Chapter 7

1. Concluding remarks and recommendations

7.1 Analysis and results

i. Step size of the BSC bank is so small to effect the voltage variation in the 33kv bus. For, eg. normally the voltage rise of the 33kV bus when 5MVAr bank switching is about half the step size voltage of the OLTC with two transformers are in parallel

ii. Therefore coordination of these two existing controllers is difficult with their present parameters. Occasions where the capacitor banks are switched ON and OFF manually by over-riding the auto controller was frequently observed.

iii. Simulations models prove that unnecessary tap changing operations of the substation transformer occurred. The switching of the BSC bank in and out, and OLTC operation with feeder tripping has to be take in to account because this will reduced the life time of the switching device. The results and analysis reveals that it is possible to achieve the purpose of optimising the OLTC and BSC bank with modifications to the existing control system [6].

iv. Simulation shows that the maximum voltage rising under different capacitor bank combinations (with effective Tap control) are 77.67kV, 77.89kV & 77.27kV respectively. The maximum percentage rise for high voltage side is 0.43% and that for low voltage side is 1.15%.

v. The response time of transformer AVR and BSC bank controller are very slow compared to SVC or TCR. [5] Therefore risk of overvoltage during sudden load rejection may affect the equipment life time. We cannot increase the integration time or error threshold of the two controllers as required by the study to coordinate the controllers.

vi. Simulation results indicate that the High Voltage side voltage measurement needed for the coordination of the two controlling system. This new parameter check the system Q-V variation to implement the capacitor banks switching which is well coordinated with the downstream OLTC operation which try to maintain the constant voltage at 33kV bus [1].

vii. Downstream voltage (33kV) variation with added reactive power can be handled by the transformer AVR and tap changer controls so that any combination of banks is feasible to connect or disconnect.

viii. The OLTC is capable enough to divert leading reactive power to upstream of the network without violating current carrying capacity of the OLTC.

ix. Power factor based controlling is a very much economical method of capacitor bank controlling compared with other methods. One of the main problem a utility may face is that, some times especially in light load conditions with long transmission lines (Galle GSS is currently facing), there may be a necessity of some lagging reactive power has to be injected to reduce the Ferranti effects.

x. CEB faced real challenge maintaining voltage stability at the 132kV bus which far away from the generation. This happened most of the utilities in the world because production of the electricity was concentrated in one placed due to resource availability. In such a case, voltage control based capacitor switching will be a good solution.

7.2 Conclusion

Considering all these factors discussed so far, followings are the conclusions from this research study.

i. Existing control philosophy does not give maximum benefits to the CEB transmission network. Two schemes neither maximizes nor optimises the utilization of the BSC and the tap operation.

ii. From the simulation the var consumption of the transformer is much high compared to delivering to the 33kV system when increasing tap operation to make the voltage constant. For example the transformer consumes 1.102MVAR vars when increasing tap from 8 to 12 for maintaining constant voltage at 33kV bus only delivering 1.479MVAR vars to the loads at 33kV.

iii. Switching in of the BSC bank on the 33kV bus has increased only half of the tap step size of the voltage. Simulation result shows that ; it is technically possible to utilize the full installed capacities in all substations without violating the technical standards.

iv. The study reveals that it is possible to consider the controllers with multi-parameter or boolean switching options. Reactive power and voltage can be the parameters to be considered in the switching decisions.

v. The study will allow for controlled switching at a location within the "load" network that is physically outside of the power distribution substation. That is, the switched reactances can be at other buses which are electrically connected through low side system impedances (lines, cables, etc.) to the OLTC transformer. This switching of remotely located reactive elements will require communication circuitry of the variety readily available through normal SCADA (system control and data acquisition) systems.

7.3 Recommendations for future studies

1. Specially the most of the future substations were unmanned and automated one can look for the possibility of integrating this system for distribution management system (DSM) to minimise losses and optimise voltage and var flow through transmission and distribution network.

2. Suitable architecture for hardware and software should be decided and total variable and the calculation that has to be handled by the controller has to be studied. The

decision variables and command can be implemented on the controller (IED) or (PLC) as studied by this research [10].

3. Further studied can be done including embedded generation which play more vital role in future (say it is planned to add 20% renewable energy by year 2020 to minimise the GHG emission) generation as renewable energy to the 33kV bus of the GSS [6].

4 The study also includes a method for regulating shunt reactance-switching in a power transmission system providing a plurality of distribution voltages including a first voltage and a second voltage for supplying power to a load including the steps of

(1) Measuring the first voltage and reactive power flowing towards the load, and

(2).Switching at least one shunt reactance to maintain the second voltage substantially constant based on the measurements made in step (1) and predetermined ranges for the first voltage and reactive power.

5. This study can be extended to investigate performance of the slow voltage collapse phenomena in the HV side because the existing system further deteriorate the voltage collapse by doing tap operations [1]