ABSTRACT

Series capacitor compensation is used in Power Systems to increase the power transfer capability of the transmission lines as well as to improve the system stability. However the use of series capacitor may introduce subsynchronous oscillations in the system. The subsynchronous oscillations may lead to the destruction of the turbine-generator shafts or loss of synchronism of the generator and this phenomenon is known as Subsynchronous Resonance (SSR). Damages of turbine-generator shafts were noticed at Mohave generating station in Southern Nevada in the United States of America in December 1970 and October 1971 due to SSR. Subsequently IEEE Power Engineering Society task force was formed to deal with the problem of Subsynchronous Resonance Phenomenon. The task force finally proposed two benchmark models for computer simulation study of SSR phenomenon. A good amount of work is reported on different techniques to analyse the Subsynchronous Resonance Phenomenon and methods to damp subsynchronous oscillations.

The main objective of this research work is to make studies on a series compensated power system to identify the unstable subsynchronous modes of oscillations by modifying the existing models and quench these unstable modes of oscillations using Power System Stabilizer (PSS), Staticvar Compensator (SVC) and coordinated control of PSS and SVC strategies.
The work reported in this thesis mainly consists of two parts. The first part deals with the modelling of series compensated power system and the analysis of subsynchronous oscillations. The second part deals with the control strategies for damping of subsynchronous oscillations using various auxiliary controls.

The IEEE bench mark model 2 system 1 is considered for analysis. It consists of single machine supplying power to infinite bus through two parallel lines one of which is series compensated. The mechanical system considered consists of six mass, viz, high pressure turbine, intermediate pressure turbine, two low pressure turbines, generator and an exciter. The excitation system considered is IEEE type 1 with saturation.

A combined modelling of the series compensated power system and the auxiliary controls is developed and represented in state space form. This model representation has built in flexibility to incorporate sub systems without involving the inversion of large size matrices. The analysis of series compensated power system is carried out using eigenvalue technique, which provides both the frequencies of oscillations and their decrement factors. The analysis of series compensated power system without any auxiliary controls is carried out with fixed compensation ranging between 0% to 100% in steps of 5% for a fixed line resistance. It is observed that mode 1, mode 2, mode 3 and mode 4 oscillations are causing system to become unstable.
The auxiliary controls considered to damp the unstable subsynchronous modes of oscillations are Power System Stabilizer (PSS), Staticvar Compensator (SVC) and coordinated control of PSS and SVC.

The three different cases adapted to study the effectiveness of power system stabilizer (PSS) to damp these unstable subsynchronous modes of oscillations at specified operating point are:

(i) One PSS with generator speed deviation as feedback signal.
(ii) One PSS with modal speed deviation as feedback signal.
(iii) Two PSS with modal speed deviation as feedback signal.

It is observed that Two PSS with modal speed deviation as feedback signal provides better damping to all the unstable subsynchronous modes of oscillations compared to other two cases of power system stabilizers.

The various staticvar compensator (SVC) strategies applied in this study for the effective damping of unstable subsynchronous modes of oscillations at specified operating point are:

(i) SVC with voltage control.
(ii) SVC with auxiliary control.
(iii) SVC with voltage and auxiliary control.

Auxiliary controls considered are Proportional control, Proportional control with filter, Proportional Derivative control with filter and Proportional Integral and Derivative control with filter.
It is observed that SVC with voltage and auxiliary controls, auxiliary control is of PID type with filter provides good damping to all unstable subsynchronous modes of oscillations compared to other cases of reactive power control strategies.

The coordinated control of PSS and SVC to damp the unstable subsynchronous modes of oscillations is studied. It is observed that among the different control strategies considered, the coordinated control of PSS and SVC strategy provides better damping to unstable subsynchronous modes of oscillations.