ABSTRACT

The focus of this thesis is the second-generation Flexible AC Transmission System (FACTS) devices, generally, the integrated power flow controllers. The most prominent of these controllers, namely, the Unified Power Flow Controller (UPFC) and the Interline Power flow Controller (IPFC) are selected for analyzing their performances. The major advantage of these devices is their operational degrees of freedom. These devices can control the real and reactive power flows in a transmission system along with regulating the voltage at the point where they are connected. This enhancement in power flow and voltage regulation coupled with the improved stability, results in a tremendous impact on the quality of the transmission system. These features become even more significant knowing that these integrated power flow controllers permit the loading of the transmission lines up to their thermal limits, imposing the power to flow through the desired paths. This results in the flexibility much needed by the power system operators to satisfy the demands that the deregulated power system will enforce.

The most cost-effective way to evaluate the effect of the integrated power flow controllers on a typical power system operation is to simulate that power system together with the UPFC/IPFC using one of the available simulations packages. Specifically, the objectives of this thesis are to (i) develop UPFC and IPFC models that can be incorporated into existing MATLAB® based Power System Toolbox (PST), (ii) design different controllers to control the performance of these integrated power flow controllers, and (iii) analyze their performances by simulating them in MATLAB® environment for steady state and transient operations. The proposed controllers are tested on the multi machine system to prove their effectiveness in controlling the power system performance.

The studies of FACTS devices are usually based on two approaches. In the first approach, a set of linearized equations using fundamental frequency model represents each converter of the FACTS device. Here, neglecting the harmonics, each converter is modelled as controllable voltage or current source to operate at the fundamental system frequency (50Hz). This approach is useful for steady-state or power flow studies. In the second approach, six-pulse, pulse width modulated converters, switched at frequencies relatively higher than the system frequency are used to approximate converter modulation techniques and harmonic content. The control system for the converter plays a vital role in the operational modes of these multi converter FACTS devices. Exhaustive studies are carried out in the operation and control of FACTS controllers using PQ controller. Studies on the performance of these FACTS controllers with other control techniques are very limited in the literature. In this thesis, the two main integrated power flow controllers, namely, Unified Power Flow Controller (UPFC) and the Interline Power Flow Controller (IPFC) are studied for their behavior, when their control circuits are modified with different techniques like series compensation method, phase angle shifter method and transformer like ratio control method apart from the generally used PQ control method. The voltage regulation, the real and reactive power flows are compared for individual controls and then under the action of all controls together. The performances of UPFC and IPFC are compared for each control and it is found that PQ control for UPFC works well whereas the IPFC works better with series compensation method. All these analyses are done with the SIMULINK models of 5-bus and 9-bus power networks. To study the usefulness of the integrated power flow controllers in improving the transient stability, a three-phase fault is applied to the 5-bus system terminals at t=1second and cleared after 1.345 seconds. The rotor angle deviation and the electrical power swings are studied with and without the introduction of the integrated power flow controllers.