Chapter-7
Conclusions and Future Scope

7.1 CONCLUSIONS

This thesis focuses on the static voltage security of a power system using FACTs devices. Different voltage stability and security criteria have been developed and simulations have been performed on typical longitudinal as well as robust power systems. The main conclusions of this research are as follows:

The static voltage stability aspects being reviewed in the arena of related stability & security indicator, the introductory part of the thesis includes a brief overview of theoretical aspects of load flow and important facts devices covering the text of chapter-1, 2, 3. The texts highlighted the appropriate models of three important facts devices (the SVC, the STATCOM & the TCSC ) which have been included in the load flow study. Chapter-3 has also been dedicated for problem formulation too.

From the simulations and observations of Chapter- 4, it can be concluded that overall system voltage security can be assessed using network equivalent of multi-bus power system. The series equivalent network of a multi-bus power system provides overall system voltage security as a whole and thus it has a high potential in planning and monitoring of power networks. Thevenin’s equivalent network also provides the voltage security status with respect to a particular load bus. The efficacies of STATCOM and SVC in improvement of voltage security of multi-bus power network have been compared and it has been observed that both of them are capable to enhance voltage security even at line contingency. STATCOM has been found to perform better to enhance system voltage security even at contingent state of power transmission lines.

This chapter also presents the efficacy of network equivalent to assess system global voltage stability of any interconnected power system at any operating point. Although both voltage stability indicators namely L-index and LVSI are also very useful for fast assessment of voltage stability, the advantage of network equivalencing technique is that it does not need rigorous load flow computation every time. The
total system generation, load and transmission line loss data, available from load centre, are sufficient for calculation of GVSI to get an overview of system voltage stability. Develop concept has been simulated in a 203 bus WBSEB system. The WBSEB system has 24 generators, 35 three-winding transformers, 37 two winding transformers and 108 load buses which are interconnected by 267 transmission lines. Installation of STATCOM at the weakest (bus no. 172) has been found more useful to arrest voltage collapse as compared to TCSC installation at critical transmission lines (line no 12 & 13). It can be inferred that proposed GVSI will alert the system operator about risk of possible voltage collapse at the early stage of voltage decline and therefore it will help to restore system stability adopting suitable corrective measures.

In chapter- 5, network equivalent of multi-bus power system has been found to be very helpful for direct assessment of voltage stability and security. Direct System voltage stability Index (DSVSI) and Fast System Voltage Security Index (FSVSI) provide the overall system voltage stability status at a glance. System transmission quality factor (STQF) indicates system power transmission quality. From equation (5.23) it is clear that as the power demand increases STQF approaches 1 as there will be no possible value of $\delta$ in equivalent network for safe power transmission. Actually STQF reflects total transmission quality of the interconnected power system.

A computer software in Matlab has been developed to simulate the proposed concept. The software has been tested on 203 bus WBSEB system & system operating status has been changed by increasing complex load at weakest bus keeping power factor constant. The magnitude of MDVC found to be threatening with increase in load. Deterioration in GVCC is observed with increase in load.

From simulation results, it can also be concluded that the developed equivalent two bus system may be applied to any multi-bus power network to assess the global voltage stability of the system in terms of MDVC and GVCC.

Application of STATCOM is found to be better to maintain voltage stability. Present study may be helpful to provide a quick overview regarding voltage stability
status of a multi-bus power network for on-line basis (as the proposed network equivalent can easily be derived from load centre database).

Chapter-6 deals with the load and loss allocation problem of any interconnected power system. In this chapter, an attempt has been made to minimize the transmission line loss using FACTS controllers. Two most commonly used FACTS controllers; TCSC and STATCOM are employed here to observe the effect of FACTS device in reducing the loss of the lines and to relieve the reactive burden in the generators. The contribution of system generators at a particular operating load has been calculated using power tracing algorithm and STATCOM is found to be most effective in order to reduce system generation as well as line loss. The analysis has been presented here using a robust practical 203-bus (Indian Eastern Grid) system.

7.2 MAIN CONTRIBUTIONS OF THE RESEARCH WORK

The main contributions of the research are summarized as follows:

- Development of the load flow software tool by adopting the Newton-Raphson Load Flow Method for the calculations of the system parameters for different operating conditions to study static voltage stability and security of power systems.
- Incorporation of the three important FACTS controllers, SVC, STATCOM and TCSC (separately) into the load flow formulation to study their impact on the voltage stability and security of the systems.
- Assessment of global voltage stability and security using the two-bus series equivalent model derived from the actual multi-bus power system.
- Study of impact of the FACTS controllers on local as well as global voltage stability of the power system.
- Study of impact of the FACTS controllers to in the context of active and reactive power tracing.
7.3 FUTURE SCOPE

Based upon the results and discussions of the research work reported in this thesis, the possible directions for the future work are the following:

- The present work can be extended towards applying the series network equivalent in real-time assessment and control of voltage stability in power systems.
- The present work may be applied to find suitable strategy for load shedding based on the voltage stability criterion.
- The power tracing method may be improved to include reactive loss minimization using facts devices.
- Other FACTS controllers like UPFC, UPQC, IPFC can also be modelled and their performance can also be explored in improvement of voltage stability of power system.