CHAPTER ONE

Introduction

1-1: Background

During last decade electrical companies challenged to meet the dramatically increase on load demand. This result in increase the generation and expansion of transmission facility to meet the increasing demand.

For generation, transmission, distribution and utilization of electrical energy, three phase AC systems are used universally. It is beneficial to use AC system because of its features like reduction of electrical losses, increasing transmission efficiency and capacity, better voltage regulation, reduction in conducting material, flexibility for growth and possibility of interconnection [1].

Use of HVAC is economical until break-even point having distance around 800 km only, after this point HVAC become more expensive than HVDC. The corona effects tend to be highly significant for HVAC and the design of AC conductors based on the corona limitations gives a cross-section much larger than that with respect to economic power transfer limits. Also it needs heavy supportive structures that lead to erection difficulties. Stability of AC networks is very low due to the line inductive reactance. Voltage control is difficult for long line due to series inductance and capacitance and requires more complex circuits. Hence the reliability issue needs to be addressed seriously [1].

Power system engineers are currently facing challenges to increase the power transfer capabilities of existing transmission system. This is where the Flexible AC Transmission Systems (FACTS) technology comes into effect. With relatively low investment, compared to new transmission or generation facilities, the FACTS technology allows the industries to better utilize the existing transmission and generation reserves, while enhancing the power system performance. Moreover, the current trend of deregulated electricity market also favors the FACTS controllers in many ways. FACTS controllers in the deregulated electricity market allow the system to be used in more flexible way with increase in various stability margins. The FACTS controllers clearly enhance power system performance, improve quality of supply and also provide an optimal utilization of the existing resources [1].

In this thesis, they have various options to increase power transfer through transmission lines such as building an additional parallel transmission line which is not a cost effective option especially for long transmission lines, using a series or series-shunt compensated transmission lines which is a very cost effective option when compared with the former one [2].

1-2: Problem Statement

Atbara – Portsudan Transmission line is one of Sudan National Grid (also called NEC grid) problem that, is a single circuit transmission line with a length of 449 km, voltage level of 220kV, when loaded above (73% of SIL = 92.875 MW, pf = 1, V_{Atbara}=220kV), an under-voltage (below critical limit -5%) occurs at Portsudan 220kV bus-bar (associated with high MW losses) and this situation may lead transmission line to tripped by distance protection (V/I). Also when loaded by below (46% of SIL = 58 MW, pf = 1, V_{Atbara}=220kV) an over-voltage (above critical limit +5%) occurs at Portsudan 220kV bus-bar and this situation lead the isolate 220kV bus-bar from other connected equipment by over-voltage protection. This significantly affects the quality of power delivered, and continuity of supplied power.

1-3: Objectives

The main objectives of the thesis are:

- Study the behavior of NEC grid (especially portion of Atbara – Portsudan) at actual peak and off-peak load condition.
- Use of FACT devices (SVC and TCSC) to enhance transmission capability and voltage profile of Atbara–Portsudan transmission line.

- Re-configuration of existing transmission line (Atbara–Portsudan) to enhance transmission capability and voltage profile.

1-4: Methodology

In order to achieve thesis objectives the following tasks are used:

Task 1: study voltage profile of NEC grid at off-peak load September 13th 2016 (with concern on Atbara – Portsudan T.L. transmission loss and loading).

Task 2: study voltage profile of Sudan National Grid at peak load July 3rd 2016 (with concern on Atbara – Portsudan T.L. transmission loss and loading).

Task 3: Arranging all 220kV transmission line with respect to line reactance.

Task 4: Arranging all 220kV transmission line with respect to line loss at peak load July 3rd 2016.

Task 5: Arranging all 220kV transmission line according to Fast Voltage Stability Index (FVSI).

Task 6: Arranging all 220kV transmission line according to Line stability Index L_{mn}.

Task 7: Use of end-point shunt compensator (SVC) and study transmission capability and voltage profile.

Task 8: Uses of combination of series-shunt compensators (TCSC, SVC) to enhance transmission capability and voltage profile.

Task 9: Uses of mid-point compensation (SVC) in Sinkat to enhance transmission capability and voltage profile.

Task 10: Investigates the effect of adding a new generation unit at Portsudan on line losses and voltage profile.

1-5: Thesis Layout

This thesis consists of five chapters and organized as:

Chapter one: Brief highlight of thesis background, problem statements, objectives and methodology.

Chapter two: Fundamentals of power transmission and the challenge facing power system operators, benefit of grid interconnection, technical objectives, conductors, requirements for ac interconnection, transmission issues and power flow.

Chapter three: Summarized the different methods used to enhance transmission line performance including FACTS controller, modeling and operation of SVC, modeling and operation of TCSC.

Chapter four: Results and discussion of case study using different scenarios based on software simulation.

Chapter five: Conclusion and recommendations.