Reactive power compensation using STATCOM

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Abstract - *This paper presents a study on MATLAB/SIMULINK model of STATCOM (Static synchronous compensator) for reactive power compensation. The STATCOM is shunt connected FACTS device used for improve voltage profile of transmission system which connected line with voltage source inverter (VSI) with DC link capacitor. Reactive power compensation using STATCOM is used for mitigates power loss & improves power factor and voltage profile in transmission system. In this paper we used PWM technique as control strategy using dq0 transformation and also study different results with different percentage of compensation. It is the best way to overcome the problem of reactive power compensation without constructing new transmission lines.*

Key Words: **MATLAB/SIMULINK, STATCOM, Inverter, Reactive Power, PWM, PCC.**

1. INTRODUCTION

The main purpose of power system is to generate & transmit power via transmission line to various consumers efficiently. It is a complex process. There are many components takes place in power system, one of the main components to form a major part is the reactive power in the system. Various loads like motor loads and other loads require reactive power for their operation. The majority of power consumption has been drawn in inductive loads. These loads are operated as lagging power factor. The feeder power losses are increased due to reactive power and also the flow of active power is disturbed in distribution system.

Reactive power compensation is defined as, to manage reactive power in an efficient way to improve the performance of ac power systems. Different "FACTS (Flexible AC Transmission System)" technologies are used to compensate reactive power. The parameters of the power system such as, series impedance (current, voltage and phase angle), and shunt impedance can be easily controlled by using FACTS technology. The main purpose of FACTS technology is to make system electronically controllable by using devices on high voltage side. However, the FACTS technology consists of collection of various types of controllers and these can be applied to the power system individually or in the combination to control the parameters [4]. Basically there are four types of FACTS controllers:

1] Shunt Controller

2] Series Controller

3] Shunt-Series Controller

4] Series-Series Controller

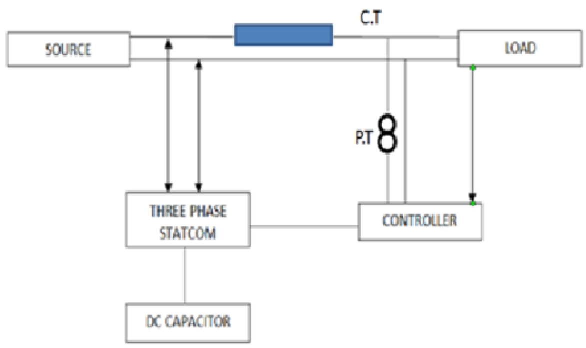


Fig.1 Block diagram

The series controller injects the voltage in series with the transmission line with any phase angle according to driving voltage to control the line current. The shunt controller draws or injects the current into the power system. The combination of shunt and series controller could inject the current via shunt controller of the system and injects the voltage via series controller of the system. These are coordinately control. The combined Series-Series controller provides independent reactive power compensation with the transmission of real power via DC link. In multiline transmission system these types of controller are used which controlled coordinately [4].

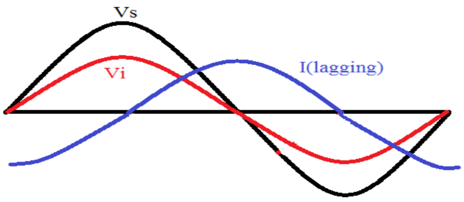
By using STATCOM, reactive power can be compensated by either absorbing or injecting. It is connected as shunt device which is used for compensation. There are more advantages of STATCOM over other devices. For ex: for same ratings of STATCOM & SVC, STATCOM is much more compact. STATCOM is also technically superior. For low values of the bus voltage, it can be able to supply required reactive current. And also design of STATCOM is such to have in built short term overload capability.

2. OPERATION OF STATCOM

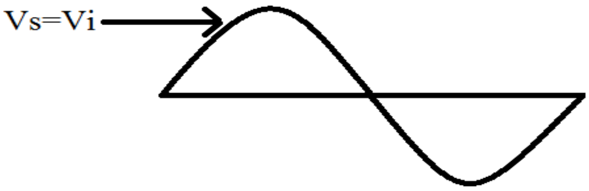
The STATCOM is connected as shunt device which is used for compensation. By using STATCOM, reactive power can be compensated by either absorbing or injecting. Voltage profile and power factor of the transmission system is also improved by using STATCOM. Generally, STATCOM is connected near the loads at distribution system.

Fig.1 shows block diagram of STATCOM placed in transmission system. STATCOM consists of DC link capacitor, AC filter, 3- phase Inverter (IGBT/MOSFET/SCR).

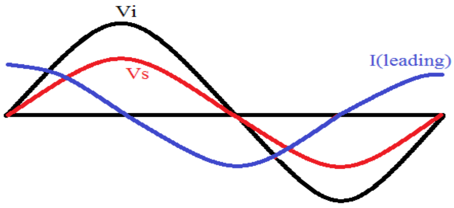
For Fig.1 we can say that, By using controller, the inverter is operated so that the phase delay between inverter voltage (Vi) and supply voltage (Vs) is dynamically controlled. By doing this STATCOM can generates and absorbs power at the point of common coupling (PCC) for suitable VAR. The operation of STATCOM for in phase, lagging, leading current with respect to supply voltage is given in given fig.2(i),2(ii),2(iii) respectively, which varies depending upon Vi. If the value of Vi is equal to Vs, there is no reactive power and the STATCOM does not generate or absorb reactive power. If the Vi is higher than Vs, the current, I, flows through the coupling inductor from the STATCOM to the ac system, and the device generates capacitive reactive power. If Vs is higher than Vi, then the current flows from the ac system to the STATCOM, resulting in the device absorbing inductive reactive power.



(iii) Inductive Operation,reactive will be absorbed



(i) No Load,No current or no reactive power



(ii)Capacitive operation,reactive will be sent

Fig.2 operation of STATCOM

3. MODELING OF STATCOM USING MATLAB/SIMULINK

SIMULINK model of STATCOM is given below in Fig 3. The modeling of STATCOM consists of three phase voltage source (415 V), three phase R-L series load (Active power=50 kW, Inductive reactive power=30 kW), two buses B1, B2, Three phase inverter connected with parallel DC link capacitor (10000 micro F, 700 V). Here we connected series inductor (3mH) with inverter and transmission line for filtering purpose to reduce harmonics. Three phase inverter operated with IGBT switches.

The control circuit is shown in Fig.4 . It consists of a phase-locked loop (PLL), ABC to DQ0 transformation block, DQ0 to ABC transformation block, PID controller. Here we used PID controller for accurate result and fast response.

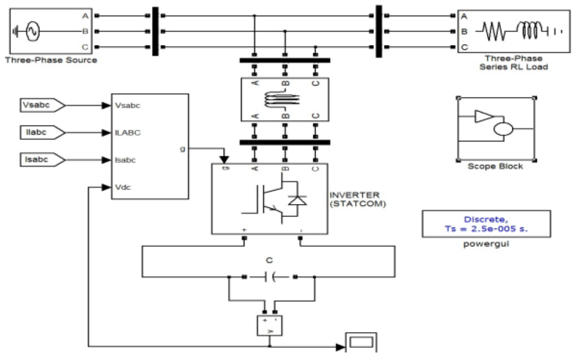


Fig.3 MATLAB/ SIMULINK model Of STATCOM

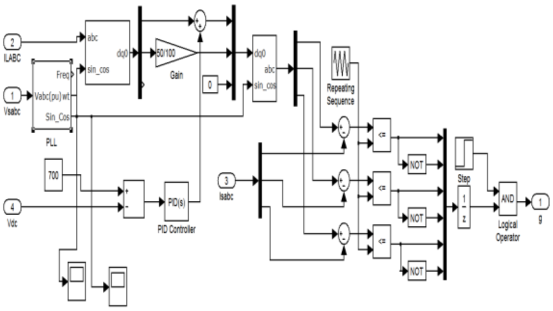


Fig.4 control circuit

This Phase Locked Loop (PLL) system can be used to synchronize on a set of variable frequencies, three-phase sinusoidal signal and it provides pu values of voltage and current. DQ and ABC transformation blocks are used to simplify the controller operation.

4. SIMULATION RESULTS

Here different results for different percentage of compensation are shown in fig. and waveforms of source current and source voltage before connecting STATCOM & after connecting STATCOM are shown in Fig.6, Fig.7, Fig.8. and also waveforms of load current and load voltage before connecting STATCOM & after connecting STATCOM in Fig.5.1, Fig.5.2.

In simulation, we set time delay 0.5 sec by using step input. Therefore after 0.5 sec STATCOM comes in operation in system. From the Fig.5.1, Fig.5.2, we can said that after connecting STATCOM, the current comes in phase with source at both load & source side and power factor becomes almost unity. By connecting STATCOM, we achieve best results of power factor and voltage profile.

The waveforms of active & reactive power are shown in below figures. Fig.6 shows 100% compensation by STATCOM, which means after 0.5 sec 100% reactive power supplied by STATCOM. Fig.7 shows 50% compensation by STATCOM, which means after 0.5 sec 50% reactive power supplied by STATCOM. Similarly Fig.8 shows 0% compensation by STATCOM, which means after 0.5 sec no reactive power supplied by STATCOM.

Here all results are shown for series inductive load with resistance (LOAD: Active power=50 kW, Inductive reactive power=30 kW).

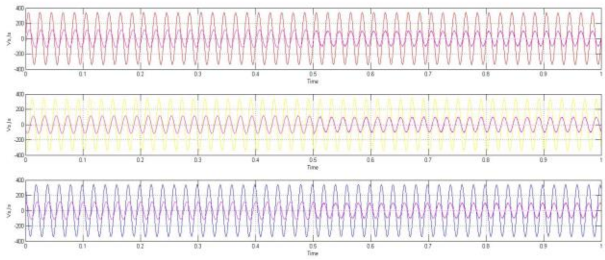


Fig.5.1 source voltage and source current waveform before and after connecting STATCOM

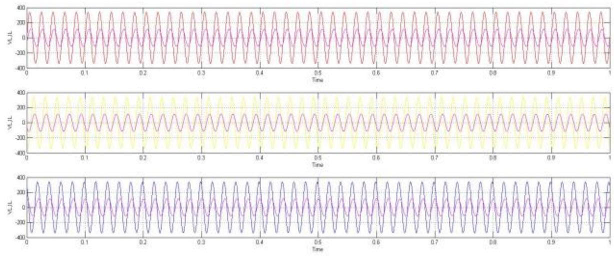


Fig.5.2 load voltage and load current waveform before and after connecting STATCOM

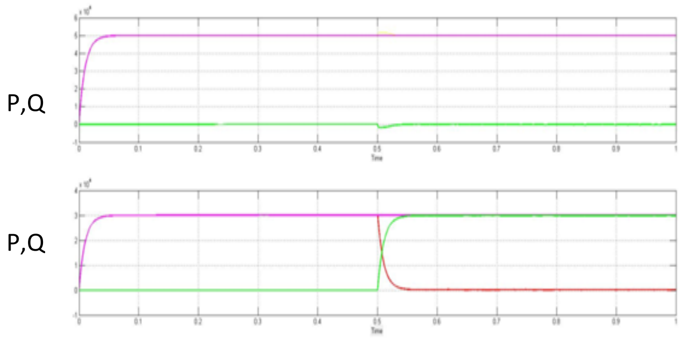


Fig. 6(i) waveform before STATCOM is connected, (ii) 100% power supply by STATCOM

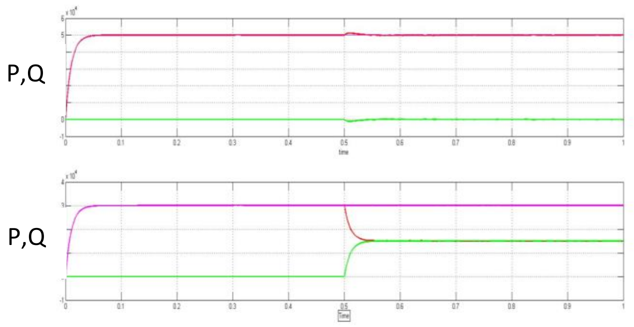


Fig. 7(i) waveform before STATCOM is connected, (ii) 50% power supply by STATCOM

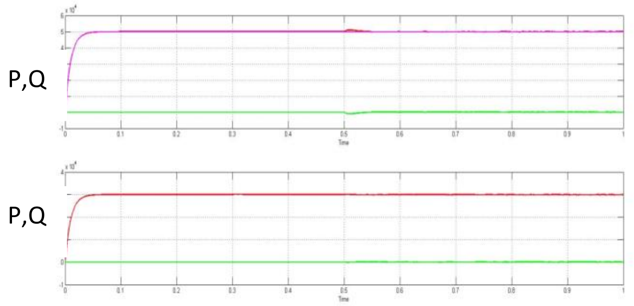


Fig. 8(i) waveform before STATCOM is connected, (ii) 0% power supply by STATCOM

5. CONCLUSION

From the above waveforms, the voltage profile of transmission system is improved after connecting the STATCOM. And we also derived different waveforms for different percentage of reactive power compensated by STATCOM. Therefore, we conclude that, by connecting STATCOM the overall voltage disturbances are reduced and power factor of the system is also improved and overall response of the STATCOM is more efficient than other devices.

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