Transient Stability Improvement of Multi Machine Power System Using Static VAR compensator

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Abstract

The objective of this paper is to improve the transient stability of a multi machine power system using STATIC VAR compensator. SVC is one of the FACTS devices which are used to make the power supply more efficient and reliable. Transient stability is one of the most important stability of the power system. The loss of Transient stability is due to overloading of some of the lines (or due to sever line fault) as a consequence of tripping off of the other lines after fault or heavy loss of loads.

The main aim of the work is to design the model of SVC in simulink as an alternate to the physical model which is not feasible due to enormous cost. The proposed work includes (WSCC) 3-machine 9-bus system incorporated with SVC controller using Matlab. The simulated SVC shows how the oscillations are damped out with SVC controller. The optimum location of the SVC in the system is also studied.

1. Introduction

Transmission networks of modern power systems are becoming increasingly stressed because of growing demand and restrictions on building new lines. One of the consequences of such a stressed system is the threat of losing stability following a disturbance. Power system stability may be defined as that property of a power system that enables it to remain in a state of operating equilibrium under normal operating conditions and to regain an acceptable state of equilibrium after being subjected to a disturbance. For convenience of analysis, stability problems are classified into three basic types – steady state stability, dynamic stability and transient stability. Steady-state stability refers to the ability of the power system to regain synchronism after small and slow disturbances and dynamic stability is concerned with small disturbance lasting for long time[3].Transient stability is the ability of the power system to

maintain synchronism when subjected to a severe transient disturbance. Transient stability studies deals with the effects of large, sudden disturbances such as the occurrence of a fault, the sudden outage of a line or the sudden application or removal of loads.

FACTS technology opens up new opportunities for controlling power and improving capability of present as well as new and upgraded lines [6]. By means of rapid and flexible control over the ac transmission parameters and network topology, FACTS technology can facilitate power control, enhance the power transfer capacity, decrease the line losses, increase power system damping and improve the stability and security of the power system. After having adopted FACTS devices, the operating point of the power system in steady state can be altered to improve the transient stability significantly. The aim of this paper is to investigate the influence of SVC on improving transient stability of multi machine power system. In multi machine system all the machine are in synchronism. But when fault occur on any bus then it will result in the oscillation. These oscillations are damped out with help of SVC. The proposed model is designed and the results are verified using matlab simulink.

2. Static VAR Compensator

The Static Var Compensator is basically a shunt connected variable Var generator whose output is adjusted to exchange capacitive or inductive current to the system. One of the most widely used configurations of the SVC is the FC-TCR type in which a Fixed Capacitor (FC) is connected in parallel with Thyristor Controlled Reactor (TCR). The model of SVC is shown in Figure. The magnitude of the SVC is inductive admittance $B_L(\alpha)$ is a function of the firing angle α and is [5] given as

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

is SVC bus bar voltage and *QL* 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
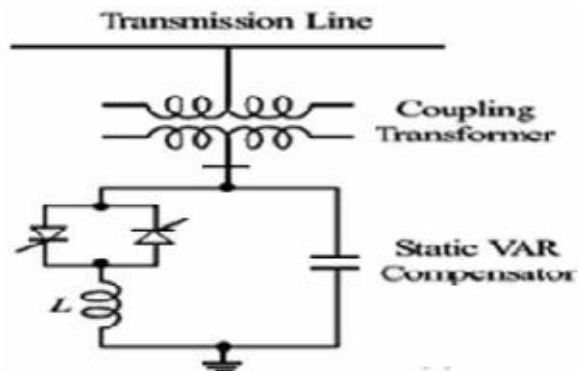
SVC basic model

3. Location Criterion for SVC

The placement of SVC is based on acceleration of machine. The equation of machine without damping is given [5] as

$$\delta = \dot{\omega}\Delta P/\,2H \tag{1}$$

Here δ denotes the machine's rotor angle, H is inertial constant and ΔP gives the mismatch between the mechanical power into the machine and its electrical output.

The machine which needs to be controlled through SVC is determined on the basis of oscillation made by it. The acceleration of the two machines at node I, j is given by[5]

$$\delta_{ij} = \dot{\omega}_o/2(\Delta P_i/\,H_i - \Delta P_j/\,H_{j)} = EF_{ij} \tag{2}$$

this equation is called ' effectiveness factor' and is used to find the location of SVC. The higher the value of this factor will give best location for SVC connection Made. SVC is a controlled Static VAR compensator can deliver or absorb the reactive power at its point of connection. SVC is also used for voltage control in power system

4. Multi Machine System Modelling

The popular Western System Coordinated Council (WSCC) 3-machines 9-bus practical power system is a widely used one and found very frequently in the relevant literature. The figure below shows a 3 machine 9 bus system (WSCC) system.
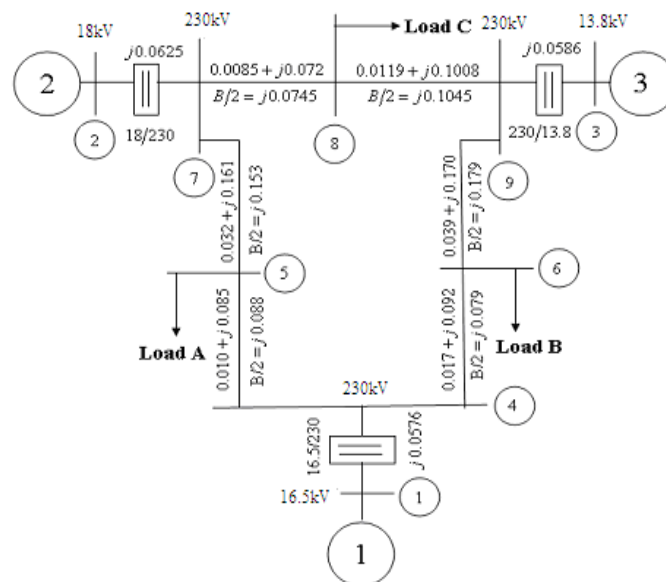
3-Machines 9-bus WSCC system single line diagram

The base MVA of the system is 100, and system frequency is 60 Hz. All time constants are in seconds. The complete system with all the required components has been modeled by using MATLAB/Simulink blocks.
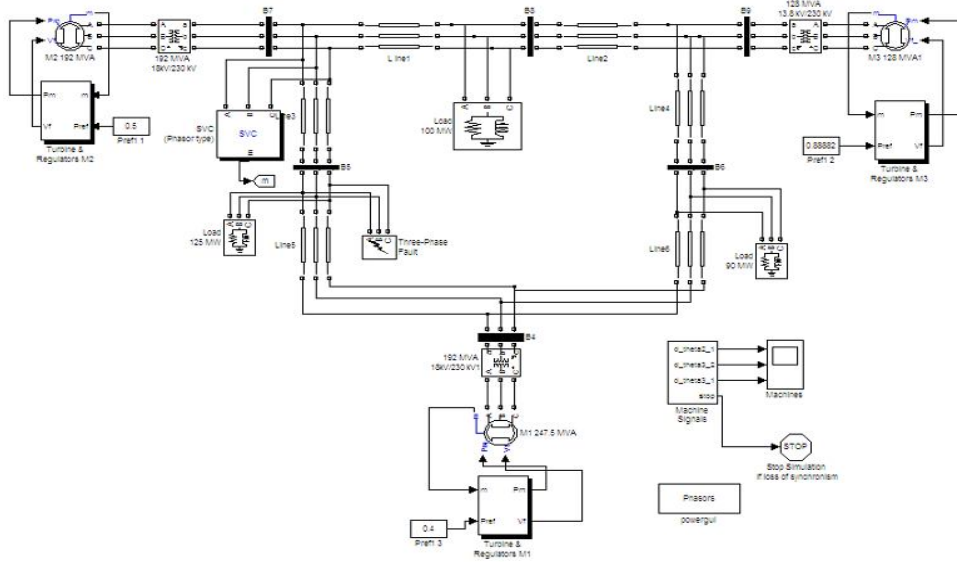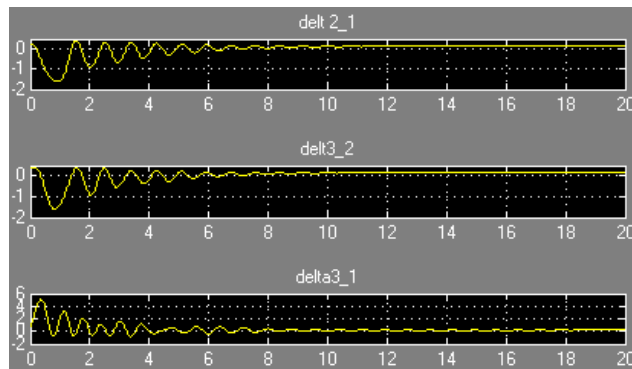
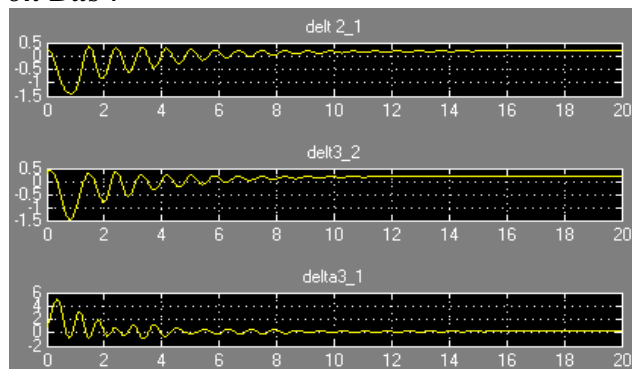Simulink Model of 3 Machine 9 bus system

5. Case Studies
5.1 Case 1 Fault Occurring Between Bus 7 and Bus 4
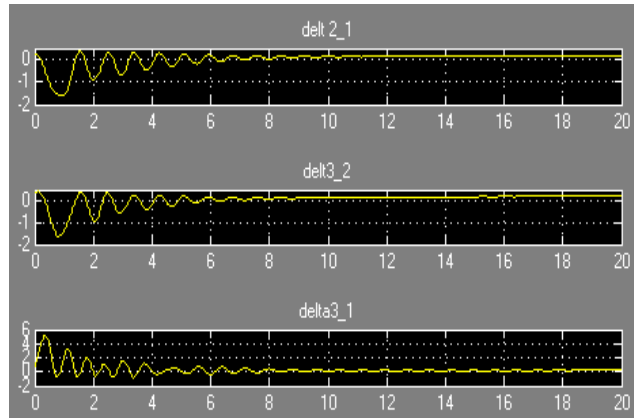*5.1.1 SVC is placed in the middle of bus 7 and bus 4*

Variation of angular position delta2_1, delta3_2, and delta1_3 with time

5.1.2 SVC Placed on Bus 7

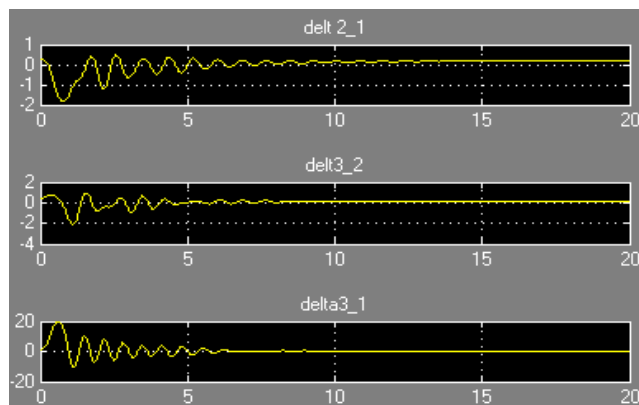Variation of angular position delta2_1, delta3_2, and delta1_3 with time

5.1.3 SVC placed on Bus 4

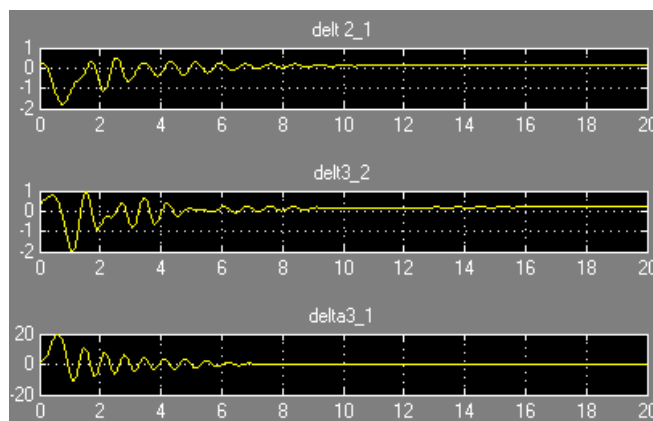Variation of angular position delta2_1, delta3_2, and delta1_3 with time

CASE 2 FAULT OCCURING BETWEEN THE BUS 9 AND BUS 4
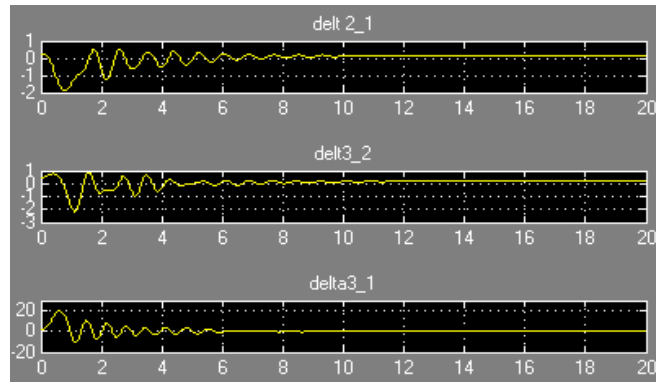
5.2.1 SVC is placed in the middle of Bus 9 and 4

Variation of angular position delta2_1, delta3_2, and delta1_3 with time

5.2.2 SVC placed on Bus 9

Variation of angular position delta2_1, delta3_2, and delta1_3 with time

5.2.3 SVC placed on Bus 4

Variation of angular position delta2_1, delta3_2, and delta1_3 with time

6. Conclusion

In this paper we studied that the oscillation produced in the system can be removed with SVC. From the simulation work it is clear that the power system can attain the stability in the best manner if the SVC is located in the middle of the lines between which the fault has occurred. Hence we can say that SVC can be used to improve the transient stability of system.

References

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