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Title of Thesis: Transmission Management in Deregulated Power System

Abstract

Deregulation of all commodities around the world has put onus on the power system operators to restructure the monopolistic structure and introduce competition in this sector. This is further being pushed by the advocators of open access market and supported financially by the World Bank. This has resulted in the development of oligopolistic energy market with three basic structures e.g., generation companies (GENCOs), transmission companies (TRANCOs) and distribution companies (DISCOs). Generation sector has invited and attracted many investors to step small generation units of conventional or renewable energy sources that are competitive enough to take part and challenge the cost being offered by the traditional generating companies. The distribution sector or the retail sector purchases the power from the generation companies and supplies it to the customers making its own profit and is ultimately responsible for the customer satisfaction. For reaping the benefits of the economy of scale, transmission sector is placed under control of single entity, so it does not attract investors unlike the generation and distribution sector. Along with it, environmental and socio-economical conditions, right of way, etc. has further minimized the entry of private players in the transmission sector. With increasing energy demand, there is a need to make the optimum utilization of available transmission capacity and further enhance the loadability of already installed transmission infrastructure. So, FACTS devices are being installed at the transmission networks in order to improve the voltage profile and enhance the maximum loading limit of transmission network.

TCSC, STATCOM and UPFC have been used in present research work for congestion management, as congestion results in technical as well as economical difficulties. Market power which is present in imperfect competitive market is further being aided by the congestion as it may result in the inability of active participation by generators providing energy at minimum marginal cost. Many market players utilise this opportunity to increase their profit by selling the energy at larger rates for the sake of providing uninterrupted energy at the time of need. The research work highlights the capability of FACTS devices in

mitigation or reduction of the market power being exercised by certain players in order tomaintain prices profitably above competitive levels for a significant period of time.

Phasor Measurement Units (PMUs) are being installed in large numbers in modern power system as it provide time-stamped magnitude and phase angle of the voltages and currents in real time which is helpful in capturing the wide area snapshot of power system. Through PMU, real time behaviour and status of power system is known, and also sequence of event is recorded in case of any major fault or blackouts in power system. India has installed 62 PMUs in power systems and planned another 1700 PMUs by 2017, which will make it largest next only to China which has presently 2027 installed PMUs. Optimal placement of PMUs results in minimum number of PMUs required for observability of the whole power system.

In this thesis, wide area control of FACTS devices is suggested through a secondary controller that can handle real time data emanating from PDC (which collects data from different PMUs), and will feed triggering signal to FACTS controller for real time operation. Power system operates closer to its stability limit, resulting in poor stability of the system. If the load demand is increased beyond maximum power transfer capability or with the occurrence of even a smaller fault without timely remedial actions, voltages of the load side will become unstable and can even collapse. Voltage stability is an important factor for determining the ceiling of tolerable loading on transmission as well as distribution network. Voltage Stability Indicators (VSIs) based on power flow analysis were not suitable for online studies before the advent of synchronized phasor measurement units (PMUs) because these calculations were dependent on conventional state estimators taking minutes to update overall power flow of the system.

With the comprehensive deployment of PMUs in power systems, it is possible to get synchronized data of large power system within seconds. PMUs with reliable and high speed communications has made possible to build wide area monitoring systems (WAMS). With WAMS based synchrophasors data, there is a possibility of early detection and prevention of eminent system instabilities by identifying the weak buses or lines in the network. The VSI proposed in this thesis uses the PMU data viz. active and reactive power, voltage and phasor angles, resistance and reactance of distribution lines for finding the most critical bus in the connected WAMS network. It is proposed to not only monitor but compensate these weak buses for improving the voltage stability of these buses. For this purpose, distributed generator (DG) is placed on the most unstable bus found using the proposed VSI technique. The placement of DG on the weak bus results in reduction of power losses and improvement of voltage profile at the targeted buses in the network.