, and devices are categorized and presented in this paper. Hence, a detailed study has been made to find an appropriate solution to mitigate the power quality issues by providing required reactive power compensation power filter and extra power will added.

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