Incorporation of TCSC for Steady State Analysis

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Abstract— Due to modernization, increase in the population and change in the life style of the people leads to increase in the power demand, The lack of generation, old electrical infrastructure old controlling techniques leads to failure of grid system and also causes the more losses in the network and power quality related issues.The incorporation of fast operating power electronics devices gives acceptable solution to operate reliable and stable operation of the power systems. In this paper TCSC placement is used for voltage profile improvement with loss reduction in the network.The obtained results gives the satisfactory improvement in efficient operation of the power systems.

Index Terms— Thyristor controlled Series Compensator (TCSC), Minimization of Power Loss, Voltage profile, Optimal Placement, Fuzzy Logic, Load flow analysis, Voltage instability.

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1 Introduction

Modern electric power utilities are facing many challenges due to ever-increasing complexity in their operation and structure. In the recent past, one of the problems that got wide attention is the power system instabilities [1]-[3]. With the lack of new generation and transmission facilities and over exploitation of the existing facilities geared by increase in load demand; make these types of problems more imminent in modern power systems.

Instability in power system could be relieved or at least minimized with the help of most recent developed devices called Flexible AC Transmission Systems (FACTS) controllers [3], [4]. The use of Flexible AC Transmission System (FACTS) controllers in power transmission system have led to many applications of these controllers not only to improve the stability of the existing power network resources but also provide operating flexibility to the power system. In addition, with relatively low investment compared to new transmission or generation facilities, these FACTS technologies allow the industries to better utilize the existing transmission and generation reserves, while enhancing the power system performance. They clearly enhance power system performance, improve quality of supply and also provide an optimal utilization of the existing resources [5].

FACTS devices are defined by the IEEE working group as “alternating current transmission system incorporating power electronic-based and other static controllers to enhance controllability and increase power transfer capability” [6]. From the above definition, two main objectives of such devices can be restated as follows:

- To increase the power transfer capability of the transmission networks
- To provide direct control of power flow over designated transmission routes.

FACTS devices are a family of high-speed electronic devices, which can significantly increase the power system performance by delivering or absorbing real and/or reactive power. There are many types of FACTS controllers available in real power system and some are under research. Static Vary Compensator (SVC), Static Synchronous Compensator (STATCOM), Thyrister Controlled Series Capacitor (TCSC), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC) are popular FACTS devices. They can be connected to power system at any appropriate location, in series, in shunt or in a combination of series and shunt. The SVC and STATCOM are connected in shunt, whereas TCSC and SSSC are connected in series. UPFC is connected in a combination of both shunt and series.

- **Choice of FACTS Controllers**

For a large power system, a system planner has to judiciously choose appropriate FACTS controllers based on technical considerations and cost benefit analysis. The effectiveness of FACTS devices in improving the performance of a system depends on

1. The location of the device in the network.
2. The size of the devices.
3. The type of the device, i.e. shunt or series type.
4. The type of control strategy employed.

Generally, the location of a variable compensation device in a large system may be decided with regard to the following aspects:

1. To improve steady-state performance:
   (a) Voltage regulation.
   (b) Power flow control.
2. To improve dynamic performance:
   (a) Rotor induced stability.
   (b) Load-induced stability.

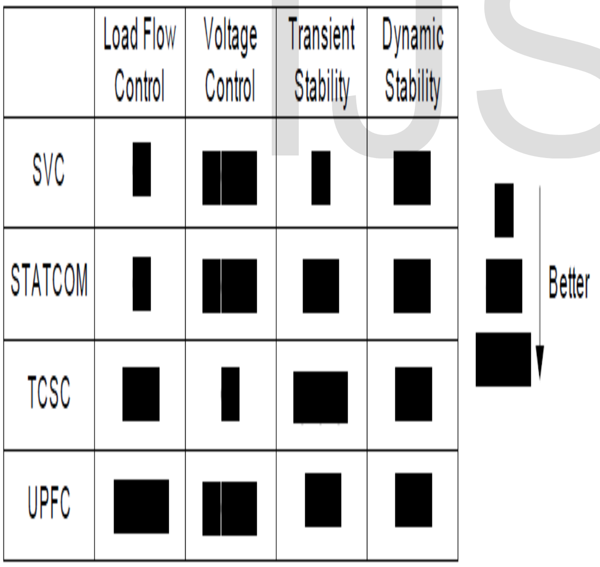
2. System Study with FACTS Devices

In order to study the influence of various FACTS controllers and their placement on the system performance, it is necessary to device methods to incorporate FACTS models in the conventional system analysis.

Researchers [3], [4], [5], [6] have demonstrated techniques to include FACTS models in the conventional power flow analysis to show the effect of the FACTS devices on steady-state performance (Voltage control and Power-flow control). Many linear analysis and simulation based techniques have been suggested to identify the candidate location of FACTS controllers to improve stability performance of a system. For example, the effectiveness of FACTS controllers to improve small-signal stability related behavior of a system, voltage stability-based identification of FACTS controllers' location is described in this project.

Based on their benefits, the required device will be identified to address the required problem. Table 1 gives the details of the technical benefits of few of the FACTS devices

TABLE 1
TECHNICAL BENEFITS OF FACTS DEVICES



2.1 Thyristor controlled Series Compensator

Thyristor Controlled Series Capacitor compensator consisting of the series compensating capacitor, whereto is parallel connected thyristors controlled reactor (TCR), and it is one of FACTS devices which are mainly used to control active power flow in power system and increase the transmission power lines capacity. TCSC is involved in a series to line (in terminal) and allows changing impedance of the transmission path and thus affecting the power flows. Control is fast, efficient and increased between the transmitted powers. Basic scheme of TCSC device is shown in the follows Fig.1

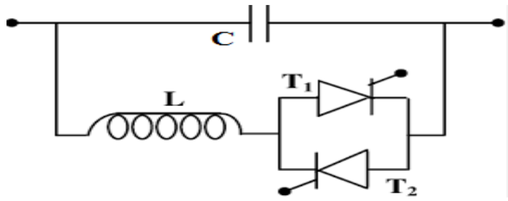


Fig.1 Basic diagram of TCSC

3. Methodology

The Five bus test system is considered for the TCSC placement is as shown in the Fig.2. The analysis is carried out in MiPower software. The five bus system consists of four loads connected at bus 2, 3, 4 and 5 with totoal load of 405MW and two generators are connected at bus 1 and bus 2. The seven transmission lines are used for interconnection of the network.Fig.2 shows the bus voltage at each bus without connecting TCSC.

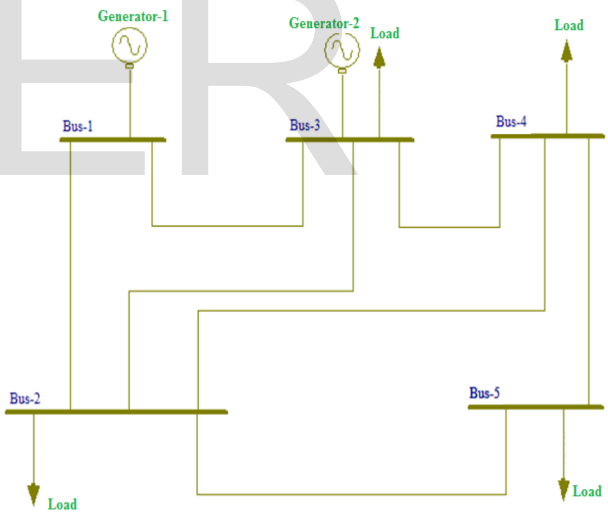


Fig.2 Single line diagram of 5 bus system

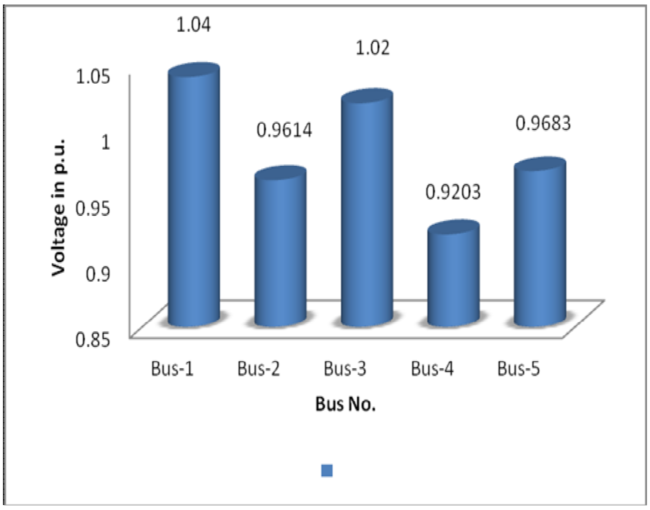


Fig.3. Basecase voltages in p.u

The TCSC placement is carried out by exhaustive load flow analysis using Newton Raphoson method. Each transmission line is taken as candidate line for TCSC placement. All the transmission lines are considered as candidate bus and each case the voltage profile and total transmission losses are computed is as shown in Table.2 and TCSC placement is as shown in Fig.4

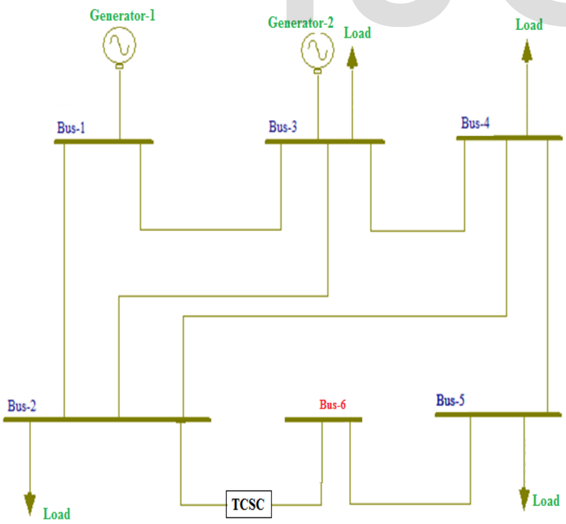


Fig.4 TCSC placement

TABLE.II VOLTAGE AND POWER LOSS COMPARISION WITH TCSC AND WITHOUT TCSC

	Base case	Line 1-2	Line 1-5	Line 3-2	Line 3-5	Line 3-4	Line 4-5
1	1.0400	1.0400	1.0400	1.0400	1.0400	1.0400	1.0400
2	0.9614	0.9663	0.9676	0.9636	0.9687	0.9686	0.9685
3	1.0200	1.0200	1.0200	1.0200	1.0200	1.0200	1.0200
4	0.9203	0.93	0.9253	0.9296	0.9294	0.9281	0.9278
5	0.9683	0.9835	0.9764	0.983	0.9827	0.9828	0.9835
Power Loss in MW	9.6741	5.5453	6.2148	5.9971	5.752	5.7866	5.8415

The optimal placement of TCSC will leads to 40% power loss reduction in the network. In five bus system the optimal location is line between bus 1 and 2. The power loss reduction came down from 9.674MW to 5.5453MW with acceptable good voltage profile is as shown in the Fig.5. The enhancement of voltage profile after connection TCSC is as shown in Fig.6.

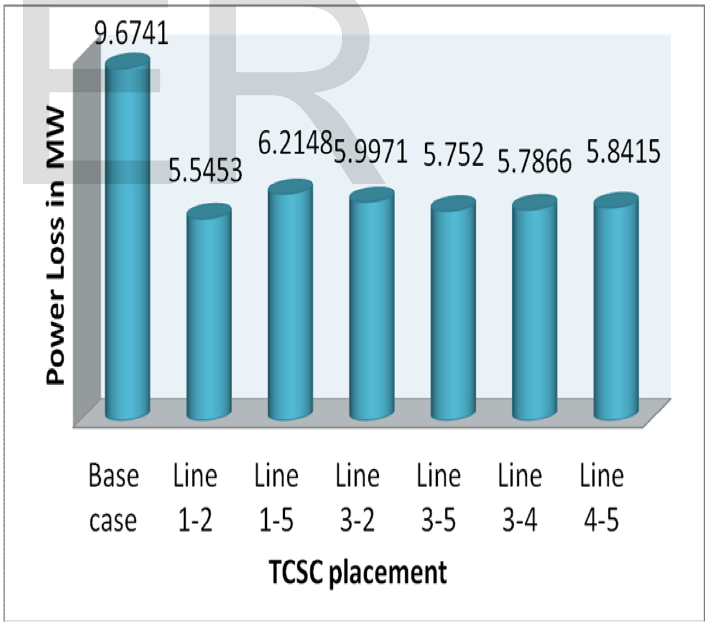


Fig.5 Power loss Comparision

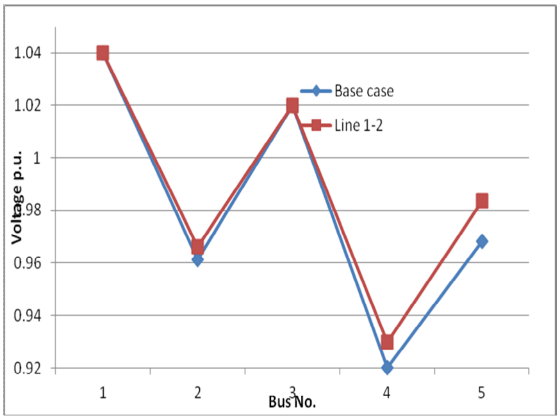


Fig.6 Voltage comparision with TCSC and without TCSC

4 Conclusion

The optimal location of TCSC is chosen for the minimization of losses and hence to improve the voltage profile of the system. Exhaustive load flow analysis is used to find optimal location of TCSC in five bus systemThe obtained results are shows the effectivesness of TCSC placement for the efficeient and stable operation of the power system.

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