ABSTRACT

Modern power system experiences a significant change in operating behavior due to the integration of renewable energy sources and dynamic loads. The complexity and uncertainties in load/generation data are increasing day by day. The research work presented in this thesis discusses various complex issues in stability and control of modern power system. In this respect, there is a need for significant revision in the existing methods. This work primarily aims to develop new efficient approaches to serve this need. One of the important contributions of this thesis is the analytical method for Hopf Bifurcation (HB) analysis to accommodate the various non-statistical system uncertainties. Boundary power flow and eigenvalue sensitivity have been used in the proposed method. This method helps to identify worst-case scenarios before it is going to happen. This information is very important for the system operator to take the right decision for secure operation of the system.

Another important challenge in the area of the oscillatory stability has been the issue of efficient and optimal utilization of controllers in a multimachine power system for enhancement of HB limit. The problem of the optimal setting of these parameters is more prone to the stressed and uncertain power system. This thesis, thus, presents a new approach for utilizing control capability of the power system for enhancement of HB limits/dynamic loadability by rescheduling the setting of control parameters such as transformer taps, and generators’ terminal voltage in stability analysis. Oscillatory stability evaluation of power system in the presence of uncertainties in forecasted data, which is very common in modern power systems, is very complex. Most of the available methods are based on statistical data, which are computationally less efficient for such applications. In this thesis, a non-statistical uncertainty-based control rescheduling strategy is proposed to postpone the bifurcation points and hence, enhance the dynamic loadability of the system.

Large power systems are subjected to low-frequency oscillations that may affect the stability of the system as well as generator performance. Power System Stabilizers (PSS) are frequently used to damp oscillations. However, stability characteristics of the system are highly depended on PSS parameter. Effective tuning of the PSS is a big concern in the large
and complex power system, especially in the presence of system/operational uncertainties. The problem of selecting design parameters of the PSS is formulated as an optimization problem with minimization of eigenvalues and damping ratios based multi-objective function that alleviates the poorly damped or unstable oscillatory modes of the power system in order to meet the guaranteed stability. Grey Wolf Optimization (GWO) algorithm is proposed to solve this optimization problem. The performance of the proposed GWO based Power System Stabilizer (GWOPSS) has been compared with Improved Harmony Search algorithm-based PSS (IHSPSS) and Genetic Algorithm based PSS (GAPSS) under wide range operating conditions. Sometimes these control setting are unable to support even very small disturbances which may be in the system because modern power systems are forced to run with very small stability margin. In this dissertation, a PSS design approach, which aims at enhancing the oscillatory stability of the multi-machine power system over the specified uncertainty range in forecasted load/generation is also presented.

The structure of power system is changing due to the integration of renewable-based DGs and power electronic based loads. The future power system is looking towards the DC network which enables the easy way to integrate the power electronic based loads, electrical vehicle charging stations and renewable generation. DC transmission is also allowed to transmit more power without violation of its limits. However, for analysis and assessment of DC power system, an effective method/tool is very important. In this thesis, modeling of modern lossless converters in DC system is proposed and formulation of modified continuation power flow (CPF) method for DC microgrid system is also carried out. This formulation is very helpful for analysis, operation, and planning of future DC microgrid system.