Frequency Regulation in Conventional, Deregulated and Wind Integrated Power Systems

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by

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Abstract

Electric power systems must be maintained at the desired operating level characterized by nominal frequency, voltage profile, and load flow configuration. For power balance, at every instant, the power generated should match with the total load demanded and associated system losses. However, the load-demands fluctuate randomly causing a mismatch in the power balance and, thereby, deviations in the area frequencies and tie-line powers from their respective scheduled values. In this context, Automatic Generation Control (AGC) aims to bring the back frequency error and tie-line power flow error to zero.

In this thesis, we focus on frequency regulation of interconnected power system in conventional and deregulated scenarios. A Thyristor Controlled Series Compensator (TCSC) model suitable for frequency regulation studies has been developed and is tested in conventional as well as deregulated scenarios. It is evident from the analysis that TCSC improves damping performances of the system in terms of better settling time, peak overshoot in area frequencies and tie-line power flow. In traditional power systems, the system inertia is responsible for maintaining the power balance immediately after the load disturbances. With increasing penetration of wind energy system, conventional power plants, which are the prime sources of system inertia, are getting replaced by wind energy systems. Hence, large frequency deviations can be viewed in high wind integrated systems. This thesis also focuses on extracting kinetic energy of the wind generator to make them behave as conventional generating systems in frequency regulation. The proposed hidden inertia emulation and coordinated operation of conventional power generation systems with wind energy can effectively alleviate the frequency excursions during sudden load disturbances. Conventional energy storage device such as Flywheel Energy Storage (FES) system can be used in conjunction with wind integrated power systems to overcome the intermittent nature of power generation. TCSC is found to be effective in damping low frequency oscillations in weak tie-lines and supplement the frequency regulation. The proposed scheme of wind energy system has also been analyzed in deregulated scenario.

New case of contract violation is considered when wind power plant deviates from their contract demand due to variation in the power generation from forecasted value.