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Analysis and Performance of PID Based STATCOM for Voltage Variations

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Abstract: The FACT device STATCOM is one of the most efficient shunt connecting regulating device which have an ability to inject and absorb the reactive power in accordance with system voltage. Now this work deals with new technique named Reference Voltage compensation(RVC)in conjunction with STATCOM based on proportional ,integral and derivative(PID) control action which reduces much the transient peak and settling time of voltage and reactive power output which were still present after application of STATCOM. It has been found that the RVC using PID control concept has proved to have an excellent performance over the other similar techniques in the improvement of power system stability by reducing transient oscillation due to faults and load switching and improving power factor thereby increased system life. The result of operation of three phase system with and without STATCOM with RVC by using MATLAB simulation are recorded.

Keywords: FACT, PID ,RVC ,STATCOM, Power Quality.

1. Introduction

Power generation, transmission and distribution are the complex processes. It requiring the working of many components of the power system in demand to maximize the output. Although in early days of the power transmission in the late 19th century problems like voltage deviation during load changes and power transfer limitations were observed due to reactive power unbalance. Hence to improve the performance of the power systems, we need to maintain this reactive power in an efficient way and this is known as reactive power compensation. The Series Capacitive Compensation is now an old and economic technique to increase the power transfer capability of the system. In the past, capacitor banks have been used to control or balance the reactive power on a power grid, but with the implementation of power electronics in the power system, STATCOM were born and obtained more attention during in recent years. STATCOM quite satisfactorily do the job of generating or absorbing reactive power with a faster time response and comes under Flexible AC Transmission Systems (FACTS).

Transients are the major cause of power system failure. The first 2 peaks of the transients are mostly affect the system operation. If the peak is higher then it will affect to insulation of equipment. It should possible to reduce instability of system which cause due to oscillations for long time by means of reducing settling time. Due to use of STATCOM it minimizes harmonic level, the inverter unit fundamental output voltages are equalized. DC link voltage balancing control can achieve by this technique. The PID controller is used for improving system performance. Due to the issue of analysis and modeling of controllers, the power electronic based devices are used to improve reliability of system and power flow to distribution system. In the design of control technique for STATCOM implemented on parallel transmission line.

A STATCOM is similar to synchronous machine, which can generate a balance set of three sinusoidal voltages with controllable phase angle and amplitude with rated frequency. The STATCOM uses reference voltage compensation (RVC) using PID for controller for reducing the first 2 peaks and settling time of fault and switching transients.

2. STATCOM Operation.

STATCOM is a shunt device. STATCOM is comes under category of FACT devices. It is a controlled reactive power source which consist DC link capacitor connected in parallel which can absorb and generate the reactive power. In general we can say solid state switching converter is capable of absorbing and generating independently controllable reactive power at output terminal when it is fed from input terminal. The DC voltage to voltage source converter is given through the energy storage capacitor. The capacitor can charge by using

battery or may be due to converter also. It can carries ripple current of converter and act as storage device for reactive power.

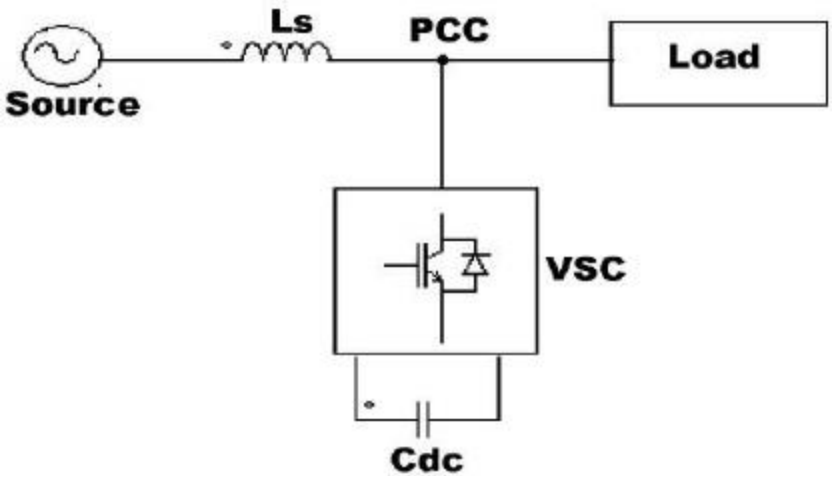

Figure1: Schematic diagram of STATCOM

The voltage source converter can convert the DC input voltage in set of 3 phase AC voltage and coupled to source voltage through reactor. The AC terminal of VSC is connected to inductance Ls through the point of common coupling. That Ls can act as a leakage inductance or filter inductance of transformer.

If the input voltage of VSC is same as that of the source voltage then no reactive power is distributed in system. And if output power is greater than that of the input then STATCOM can work in capacitive mode and vice versa. The difference between two voltages is proportional to reactive power delivered through the system but the power factor correction and voltage regulation at point of common coupling should not be maintained simultaneously. Whereas the STATCOM is used for the voltage regulation at point of common coupling.

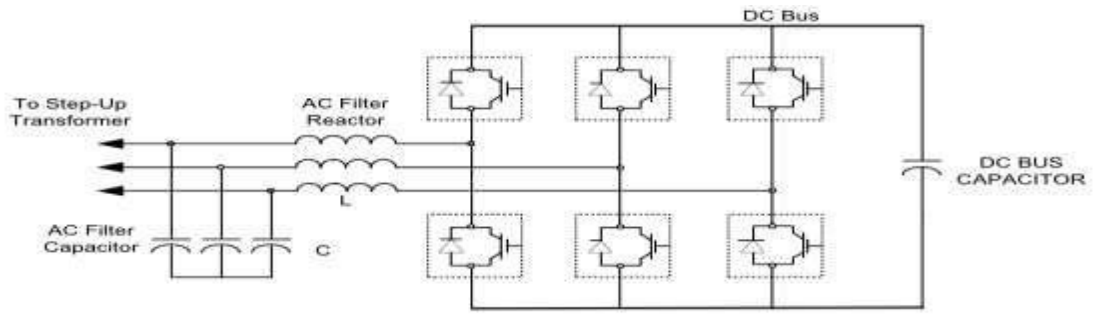

Figure 2: Single line diagram of STATCOM.

The sinusoidal voltage should generated by VSC having suitable frequency , magnitude and phase angle. This are most commonly used in adjustable speed drives also they can protect system from problem of voltage sag. The important function of VSC is to improve power quality.

3. Simulation Modeling

The figure shows the MATLAB simulation of PID based STATCOM for voltage variation.The model has been designed on MATLAB 2010.

The system given in model operates at voltage of 11KV and frequency of 50 Hz is of 3 phase system.

The waveform for without STATCOM circuit, with STATCOM and STATCOM with RVC shown in next section.

In presence of RVC we will manually refer the values of proportional, integral and derivative constants for trial and error method as:

Propotional gain (Kp)=0.1

Integral gain (Ki)=0.005

Derivative gain (Kd)=1.

The waveforms for different operating condition are shown below:

3.1 Load Voltage Without STATCOM

Figure 3 shows the waveform of output voltage when STATCOM is not used in system for protection. It consist highest amplitude voltage wave

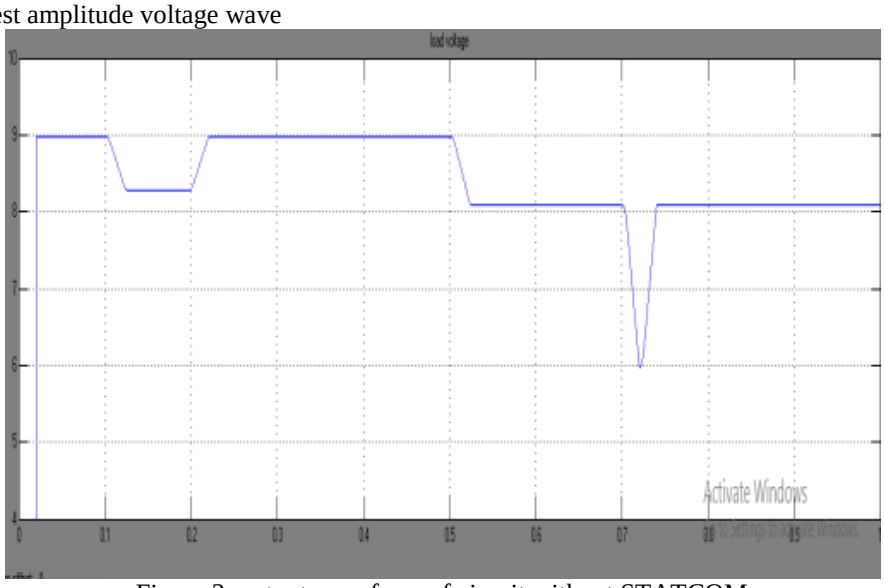

Figure 3: output waveform of circuit without STATCOM

3.2 STATCOM CIRCUIT:

The figure 4 shows the STATCOM circuit use in the system to reduce voltage variation . It consist of 6 MOSFETS and output voltage the system is measured by using 3 phase V-I measurement block.

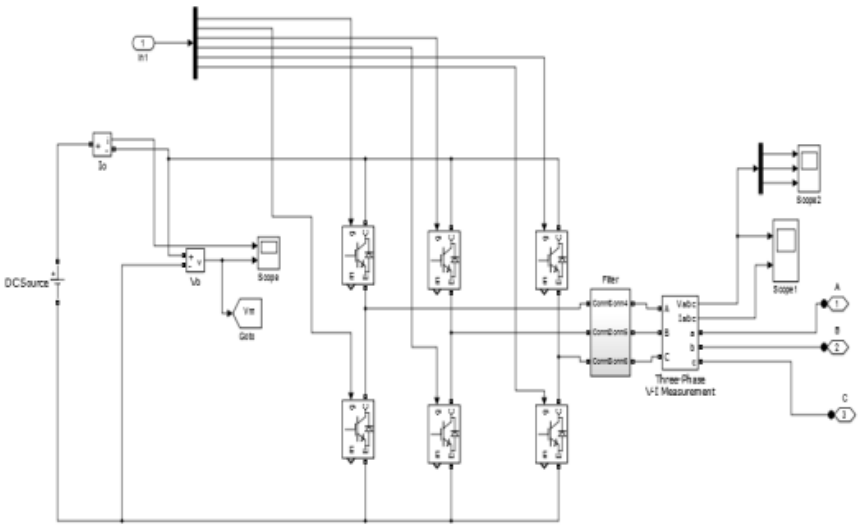

Figure 4: STATCOM circuit

The below figure 5 shows the output voltage waveform of system while using STATCOM in system.

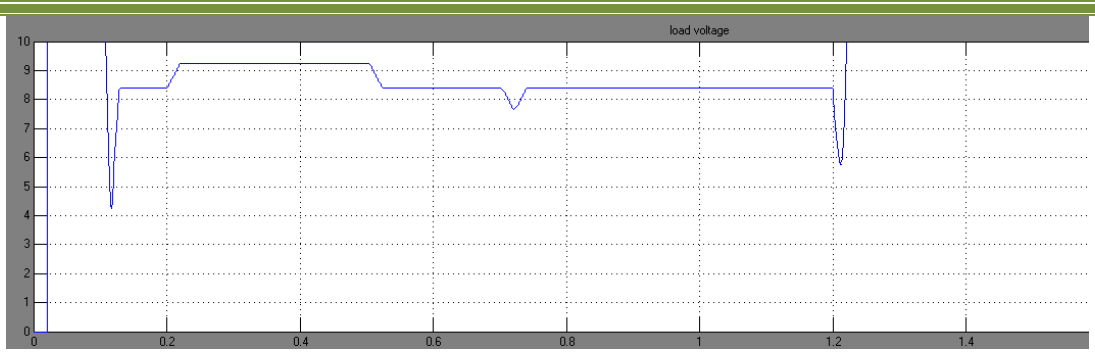

Figure5: Output voltage of circuit with STATCOM

4. Simulation Model of STATCOM with RV

In our project we are using PID controller with RVC (reference voltage compensation) technique which can use to reduce first peaks and reduces settling time. The given figure 6 shows the circuit with RVC model.

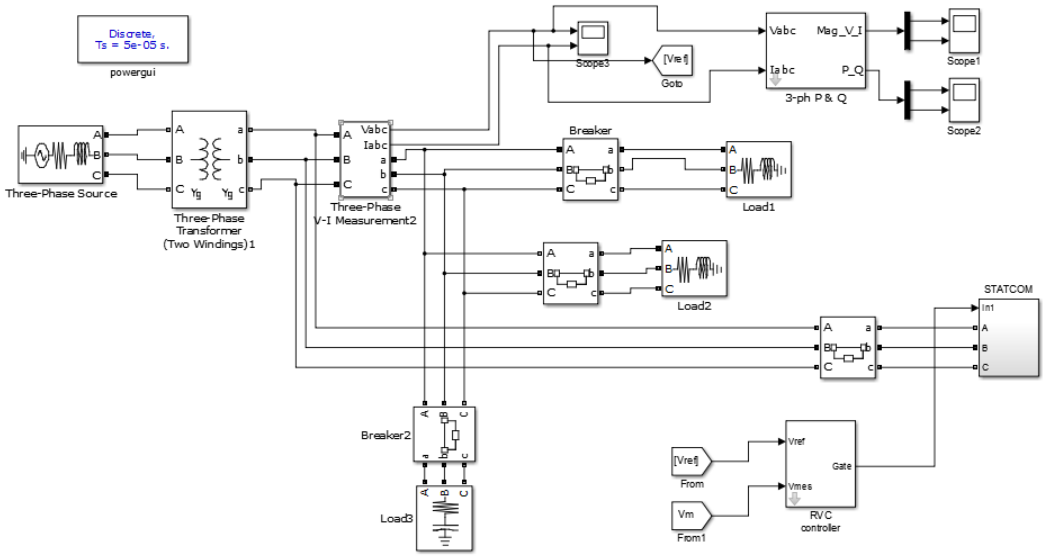

Figure 6: simulation model.

The output voltage waveform of the above simulation model is given in figure 7. This results that the voltage variation in system can be reduce by adjusting control action.

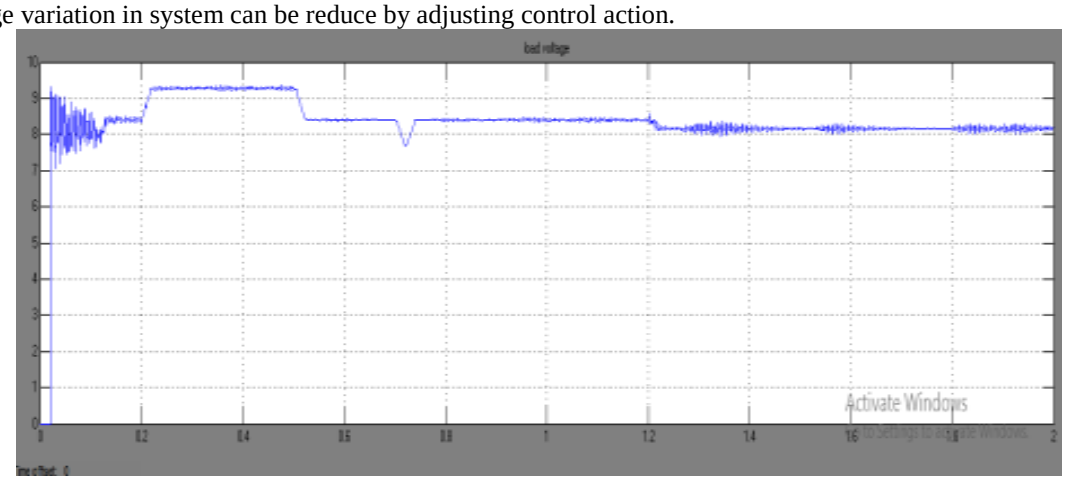

Figure 7: waveform of output voltage using RVC

5. Conclusion

The main aim of this work is to control the voltage profile in a system .The proposed method consist of the most efficient device STATCOM (Static synchronous compensator). The STATCOM can help to reduce settling time and first peak by maintaining the reactive power stability.

But by further introducing the concept of (RVC) reference voltage compensation we have observed that further oscillations are reduced and helps to improve the system stability. The proposed system is operated with and without STATCOM and for both the cases the source voltage, source current and output of statcom are recorded. The respective results are analyzed. The single phase prototype hardware of STATCOM is implemented to improve the voltage profile .The designed model is analyzed with simulation and hardware. The obtained results will be satisfactory.

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