ABSTRACT

In this thesis, the reactive power management problem in power systems, both vertically integrated utility and deregulated power system, is investigated. In vertically integrated utility, the reactive power management comprises the reactive power planning and the reactive power scheduling problems. Each of these two problems is formulated as a Security and Voltage Stability Constrained Optimal Power Flow (SVSCOPF) problem which is Non Linear Programming (NLP) problem. It is a preventive mode security constrained optimization problem which consists of determining the best values of control variables to be set in the base case state to minimize an objective function and to satisfy the bus voltage magnitude and MVA line flow operating constraints in the base case state, in the post contingency states and in the stressed base case state which is introduced to enforce a prescribed Voltage Performance Stability Margin (VPSM). An algorithm is proposed which transforms the NLP problem into a sequence of Linear Programming (LP) problems using linearized models and solves it using Sequential Linear Programming (SLP) technique.

In the planning problem, a projected state is taken as the base case state, the control variables chosen are the quantum of capacitors to be installed at the prospective buses and the objective function is the total quantum of capacitors to be installed. In the hourly scheduling problem, the operating state is taken as the base case state, the control variables chosen are voltage settings of generators, tap settings of On load Tap Changers (OLTC’s)
and the bus injected reactive power of switchable capacitors, and the objective function chosen is the transmission loss. The effectiveness of the proposed algorithms for both the planning and scheduling problem has been tested using a 6 Bus Ward and Hale System and an 119 Bus Indian Utility System.

In deregulated power system, the Independent System Operator’s (ISO) problem of providing ancillary service of reactive power support (both delivery of reactive power demand and voltage support to consumers in a pool cum bilateral market is treated as a proper sequence of optimization problems so as to result in economic procurement of this reactive power support and fair (transparent and equitable) allocation of these charges to the participants. The following sequence is used.

The first Optimal Power Flow (OPF) problem which is a preliminary step to reactive power support service problem, comprises determining the set of “feasible” primary transactions from the “desirable” transactions using congestion management, assuming zero reactive power demands. The congestion management problem comprising congestion relief and congestion charges allocation is formulated as an Linear Programming (LP) optimization problem which minimizes congestion relief charges arising from willing relief providers and satisfy the MW line flow constraints. This Linear Programming LP problem uses sensitivity factors derived from DC load flow and is solved using interior point algorithm. The second OPF problem determines the least cost supply of reactive power support required for the “feasible” primary transactions assuming zero reactive power demand and allocating these charges equitably to the respective transactions. The third
OPF problem determines the least cost supply of reactive power support required for both the “feasible” transactions and reactive power demand of Distribution Companies (DISCOS). The difference between the charges for reactive power support obtained from the third OPF problem and the second OPF problem is allocated equitably to the various DISCOS. The second and third OPF problems are formulated as NLP problems of minimizing the reactive power support charges satisfying the bus voltage constraints and MVA line flow constraints pertaining to the respective base case operating state and solved through SLP technique. The effectiveness of the proposed algorithm for congestion management as well as economic supply of reactive power support and equitable allocation of reactive power charges to the transactions and DISCOS has been tested using a Modified IEEE 24 Bus Reliability Test System.