TRANSIENT STABILITY ENHANCEMENT OF MULTI MACHINE SYSTEM USING STATIC VAR COMPENSATOR

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Abstract—The growing stress on power system increases the complexity that becomes concern for power system stability and mainly for transient stability. For stable operation of system in event of faults, FACTS devices are used which provide opportunities in controlling power and damping oscillations. This paper presents the improvement of transient stability of multi machine power system using Static Var Compensator. SVC is an effective FACTS device in controlling voltage at required bus by means of reactive power compensation .Simulation of IEEE 3 machine 9 bus system incorporated with SVC controller is carried out in MATLAB/Simulink .The simulation results shows the effectiveness of SVC in improving the voltage profile and transient stability by damping the oscillation.

Keywords— FACTS, MATLAB/Simulation, oscillations damping, reactive power, SVC, transient stability, voltage control

INTRODUCTION

As a consequence of increase in demand of power, transmission networks of power systems are becoming increasingly stressed. This leads to many stability problems like overloading of some transmission lines following a disturbance. So the problem of transient stability after a major fault can become a transmission limiting factor [1]. Transient stability refers ability of power system to maintain synchronism when subjected to a severe transient disturbance like faults, sudden change of load [2]. The resulting system response involves large oscillations in generator speed and rotor angle. Transient stability of complex power system can be improved by use of FACTS devices [3].

FACTS controllers are capable of controlling network condition very fast. This allows existing network to be utilized efficiently and thus avoid need for constructing new transmission lines [4]. The modeling and optimal tuning of various FACTS devices for a dynamic stability enhancement of multi-machine power systems studied in [5]. SVC is a shunt FACTS device which has ability to improve stability and damping by dynamically controlling its reactive power output rapidly [6]. The dynamic nature of SVC lies in use of thyristor devices in modeling of controller. SVC increases the transient stability of power system as when system voltage is low, it generates reactive power and when voltage is high, it absorbs reactive power [8]. Reference [9] presents basic SVC compensator with PSS in improving synchronizing & damping powers of a single machine infinite bus system.

STATIC VAR COMPENSATOR (SVC)

SVC is basically a shunt connected variable var generator whose output is adjusted to exchange capacitive or inductive current to system. SVC regulates voltage at required bus by controlling amount of reactive power injected into or absorbed from power system. Most widely used svc configuration is fixed capacitor- thyristor controlled reactor (FC-TCR). In this a fixed capacitor is connected in parallel with thyristor controlled reactor as shown in figure 2.1. The effective reactance of FC-TCR is varied by firing angle control of anti-parallel thyristors. The firing angle is controlled through a proportional-integral (PI) controller in such a way that voltage of bus where svc is connected is maintained at reference value.

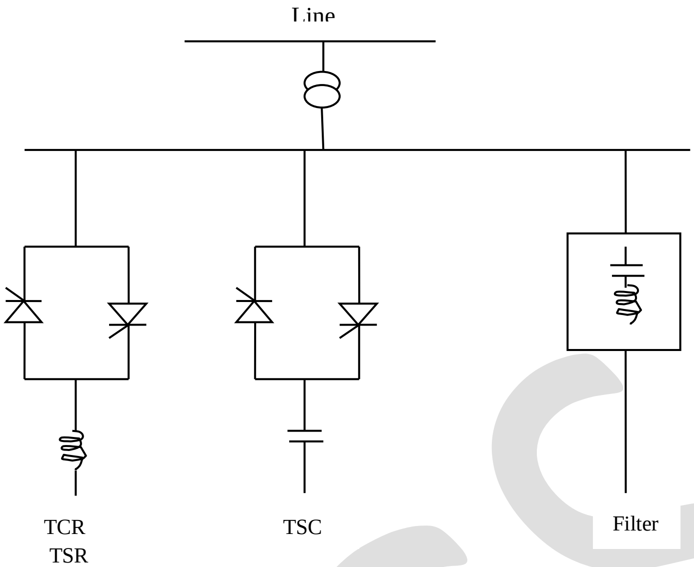

Figure1. Basic model of SVC

The magnitude of the svc is inductive admittance $B_L(\alpha)$ is a function of the firing angle α and is given as

$$B_L(\alpha) = \frac{2\pi - 2\alpha + sin2\alpha}{\pi X_S} \qquad \text{where} \quad \frac{\pi}{2} < \alpha < \pi \,, X_S = \frac{V_S^2}{Q_L}$$

V_S is SVC bus bar voltage and Q_L is MVA rating of reactor. As the SVC uses a fixed capacitor and variable reactor combination (TCR-FC) , the effective shunt admittance is

$$B_S = \frac{1}{X_C} - B_L(\alpha)$$ where X_C is capacitive reactance.

MULTI-MACHINE SYSTEM MODELLING

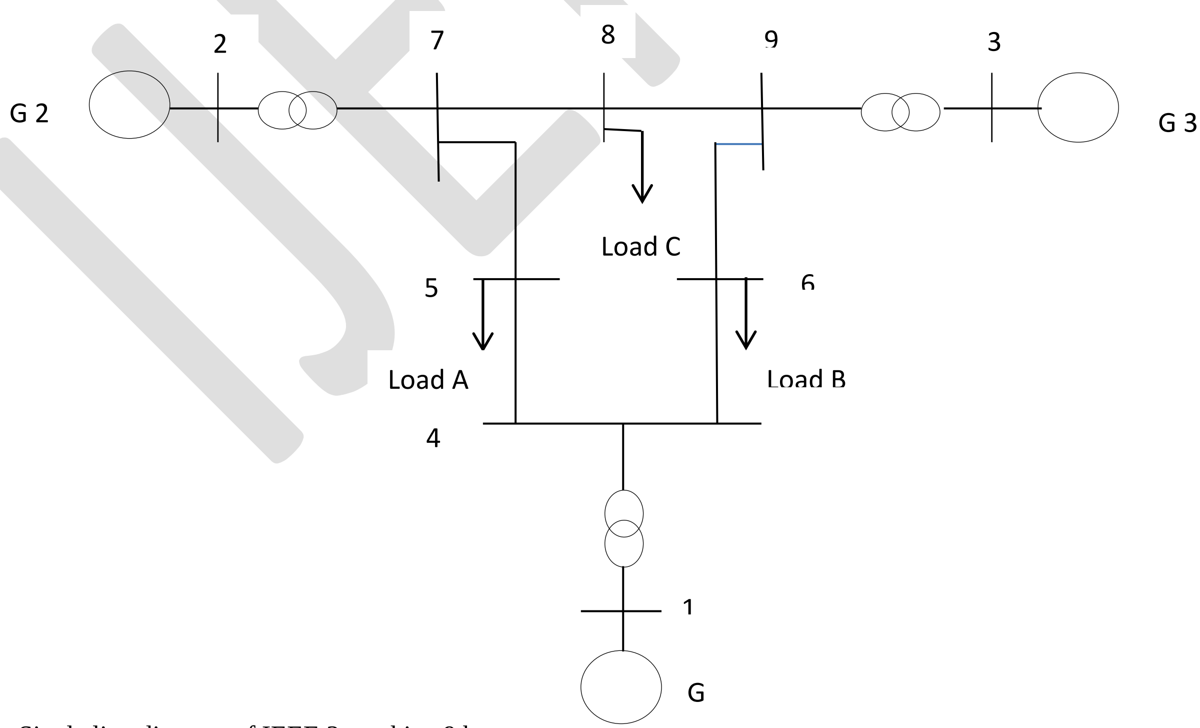

Figure2. Single line diagram of IEEE 3 machine 9 bus system

The single diagram of IEEE 3 machine 9 buses power system is shown in figure 3.1. The power system comprises of three generators G1, G2 AND G3 supplying 247.5 MW, 192 MW and 128 MW respectively. The system has three transformers with 16.5/230 KV, 18/230 KV and 13.8/230 KV respectively. It comprises of three loads, load A with 125 MW 50 MVAR, load B with 90 MW 30 MVAR and load C with 100 MW 35 MVAR connected at buses 5, 6 and 8 respectively. The transmission system is of 230 KV. The base MVA of the system is 100 and system frequency is 60 Hz. All the time constants are in seconds.

SIMULATION RESULTS AND DISCUSSION

The complete system of IEEE 3 machine 9 bus system with all the required components has been modeled by using MATLAB/Simulink blocks. The simulation is done with the single line to ground fault occurred at 5.2 sec at bus 8 and the simulation model is shown in figure 4.1. The fault is cleared at 5.6 sec which means the fault clearing time is 0.4 sec. The simulation results show that the system voltage and power with fault and without SVC damp in 7 s, 7.5s respectively. The simulation results of the system with SVC connected at bus 5 shows that the voltage and power damp in 6.4s, 7s respectively. The simulation result also shows that the magnitude of machine oscillations is also reduced with the use of SVC. It is also seen that the SVC is placed at the mid of the transmission line as it provide better results when placed at the center rather than at the end of line.

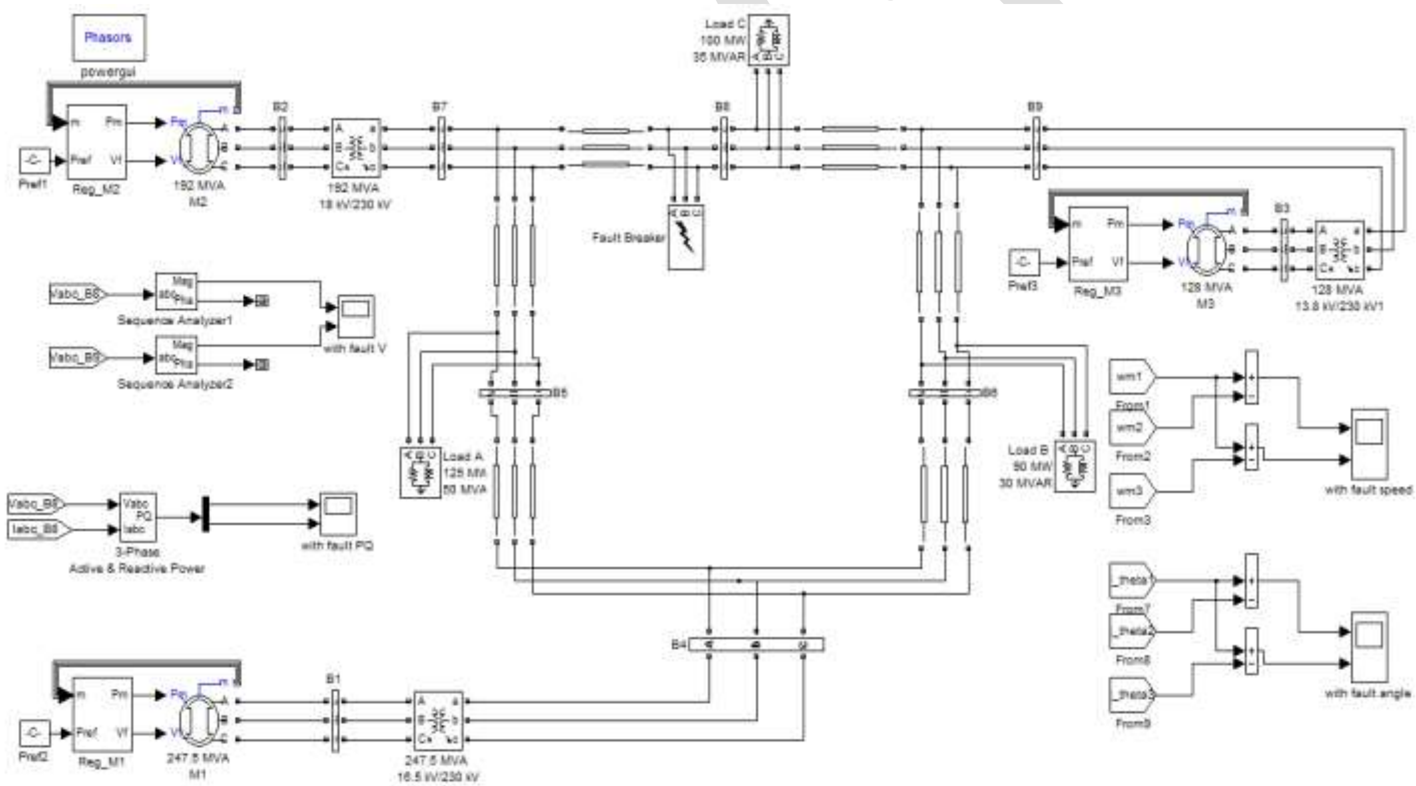

Figure3. Simulink model of 3 machine 9 bus system with fault

Output waveforms

The output waveforms without SVC are:

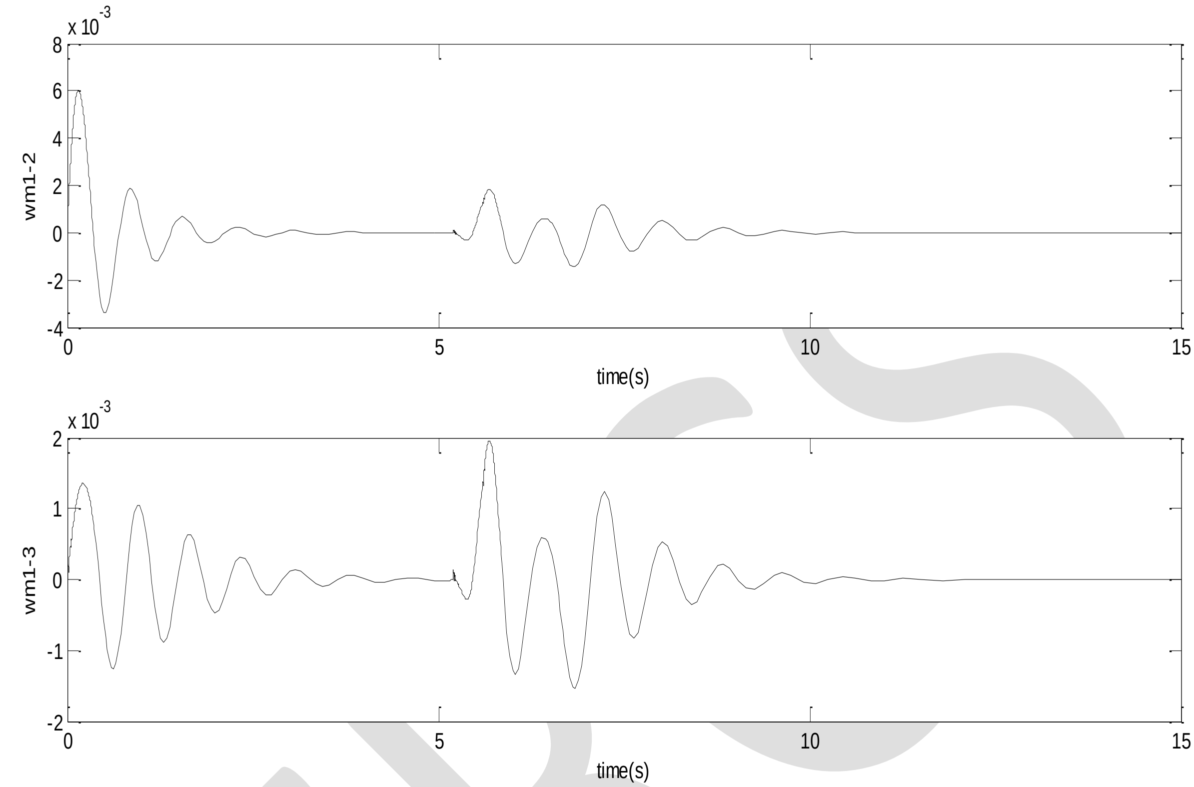

Figure4. Speed variation of generators when fault occur without SVC

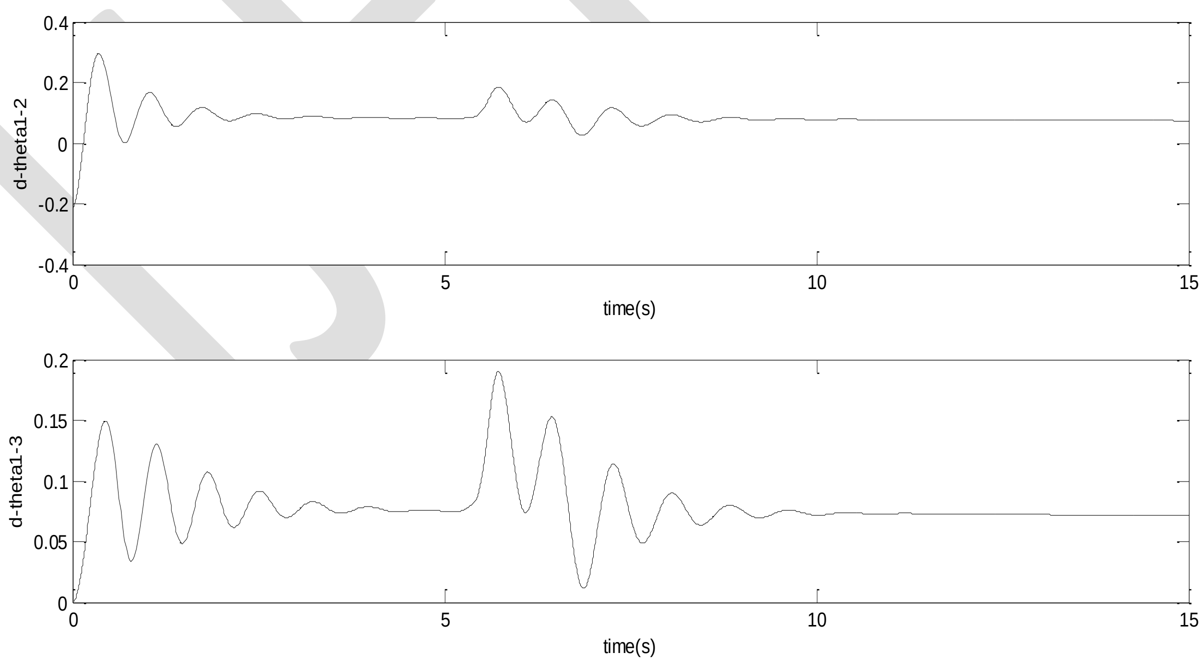

Figure5. Rotor angle variations of generators without SVC

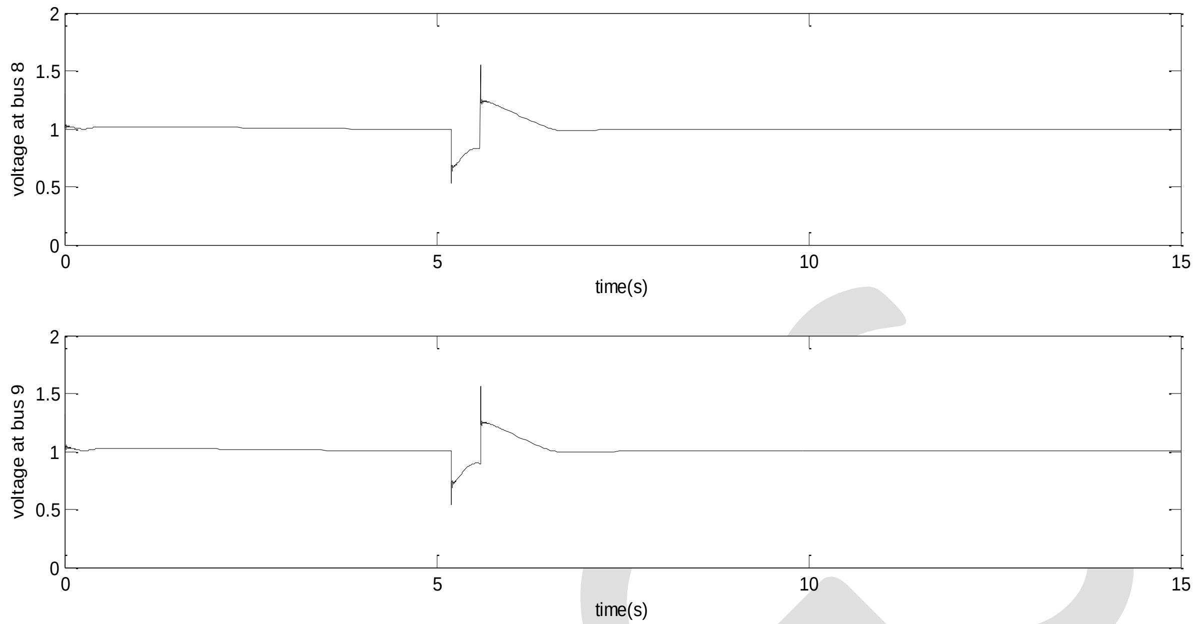

Figure6. Voltage variation at bus 8 and 9 when fault occurs without SVC

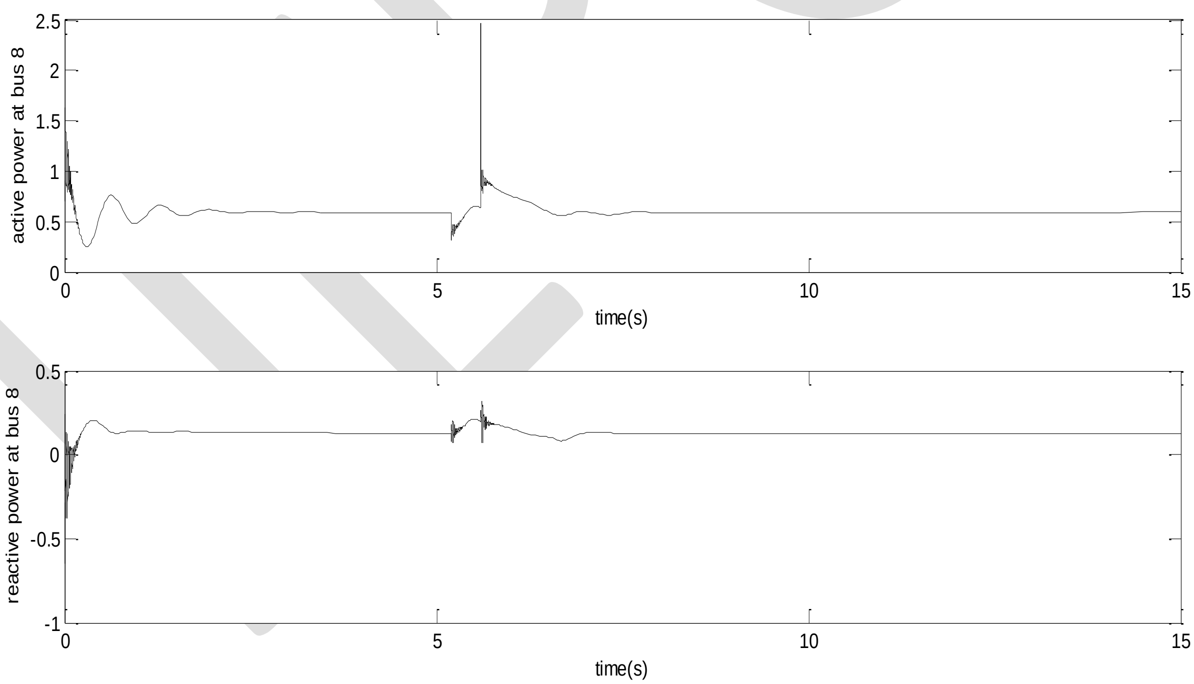

Figure7. Active and reactive power variation at bus 8 when fault occurs without SVC

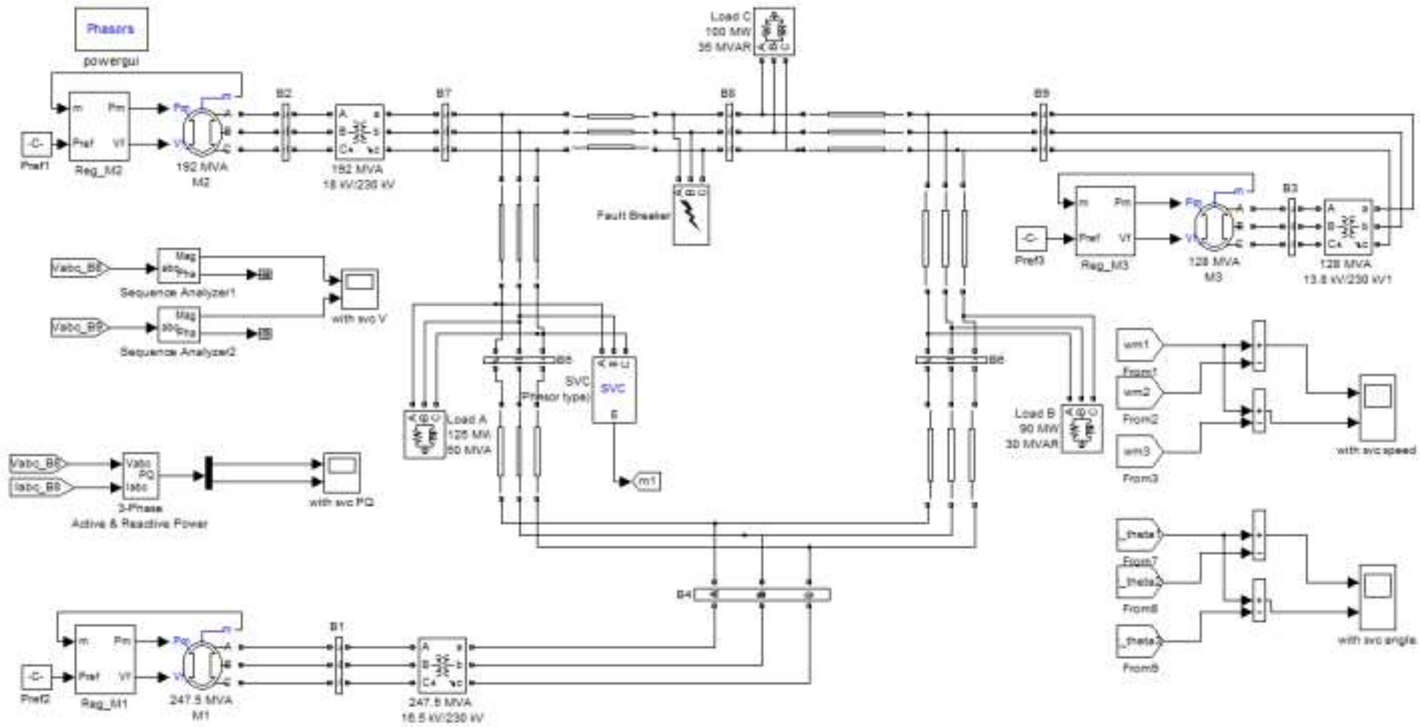

Figure8. Simulink model of 3 machine 9 bus system with SVC

Output waveforms with SVC are:

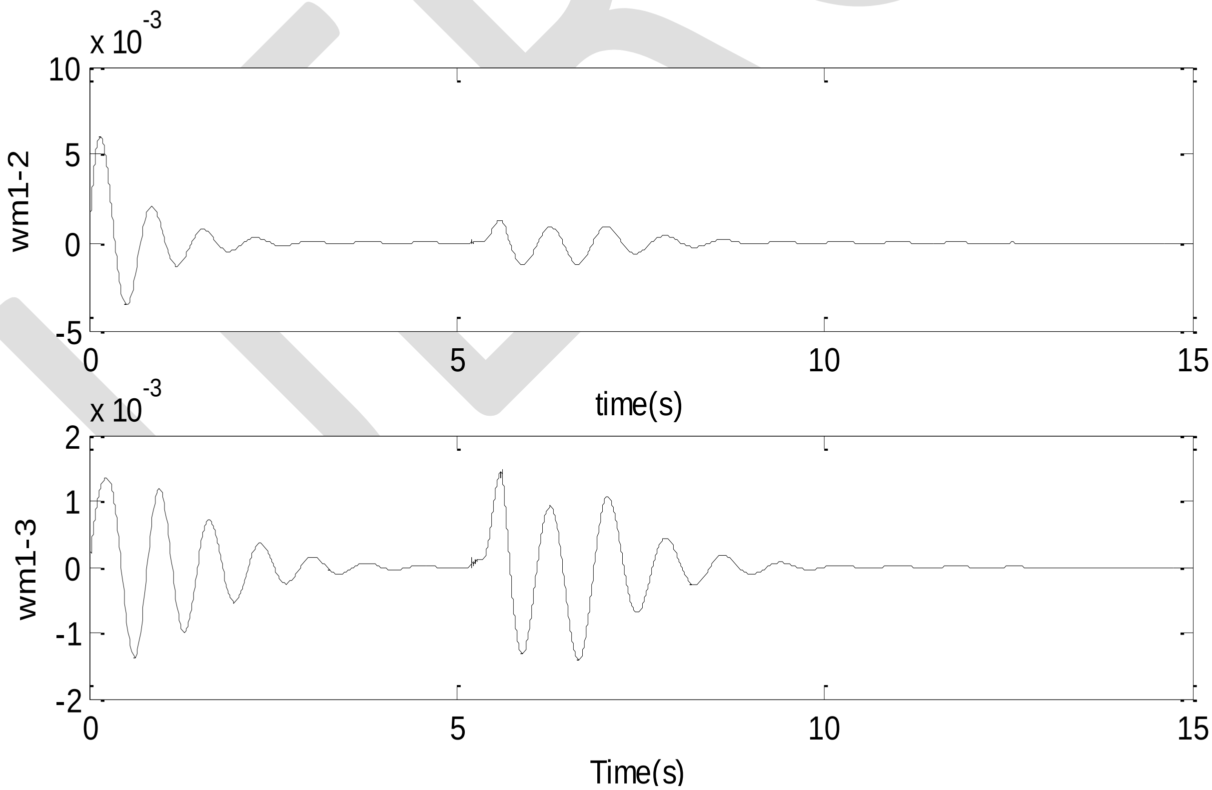

Figure9. Speed variation of generators when fault occur with SVC

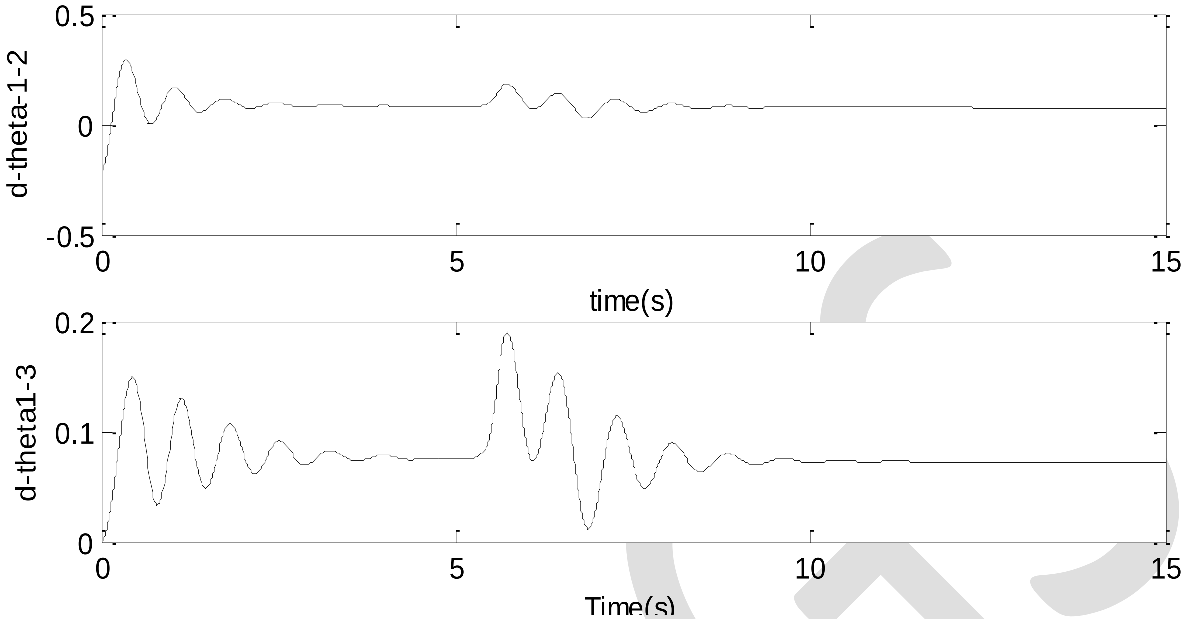

Figure10. Rotor angle variation of generators when fault occur with SVC

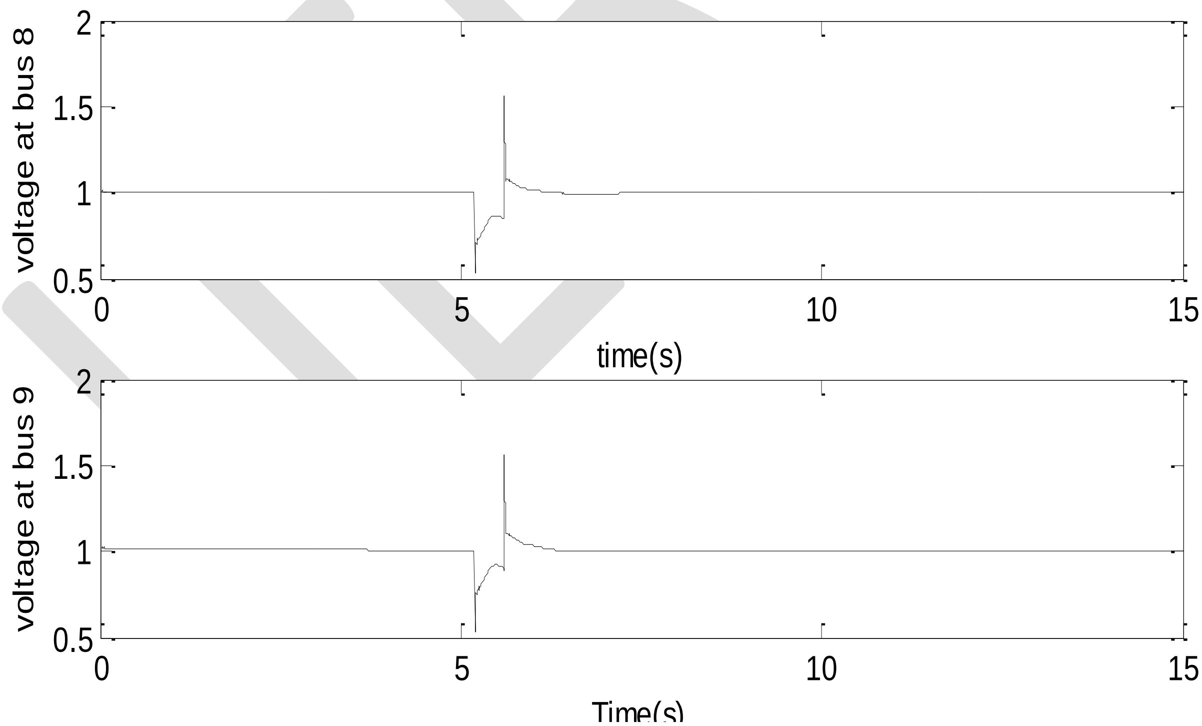

Figure11. Voltage variation at bus 8 and 9 when fault occur with SVC

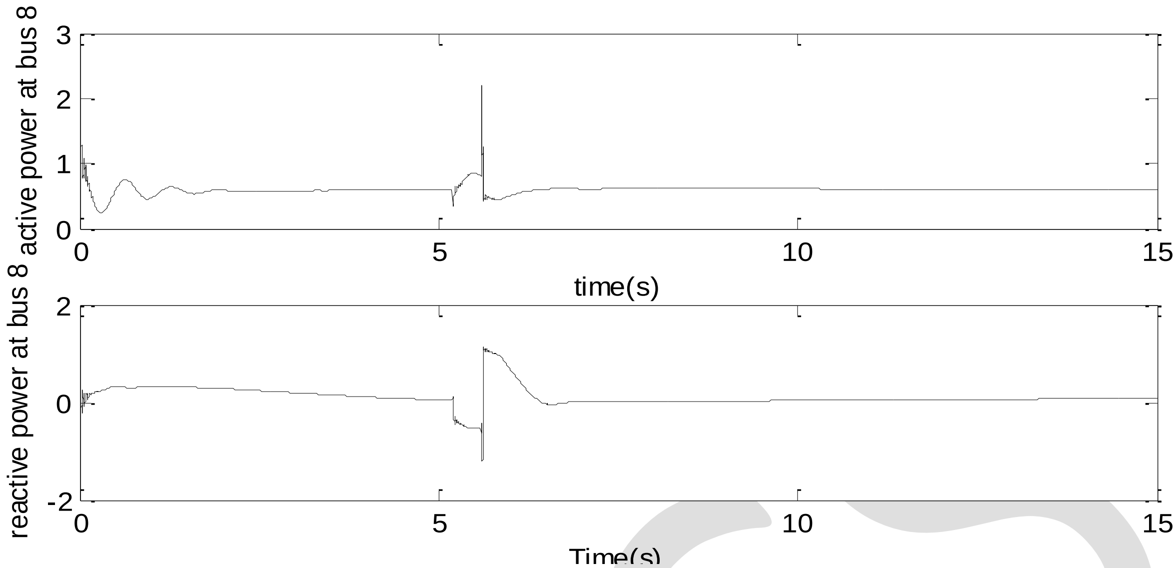

Figure12. Active and reactive power variation at bus 8 when fault occurs with SVC

CONCLUSION

This paper presents the transient stability improvement of nine bus system with SVC.IEEE nine bus system is modeled in MATLAB/SIMULINK and a single line to ground fault is created at a bus. Results show that oscillations in speed and rotor angle difference of the generators are damped out speedy with the insertion of SVC thus enhancing the transient stability of the system. SVC also improves the voltage profile of the buses.

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