ABSTRACT

Variable impedance devices using power electronic technology, such as Static VAR Compensators (SVCs) Thyristor-Controlled Series Capacitors (TCSC) and Unified Power Flow Controller (UPFC) have the potential to increase power control and system damping [1, 2]. The allocation of these devices to get the most effective stabilisation of system modes is a complex problem that requires consideration of many factors. Major design considerations include the identification of busbars and branches in which to locate the system controllers and the choice of suitable feedback signals to be used as input to a stabilising control function [3-6]. Several analytical criteria for placement of damping controllers have been proposed in the literature. Specifically, modal analysis techniques based on the calculation of participation factors, transfer function residues and controllability and observability indices have been used to identify optimal locations for SVCs, TCSC, UPFC and power system stabilisers [2, 7-11]. The computation of controllability and observability measures is of particular interest as it provides valuable information about system dynamic characteristics and the ability of system controllers to enhance damping. This work presents an efficient analysis and design method to place variable impedance devices for enhancement of small signal stability in complex power systems. Controllability is first explored to allocate damping controllers in those busbars and system branches in which they are more effective to enhance damping of a given subset of critical oscillation modes. Observability indices are, in turn, taken to assess supplementary signals that are to be used in a given controller and which are required to "show" the oscillation mode. In this approach, the computation of controllability and observability is based on a measure of the distance of a state representation from the nearest uncontrollable system [12, 13]. This method is numerically stable and can be used to assess the numerical rank and other properties of state models. The study of inter-area oscillations and placement of controllers is done using modal analysis of a linearised model of the power system that includes a detailed representation of variable impedance controllers. The devices presently considered in this research include SVC, TCSC and UPFC. A reduced order equivalent of the interconnected New England test system (NETS) and New York power system (NYPS) is used to illustrate the proposed algorithms.