CHAPTER-6

CONCLUSIONS AND
FUTURE SCOPE
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6.1 GENERAL CONCLUSIONS

The most challenging criteria for real time planning, operation and control of a modern deregulated power system which is significantly influenced by competitive electricity markets is redesigning traditional OPF to incorporate numerous constraints which dictates system security. Power system stability also has emerged as an important concern for secured operation and is influenced by numerous factors like complex interconnected power network, bulk power transfer through already stressed transmission lines, varying and new loading patterns, large penetration of renewable energy sources like wing generators etc. A comprehensive review of secured OPF solution, voltage stability coupled OPF solution and power system transient stability improvement with FACTS devices is presented. Different modern stochastic optimization techniques are implemented to achieve the objectives of the thesis work.

FACTS devices are considered as a huge breakthrough which have emerged as the most dominant and unexcelled equipment for deregulated power sector providing better utilization of existing infrastructure, increased controllability, enhanced adaptability, cost effective alternative to requirement of installation of new transmission lines owing to cascading load demand and above all rendering flexibility to power system operation.

The work presented in this thesis predominantly focuses on the application aspects of TCSC which is regarded as one of the most prominent and versatile series connected FACTS controller. The TCSC essentially consists of a capacitor shunted by a TCR with no interfacing equipment required for operation. Thus, TCSC is considered economically more viable as compared to other competing FACTS devices. The work encompasses two vital attributes of power system i.e. optimal power flow and power system stability which are considered as the fundamental
requirement for reliable power system operation and control. So, the work delivered in this thesis deals with evaluation and contribution of TCSC for secured optimal power flow solution and system stability improvement with respect to voltage stability and transient stability.

The inclusion of an optimal controller to enhance system performance is almost imperative in modern power sector however the controller must be resilient to loading variations, operate perfectly for wide range of system parameters and also be computationally viable. Numerous modern heuristic optimization techniques have been utilized to generate satisfactory results for OPF and in stability domain, however with increased complexities in power system proposing new computational techniques to improvise the existing solution and conditions is always recommended. In this respect, the work depicted in this thesis presents a systematic approach of designing and optimally tuning parameters of TCSC based controller for transient stability enhancement and parameter setting, optimal location and cost sizing of TCSC controller for secured OPF coupled with voltage stability. The population based search methods employed are PSO, GSA and novel approach of hybrid techniques based on GSA like Fuzzy-GSA, RBFNN-GSA and IGSA-FA algorithms.

So, in this thesis a sincere attempt has been made to provide secured and voltage stability based OPF solution and enhanced transient stability by inclusion of TCSC controller for providing better capability in solving multi objective optimization problem and identifying the gaps prevalent in classical approach. Extensive simulation studies are performed utilizing MATLAB/SIMULINK working platform to support the potency of the proposed techniques.

Remaining of the chapter is organized as follows: Section 6.2 summarizes the essential contribution of this thesis. The essence of outcomes as provided in each chapter is stated concisely and Section 6.3 highlights the scope for future research work in this domain.
6.2 CONTRIBUTION OF THESIS

The important and relevant findings of the research work undertaken are listed below:

- The thesis begins with an introduction to power system stability and optimal power flow concept which are two important aspects of power transmission system and is one of the most extensive research areas in the field of power system. It also presents an insight to FACTS devices which have opened a completely flexible and innovative approach of controlling and improving power system operation. So, the motivation for research work, thesis objectives and thesis basic outline is presented in this chapter.

- Chapter 2 provides an extensive literature survey about the FACTS technology and its implementation in enhancing power system stability and providing improved OPF solution under varying system conditions. TCSC is considered as the chosen FACTS device for the work presented in this thesis and hence the literature review is presented considering the application potential of FACTS controller in general and TCSC in particular. It highlights the significant contributions achieved and various computational techniques implemented to improve power system performance considering OPF and stability as pivotal areas of research.

- In Chapter 3, new hybrid optimization techniques based on GSA is implemented for providing optimal location and parameter setting of TCSC controller for secured OPF solution. The robustness of the proposed techniques is validated on three IEEE standard test systems where the simulation results are obtained considering base loading and contingency case of overloading conditions. The statistical analysis performed justifies the superiority of the proposed methods as compared to that existing in literature. The hybrid methods of Fuzzy-GSA and RBFNN-GSA exploit the merits of traditional GSA approach and at the same time generate better result in terms of computational efficiency and simulation outputs for given objectives.
In Chapter 4, the secured OPF problem is modified to include additional constraint for voltage stability both for uncompensated (without TCSC controller) and compensated system (with TCSC controller). The computational method used is IGSA-FA to attain the objectives and the results are validated and compared with the other existing methods. As evident from literature survey, very few works are done in secured OPF formulation using the above technique and hence it is a novel approach which provides the desired result for secured OPF coupled with voltage stability.

In Chapter 5, TCSC controller design is considered with respect to power system transient stability in a SMIB system. The modified Philips Heffron model is simulated considering three cases of TCSC, PSS and coordinated design of TCSC and PSS controller respectively. The parameter tuning is done using PSO algorithm and the work is further extended to multi machine test system to study the impact of TCSC damping controller in improving system transient stability.

6.3 SCOPE FOR FUTURE WORK

The operational aspects of a restructured power sector postulates demanding complications where in research and development constitutes an evolving process. So, for any research work performed, there always exist a possibility for paving the way for more avenues and future growth. With respect to investigations performed in the area of secured and voltage stability based OPF and transient stability performance with inclusion of TCSC controller the following aspects are identified as future scope of research which can be performed in these domains.

- Development of new OPF model which accentuates on accuracy and robustness keeping in view the competitive electricity market applications.

- Secured OPF is considered with constraints of active and reactive power, voltage limits with index of optimal TCSC placement. The work can be further extended by considering more constraints.
The work can also be reformulated considering other advanced and hybrid optimization techniques to achieve reduced power loss and reduced generation cost.

The problem formulation can be revisited to incorporate the location aspect of TCSC controller for congestion management in a deregulated electricity market for superior utilization of grid infrastructure.

The work can also be reconsidered with integration of other FACTS device like Unified Power Flow Controller, Static Synchronous Series Compensator and compare their performance with TCSC controller.

The multi machine system investigated for transient stability studies is a three machine test system however the work can be extended to a larger system and torsional oscillation damping aspect may be studied.