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Effectiveness of Statcom and SVC on Stability of Power System

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Abstract: **This paper focuses on the placement and selection of suitable VAR source (STATCOM or SVC), for improving the voltage profile and reducing the real power losses for a reality power system. SVC and STATCOM is shunt FACTS devices which is designed to maintain the voltage profile in a power system under normal and contingency conditions. However the selections of suitable VAR source (STATCOM or SVC) also need to be considered. The purpose of this paper is to solve the above problems in order to suggest a solution of the appropriate shunt compensator for a reality power system. In practical power systems, all buses have different sensitivity to the power system security and stability. If SVC and STATCOM is allocated at more sensitive buses, it will effectively improve the voltage profiles and stability.**

All the simulations for the above work have been carried out using MATLAB-SIMULINK environment.

1. INTRODUCTION

Power Generation and Transmission is a complex process, requiring the working of many components of the power system in tandem to maximize the output. One of the main components to form a major part is the reactive power in the system. It is required to maintain the voltage to deliver the active power through the lines. Loads like motor loads and other loads require reactive power for their operation. To improve the performance of ac power systems, we need to manage this reactive power in an efficient way and this is known as reactive power compensation. There are two aspects to the problem of reactive power compensation: load compensation and voltage support. Load compensation consists of improvement in power factor, balancing of real power drawn from the supply, better voltage regulation, etc. of large fluctuating loads. Voltage support consists of reduction of voltage fluctuation at a given terminal of the transmission line. Two types of compensation can be used: series and shunt compensation. These modify the parameters of the system to give enhanced VAR compensation. In recent years, static VAR compensators like the STATCOM have been developed. These quite satisfactorily do the job of absorbing or generating reactive power with a faster time response and come under Flexible AC Transmission Systems (FACTS). This allows an increase in transfer of apparent power through a transmission line, and much better stability by the adjustment of parameters that govern the power system i.e. current, voltage, phase angle, frequency and impedance.

2. STATIC VAR COMPENSATOR (SVC)

Static VAR systems are applied by utilities in transmission applications for several purposes. The primary purpose is usually for rapid control of voltage at weak points in a network. Installations may be at the midpoint of transmission interconnections or at the line ends. Static VAR Compensators are shunting connected static generators / absorbers whose outputs are varied so as to control voltage of the electric power systems. In its simple form, SVC is connected as Fixed Capacitor Thyristor Controlled Reactor (FC-TCR) configuration as shown in Fig. 1.

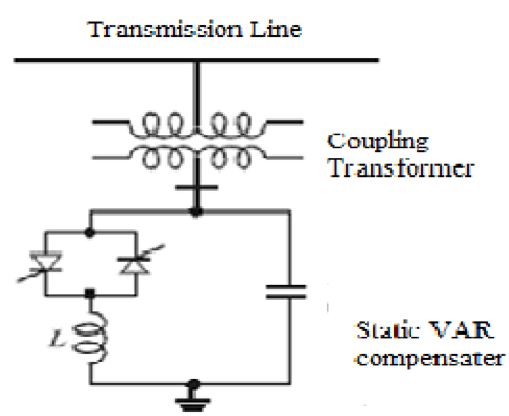


Fig. 1: Static VAR Compensator of SVC.

The SVC is connected to a coupling transformer that is connected directly to the ac bus whose voltage is to be regulated. The effective reactance of the FC-TCR is varied by firing angle control of the anti-parallel thyristors. The firing angle can be controlled through a PI (Proportional + Integral) controller in such a way that the voltage of the bus, where the SVC is connected, is maintained at the reference value.

3. STATIC SYNCHRONOUS COMPENSATOR (STATCOM)

The STATCOM is based on a solid state synchronous voltage source which generates a balanced set of three sinusoidal voltages at the fundamental frequency with rapidly controllable amplitude and phase angle. The con- figuration of a STATCOM is shown in Fig. 2.

Basically it consists of a voltage source converter (VSC), a coupling transformer and a dc capacitor. Control of the reactive current and hence the susceptance presented to power system is possible by variation of the magnitude of output voltage (VVSC) with respect to bus voltage (VB) and thus operating the STATCOM in inductive region or capacitive region.

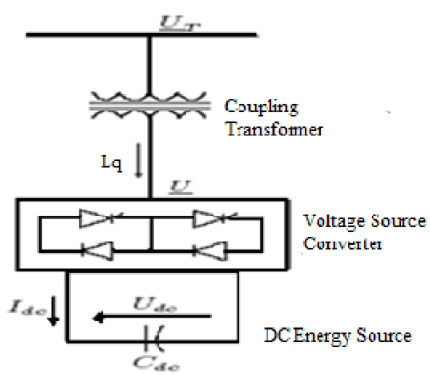


Fig. 2: Static Synchronous Compensator (STATCOM).

4. RESULTS AND ANALYSIS

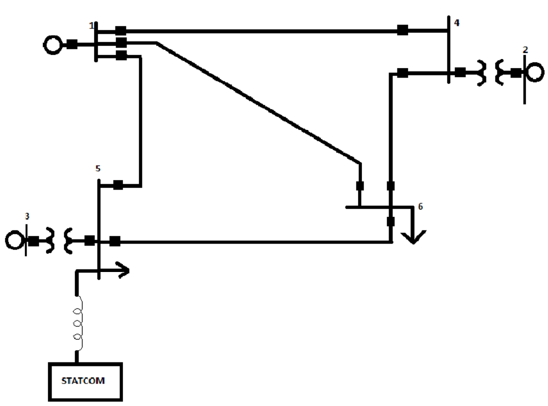
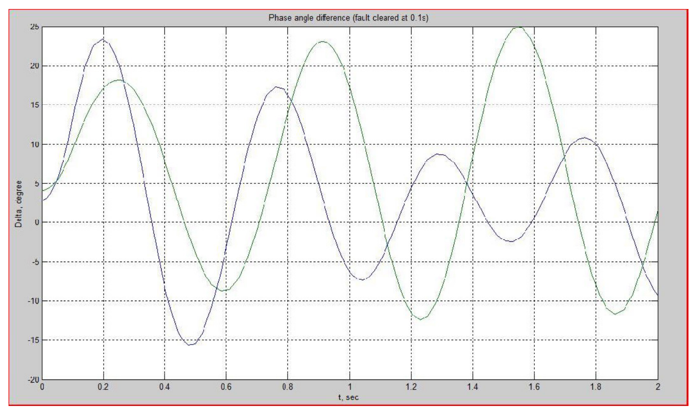


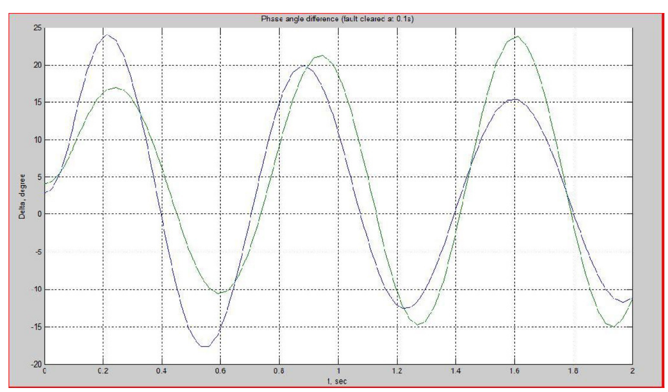
Fig .3

The 6 bus system shown above describes a transmission line network. The load data, voltage magnitude, generation schedule, and the reactive power limits for the buses are tabulated in the appendix. Bus 1, with a voltage specified as, is taken as the slack bus, and accounts for all the losses associated with the transmission line as well as the generators. The base MVA is taken 54 as 100 MVA. All the resistances, reactances, susceptances and other parameters are calculated on the basis of this MVA. First we analyse the system without the implementation of a STATCOM and see the results of the fault at different buses and removing different lines. Then we compare the graphs of the different buses with their respective faults, and find out the point where it would be best suited to implement a STATCOM. Thereafter we analyse the system with a STATCOM and check out the improvement if any. The transient stability due to the sudden fault at any point is analysed.

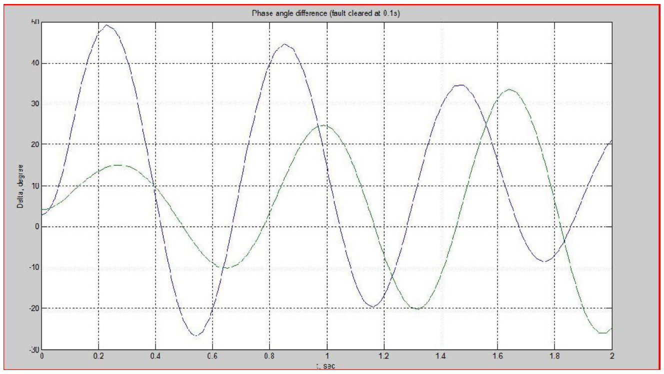
Case 1: We analyse the 6 bus system and for fault at bus 6 with (5,6) being the lines removed, we get The fault is cleared at 0.1 secs for a simulation time of 2 secs.



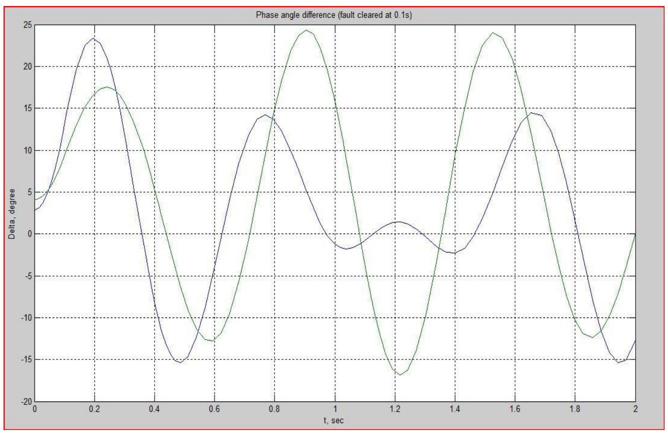
Case 2: Similarly, we analyse for fault at bus 1 by removing lines (1,4) for the same simulation time and fault clearance time.



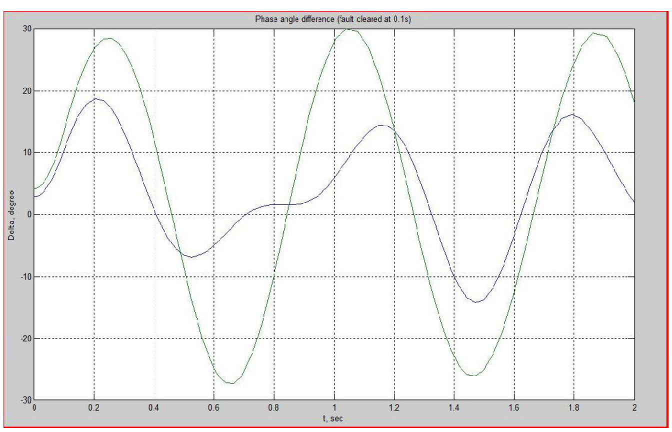
Case 3: Fault at bus 4, lines removed are (4,6)



Case 4: Fault at 6, lines removed are (1,6)

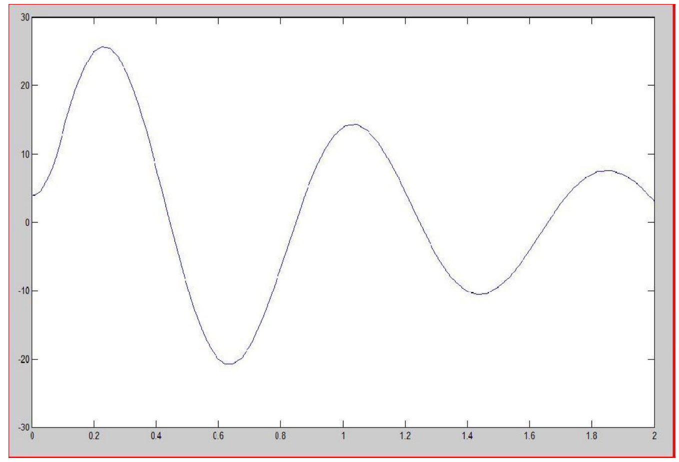


Case 5: Fault at 5, lines removed are (1,5)

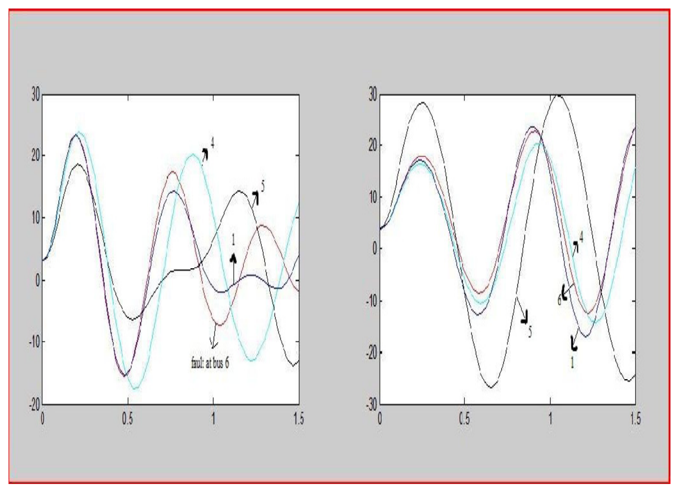


Therefore we find out that fault at bus 5 causes the maximum excursion of rotor angle of Generator 2 and 3 with respect to Generator 1. The angle of mismatch varies much in this case and it deviates much compared to the previous cases. Thus it would be an appropriate point for the implementation of STATCOM. Hence we put the STATCOM in shunt with the bus 5, and the value of STATCOM reactive power is assumed to be 30 MVAr. Thus the bus 5 and STATCOM together have a total reactive power of 60 MVAr.

STATCOM implementation:



Next we find from the graphs that the bus system without and with STATCOM and see the difference in rotor angle characteristics. Improved rotor angles can be seen from both the graphs and the implementation of STATCOM has made the transient characteristics much better.



The above graph shows the difference between the behaviour of the system with faults at all the connected buses without and with the STATCOM. We can see that the waveform of the rotor angle of generator 3 with respect to generator 1 shows much better characteristics with the STATCOM and the harmonics are removed due to its action.

5. CONCLUSION

The study of the basic principles of the SVC and STATCOM is carried out as well as the basics of reactive power compensation using a STATCOM. The bus system shows improved plots and the thus we can conclude that the addition of a SVC or STATCOM controls the output of a bus in a robust manner and improves stability.

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