Revamped utilisation of the existing power system to enhance their controllability is adequately addressed through installation and implementation of power electronics based equipment called as Flexible AC Transmission Systems (FACTS). In this thesis, a series connected FACTS device, Thyristor Controlled Series Capacitor (TCSC) is being considered and implemented suitably to improve the performance of power system models under study.

Among all the FACTS devices, TCSC is one of the most preferred series compensator and its ability to operate in variety of modes results in increased compensation, more power transfer and enhanced stability in an interconnected power network. In the present study an attempt has been made to explore the possible benefits of modern stochastic optimisation techniques for TCSC implementation considering two basic power system operational issues of secured optimal power flow (OPF) and stability enhancement. The work proposed in the thesis focuses on optimal location and parameter selection of TCSC for secured OPF solution and extending the approach to establish voltage stability also under variable loading conditions. Thus the work is to address the issue of a deregulated electricity markets where conventional OPF formulation are now being restructured to include additional constraints among which voltage stability constrained OPF is of paramount importance for reliable power system operation and control.

TCSC is also considered as the most prominent FACTS device suitable for transient stability enhancement which is considered one of the prime objectives in the thesis work. The work includes TCSC controller design for enhancing power system stability subjected to a disturbance and its inclusion in a linearized model. Further, the performance analysis is done considering individual and coordinated design of TCSC controller are Power System Stabilisers (PSS) for transient stability studies.

Numerous population based methods have been developed which are inspired by nature like Particle Swarm Optimisation, and some stochastic algorithm like Gravitational Search Algorithm (GSA) is based on Newton’s Law
of Gravity. The optimisation techniques employed for designing and placement of TCSC based controller includes Particle Swarm Optimisation (PSO), Gravitational Search Algorithm (GSA) and hybrid methods based on GSA like Fuzzy-GSA, Radial Basis Neural Network based GSA (RBFNN-GSA) and Improved GSA with Firefly Algorithm (IGSA-FA).

The work encompasses the possible benefits of TCSC implementation for achieving optimal power flow, retention of voltage stability during overloading and improved transient stability under the influence of large disturbances considering optimised TCSC parameters and its suitable placement. The results obtained for TCSC controller design, optimal placement and parameter optimisation addressing the above objectives envisage the effectiveness of proposed methods by generating superlative results.