ABSTRACT

Analysis of power system blackout shows that the root cause of such events is the lack of situational awareness at the control center. In order to prevent blackout, development of advanced technologies for improvement of system monitoring, protection and control are essential. In the context of smart grid, wide area measurement system (WAMS) is able to provide a complete scan of power system at every power cycle using synchronized data obtained through phasor measurement units (PMUs). Thus WAMS provides a platform to enhance the performance for overall system monitoring, control, operation and protection using the synchrophasor measurements through PMUs. Use of PMU measurements for different power system applications is a new development. In order to apply synchrophasor measurements in an optimal manner, suitable techniques are required to be developed for power system.

This thesis focuses on the development of new application tools for power system utilizing synchronized phasor measurements. Three key applications developed in this work are (i) optimal PMU placement for power system observability, (ii) identification of faulty transmission lines for enhancing protection decision and (iii) online dynamic security assessment of power system.

In the thesis, two new optimal PMU placement methods are proposed for complete observability of power systems. These methods achieve complete topological observability with minimum number of PMUs. Proposed methods are based on heuristics and are developed using network configuration and bus connectivity information. Due to high cost involved, it is difficult for utilities to deploy the full set of optimal PMUs at a time, required for complete observability of the system. Many utilities prefer to install PMUs in different stages over a time period. A new multistage PMU placement method is proposed for improvement of power system state estimation. An index for measurement of degree of unobservability called ‘tier’ (location of unobservable bus from nearest observable bus) is proposed for installation of PMUs in the intermediated stages.

An integer linear programming based optimal PMU placement method is proposed for fault location observability of transmission lines. The proposed method successfully overcomes the limitations of zero injection bus modeling of the earlier attempts for finding optimal solution. With this optimal PMU placement set, a fault detection algorithm is also proposed in this thesis to locate the faulted transmission line using superimposed bus voltage and branch currents.

Methods for online dynamic security assessment of power system using synchrophasor measurement are proposed in this thesis. Pattern recognition is used for finding critical clearing time for a new operating condition (obtained by state estimation using PMU measurements) from knowledge base. One new system severity index based on the angle of generator bus voltage is developed. This index predicts system instability in real-time when a contingency occurs in the system. Simulation results for a number of standard IEEE test systems are presented to validate the effectiveness of the proposed methods.

Keywords: WAMS, Phasor measurement unit, observability, optimal placement, heuristics, network connectivity, multistage PMU installation, tier, observability index, state estimation, fault location, transmission line, superimposed voltage, dynamic security, prediction, severity index.