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# Power System Transient Stability Improvement Using STATCOM

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*Abstract: A static synchronous compensator is one of the FACTS devices used to improve the transient stability of the power system.In this paper PI based STATCOM controller is designed. The proposed controller is tested on two machine system using Matlab Simulink Environment. The results are compared with conventional PI STATCOM Controller to without STATCOM controller.*

*Index Term: FACTS, STATCOM, Transient Stability*

## 1. INTRODUCTION

Today Transmission & Distribution network of power systems are very stressed due to growing demand of better quality of power at low cost. As a result transmission networks are operating on high transmission levels. Transient stability, damping oscillations etc are the major operating problems that power engineers are confronting during transmitting power at high levels. Transient stability indicates the capability of the power system to maintain synchronism when subjected to a several transient disturbance such as fault on heavily loaded lines, loss of large load etc[10]. Generator excitation controller with only excitation control can improve the transient stability for minor fault but it is not sufficient to maintain stability of system for large faults occur near to generator terminals [1]. Researchers worked on other solution and found the Flexible ac transmission systems (FACTS) is one of the most prominent solution that can improve stability by changing electrical characteristics of power system [2],[11]. A static synchronous compensator is one of the FACTS device operated on principle of reactive power compensation can use to improve the transient stability of power system by increasing (decreasing)the power transfer capability when the machine angle increases (decreases)[3]. Static synchronous compensator's three modes i.e. capacitive mode, inductive mode and no load mode regulates voltage in transmission system. When converter a.c. output voltage (Vc) > transmission system voltage (Vs), STATCOM considered to be in capacitive mode and when Vs > Vc, STATCOM considered to be in inductive mode and in No-Load mode Vs=Vc. No reactive power exchange takes place [4]. STATCOM mainly comprise of step down transformer with leakage reactance, three phase GTO voltage source inverter and a dc capacitor voltage [14]. Fig. 1. Shows equivalent circuit diagram of STATCOM system [5].

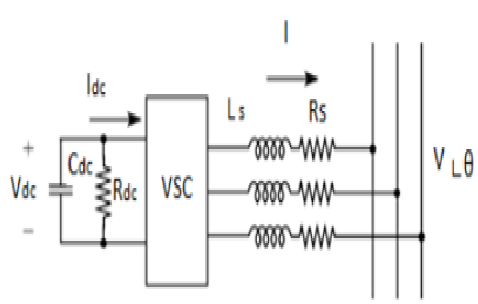


Fig. 1. STATCOM's Basic circuit Diagram

Voltage across capacitor i.e. Vdc is given by following equation

$$C\frac{dV_{dc}}{dt} + GV_{dc} = mk[\sin(\alpha+\theta)I_D + \cos(\alpha+\theta)I_Q]$$

Where G is conductance across the capacitor that represented losses in the capacitor while m is control variable of inverter which affected the magnitude and phase angle of the voltage injected by the inverter [12]. In STATCOM different technologies used dependent upon the power rating of STATCOM. For high power rating of STATCOMs GTO based technologies are used while for low power rating of STATCOMs IGBT based technologies used [15]. In this paper GTO based technologies used. In GTO based static synchronous compensator m is normally kept constant and angle varied to control reactive power [12]. Amount of real power generated or absorbed by STATCOM depends upon the size of capacitor. As compare to SVC, STATCOM provide s a number of performance advantages for reactive power control applications because of its greater reactive current output capability at depressed voltage, faster response, better control stability, lower harmonics and small size etc [6], [16]. In this paper a PI based STATCOM controller is designed. The proposed controller is tested on a two machine power system under Matlab Simulink environment.

## 2. TWO MACHINE SYSTEM

Fig. 2. Shows single line diagram of two area system (area 1 & area 2). Area 1 ( 1000 MW hydraulic generation plant) connected to area 2 ( 5000MW hydraulic generation plant) through 500kV, 700km transmission line.

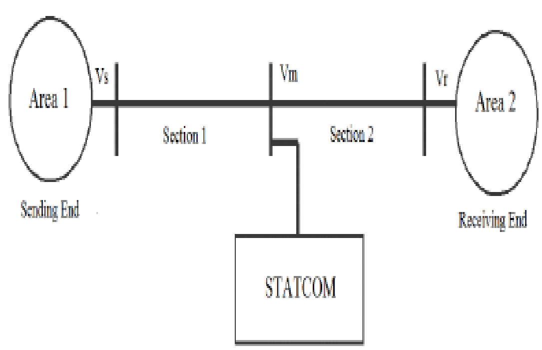


Fig. 2. Single Line Diagram of Two Area Interconnected System

Both plants fed to a load center, modeled by a 5000MW resistive load. System is initialized so that line carries 950MW which is close to its surge impedance loading. In order to maintain system stability static synchronous compensator of 200 MVA is connected at midpoint of transmission line. By connecting it at midpoint the power transfers capability of system increases significantly [7], [8].

## 3. PI CONTROLLER

Proportional-Integral Controller is one of the most commonly used controllers in Industries. This proportional-Integral Controller is mostly referred as PI Controller in industry where Preferred to proportional term while I referred to integral term. The proportional function is to adjusts controller output according to the size of error while function of integral is to eliminates the steady state offset. A General arrangement of PI Controller in matlab under continuous and discrete mode as shown in Figure 3 and Figure 4,

 

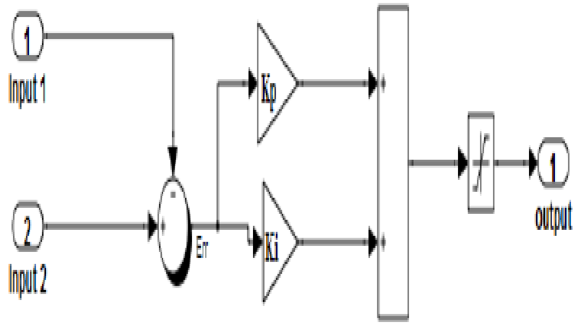


Figure 3: PI Controller in discrete mode

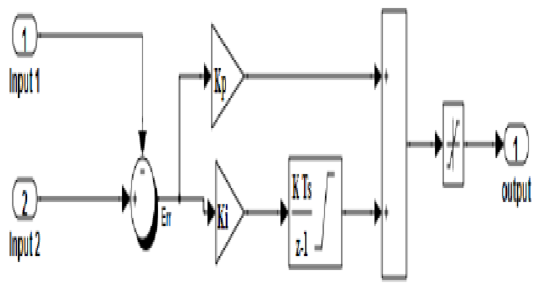


Figure 4: PI Controller in Continuous mode

## 4. SIMULATION MODEL

Simulink model of two machines (M1 & M2) system is shown in Fig. 5 Machine M1 referred to a 1000 MW hydraulic generation plant while Machine M2 referred to 5000MW generating plant. Each machine equipped with a Governor, Excitation system and Power system stabilizer. These components are included in Turbine & Regulator 1 and Turbine & Regulator 2. Both machine connected to a 500kV, 700km transmission line. Resistive load of 5000MW connected on Machine M2 side. GTO based STATCOM having rating of 200 MVA connected at transmission line. Given simulation model run under discrete mode with sample time (Ts) set at20×10-6s.

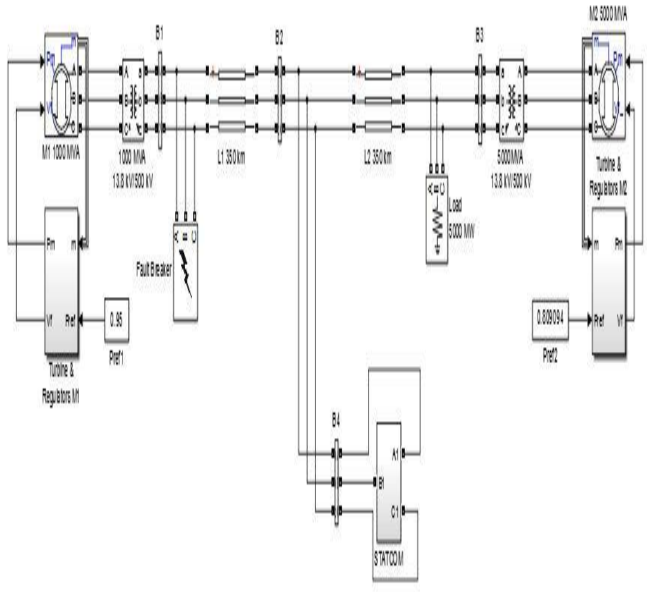


Fig 5: Two Machine System with STATCOM

## 5. SIMULATION RESULT

<u>System without STATCOM (under fault) :</u>

A three phase fault having clearing time of 0.2 sec is given during time period of 0.6 sec to 0.7 sec. System installed without STATCOM becomes unstable as shown by in the below figure which tends towards infinity.

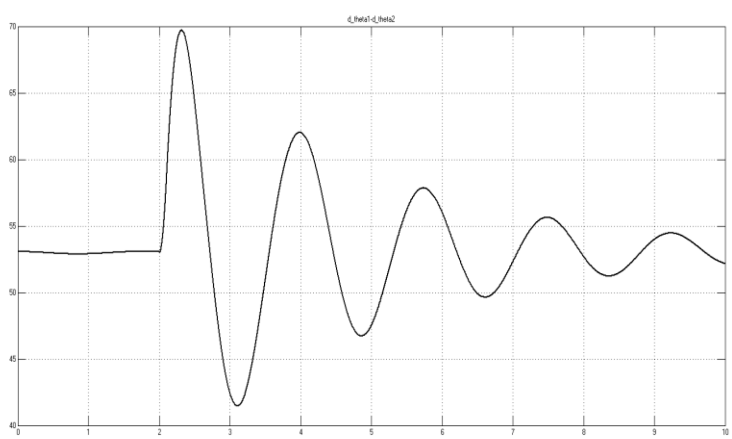


Figure 6: Deviation of Rotor angle with time

 

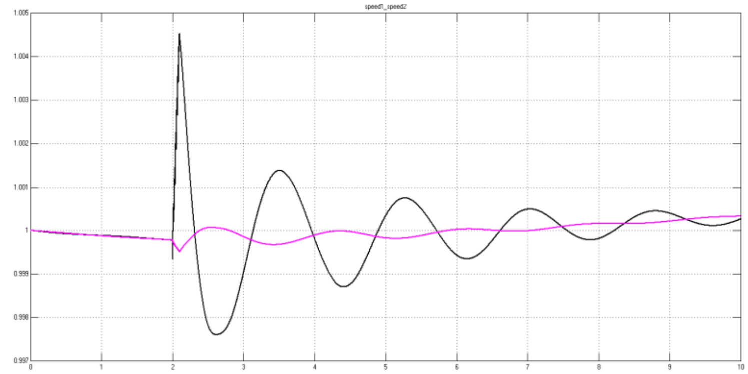


Figure 7: Speed with time

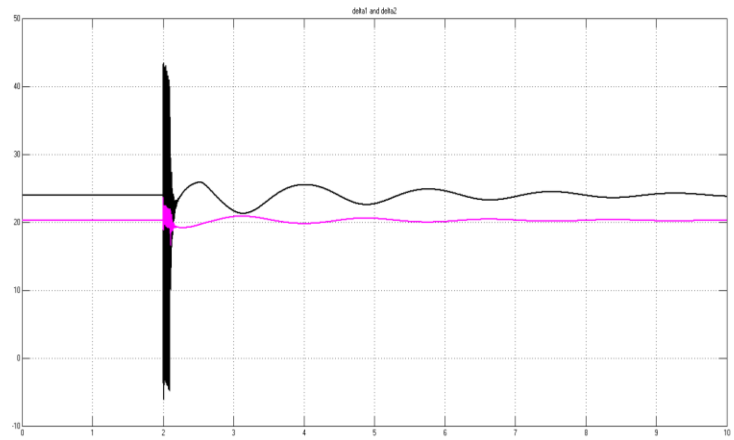


Figure 8: Load angle with time

System installed with PI based STATCOM (under fault):

Now System is installed with PI based STATCOM and fault having clearing time of 0.2 sec is given. System becomes stable after fault is shown in Figure 9 to Figure 11 along with response of different parameters of STATCOM during fault.

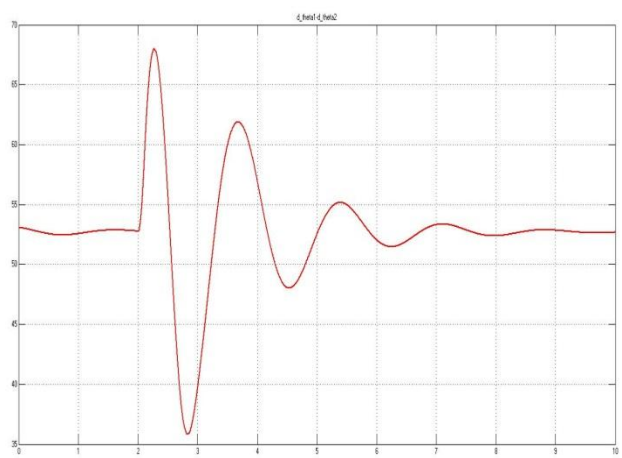

Figure 9: Rotor angle vs. time with STATCOM

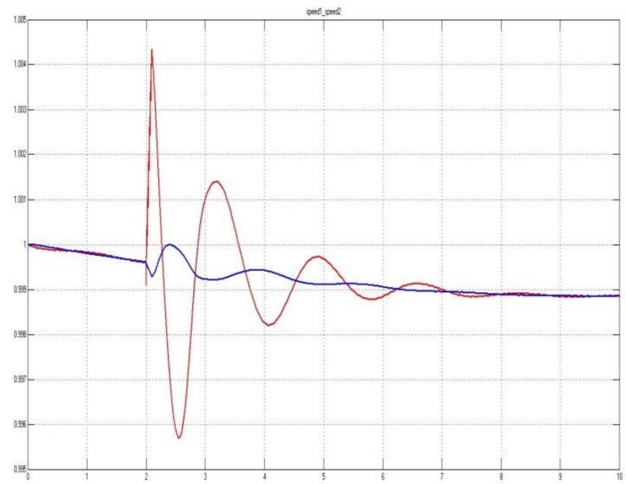

Figure 10: Speed vs. time with STATCOM

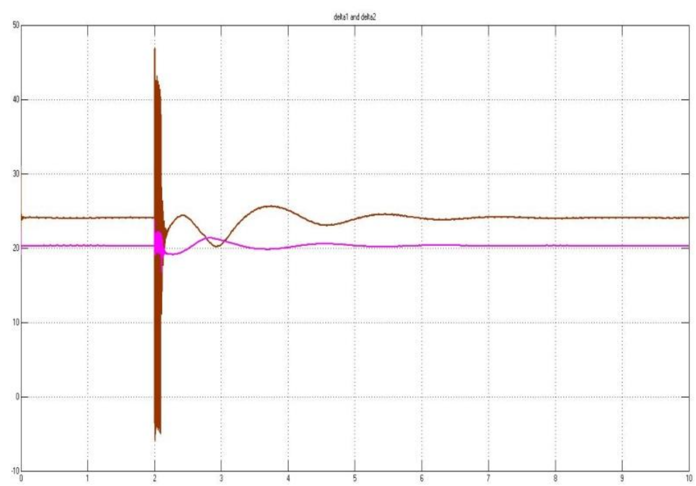

Figure 11: Load angle vs. time with STATCOM

**5.CONCLUSION**

In this Paper, dynamic behavior of two machine system installed with and without STATCOM is investigated under 3-phase fault. PI based STATCOM controllers are designed to improve the transient stability of the given system. Proposed controllers are implemented using MATLAB/SIMULINK. The study takes into consideration the comparison between system Without STATCOM controller and PI based STATCOM controller and the simulation results indicate that the transient stability improvement for two machine system installed with PI based STATCOM controller is better than without STATCOM controller.

 

## DATA

Data for various components used in matlab simulink model of Fig 6 are as follows:
Generator Parameters: M1 =1000 MVA, M2=5000 MVA, V =13.8 KV, f =60 Hz, Xd =1.305, Xd'= 0.296, Xd'' =0.252, Xq =0.474, Xq''=0.243, X=0.18, H= 3.7
Transformer Parameters: T1=1000MVA, T2=5000MVA, 13.8/500 KV, Rm=Lm=500 ohm
Transmission Line Parameters per km: R1=0.01755Ω, R0=0.2758 Ω, L1=0.8737mH, L0=3.22mH, C1=13.33nF, C2=8.297nF.
STATCOM: 500KV, 200MVA, Vref =1 V, Ts=20×10-6
Cp =Cm=5000×10-6

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