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Enhancement of Active, Reactive power flow in the Deregulated Powersystem using TCSC

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Abstract— In a power systems,power flows from generating center's to the load centers.In this process many things require investigation,such as flow of Active power(MW) and Reactive power(MVAR) in transmission lines for different loading conditions. This paper presents a new method to Enhance Active,Reactive Power in a deregulated Powersystem.In deregulated electricity market transmission overloading occurs when there is insufficient transmission capcity to simultaneously accommodate all constraints for a transmission line.The Increased power demand has forced the power system to operate very closer to its stability limits.So Transmission Overloading,Voltage instability and power loss problems are arise in the power system. These are very serious problems which cause damage to the power system.The above mentioned problems are mitigated by incorporating Series Facts device in optimal location by Sensitivity analysis.The Simulation results were successfully tested on modified IEEE 14 bus system using MATLAB-SIMULINK .

Index Terms— Deregulated powersystem, Thyristor Controlled Series Capacitor (TCSC), Enhancement , Overloading, Total VAR Powerloss, Active ,Reactive power flow.

1 INTRODUCTION

In the recent year with the deregulation of the electricity market the traditional concepts and practice of the power system are changed.As power systems are becoming more complex it requires careful design of the new devices for the operation of controlling the power flow in transmission system,which should be flexible enough to adapt to any momentary system conditions.The operation of an ac power transmission line,is generally constrained by limitations of one or more network parameters and operating variables by using FACTS technology such as Thyristor Controlled Series Capacitor (TCSC) Active, Reactive power flow in the power system can be regulated.

Because of the Economic considerations, Instalation of facts Controllers in all the buses or lines is impossible and Unnecessary.There are Several methods for finding the optimal location of FACTS devices in a power system.In [1],sencitivity approach is used to find the optimal location for placement of TCSC[6].The reduction of total system reactive Power loss method is one used to find optimal loation for placement of series FACTS device. Power flow index is used to find optimal location of FACTS device mitigation of overloading.The method firstly put all the busses in the orderby voltage reactive power sensitivity then choose the optimal location and appropriate capability of Thyristor controlled series capacitor (TCSC).

The issue of transmission overloading is more pronounced in deregulated and competitive markets and needs a special treatment.In this environment, independent system operator(ISO) has to relieve the overloading,so that the system is maintained in secure state. To Enhance power flow ISO can use mainly two types of techniques which are as follows:

A. Cost free means : using sreies FACTS devices
B. Re-dispatching the generation amounts

Among the above two methods cost free means do have advantage such as not touching economical matters, So GENCO and DISCO will not involved. FACTS devices,especially series FACTS devices like TCSC are considered one such technology that reduced the transmission overloading,powerloss (active,reactive) and allows better utilization of existing grid infrastructure,along with many benfits.

2. Thyristor Controlled Series Capacitor(TCSC)

The basic Thyristor –Controlled Series Capacitor scheme, proposed in 1986 by Vithayathil is shown in figure 1. It consists of the series compensating capacitor shunted by a Thyristor-controlled Reactor. In a practical TCSC implementation, Several such basic compensators may be connected in series to obtain the desired voltage rating and operating characteristics.

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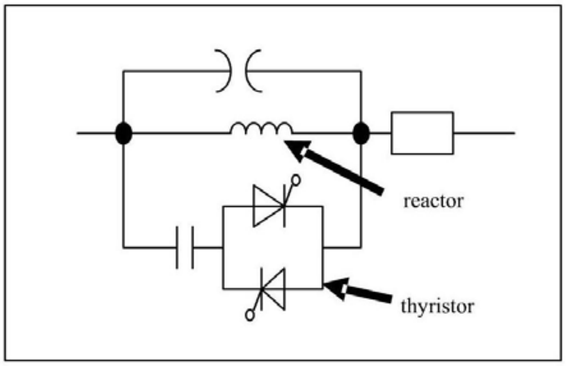
Fig 1. Equivalent circuit of TCSC



2.1 Transmission line modeling with TCSC

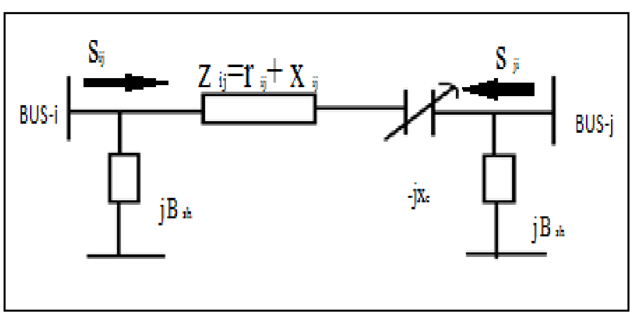
The series impedance of a high voltage transmission line is usually inductive,with only 5 to 10 percentage of resitance This provides convenient condtion to control the steady state impedance of transmission line by adding both a Thyrister Controlled Series Capacitor(TCSC) and a Thyristor Controlled Series Reactor

$$P^c_{ij} Q^c_{ij} P^c_{ji} Q^c_{ji} P_{ic} Q_{ic} P_{jc} Q_{jc}$$

Determined from [7] Method.

A General equivalent circuit of TCSC injected in transmission line is shown in fig2.

Fig 2. Injection Model of TCSC



3. DEVICE PLACEMENT USING LOSS SENSITIVITY INDEX METHOD

The objective of the device placement may be reduction in the real power loss of a particular line,reduction in the total system real power loss,reduction in the total reactive power loss and reduction in the overloading of the system.Loss sensitivity index is method based on the sensitivity of total system active and reactive power loss with respect to control variable of the FACT device.

The power loss sensitivity index with respect to this control variable can be formulated as

$$a_{ij} = \frac{\partial Q_L}{\partial X_{ij}} \text{ Loss sensitivity with respect to TCSC}$$

$$\frac{\partial Q_L}{\partial X_{ij}} = \left[v_i^2 + v_j^2 - 2 v_i v_j \cos(\delta_i - \delta_j)\right] \frac{R_{ij}^2 - X_{ij}^2}{\left(R_{ij}^2 + X_{ij}^2\right)^2}$$

$$Q_L = \sum_{i=1}^{n} \sum_{j=1}^{n} \left[\gamma_{ij}\left(P_i P_j + Q_i Q_j\right) + \in_{ij}\left(Q_j P_i - P_j Q_i\right)\right]$$

Where α, β, γ and $\in$ are loss coefficients computed from the elements of the bus impedance matrix and the bus voltage defined as :

$$\alpha_{ij} = \frac{\gamma_{ij}}{V_i V_j} \cos\left(\delta_i - \delta_j\right)$$

$$\beta_{ij} = \frac{\gamma_{ij}}{V_i V_j} \sin\left(\delta_i - \delta_j\right)$$

$$\gamma_{ij} = \frac{X_{ij}}{V_i V_j} \cos\left(\delta_i - \delta_j\right)$$

$$\in_{ij} = \frac{X_{ij}}{V_i V_j} \cos\left(\delta_i - \delta_j\right)$$

4. Criteria for Optimal placement for TCSC

The FACTS device should be placed on the most sensitivity bus or line. For the TCSC the location is the line with most positive sesetivity index. The TCSC should be placed on the line having most positive loss sensitivity index.

5.1 Simulation results for modified IEEE 14-bus system.

Test results are optained by considering practical IEEE 14 – bus system.OPF soluction is obtained on the system to determine the optimum genatation schedule than satisfied the objective of minimizing the losses from the desire transations and controling of voltage magnitude. Here the sensitive index for TCSC has been calculated for the placement of FACTS device. The FACTS device placement method known as sensitivity index has been tested on IEEE 14- bus system.

With out TCSC

14-bus system has 5 generators and eleven load buses.

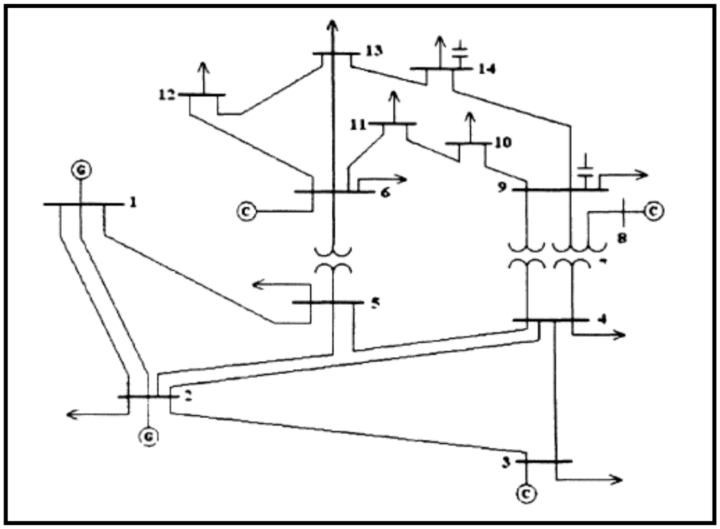


Figure3. Shows the single line diagram of IEEE 14-bus System

5.1 Simulation results on IEEE 14-bus system without TCSC

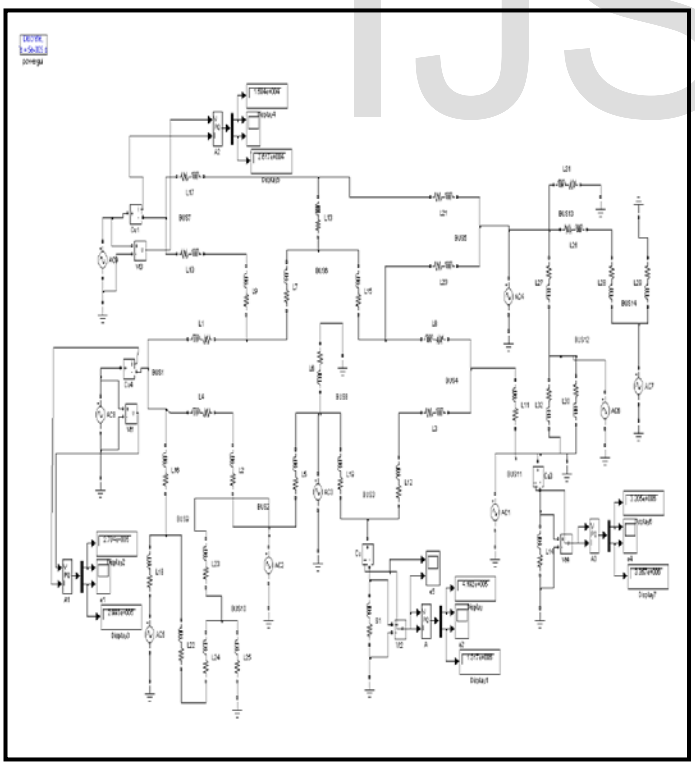
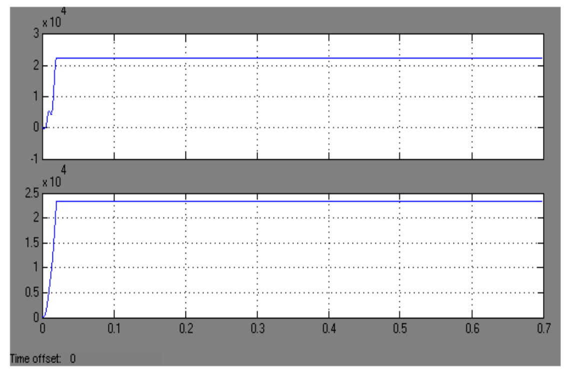


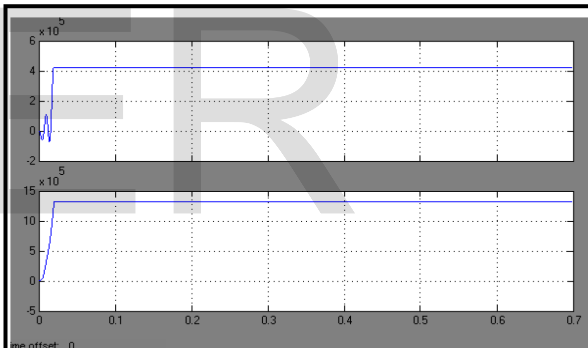
Figure4.Matlab simulink model for IEEE 14-bus line model

Test results are obtained by considering practical IEEE 14-bus system.Real and Reactive Power at each bus shown following graphs for without TCSC.

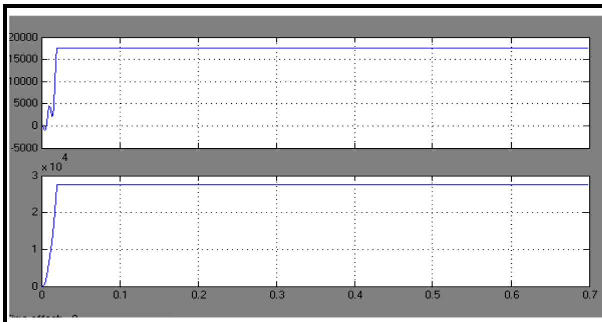
5.1.1Graphs for without incorporation of TCSC



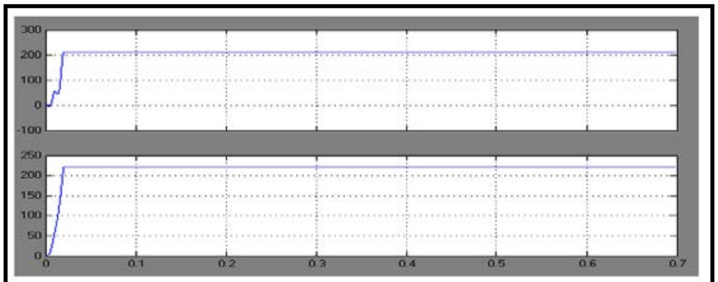
Bus1 real and reactive power



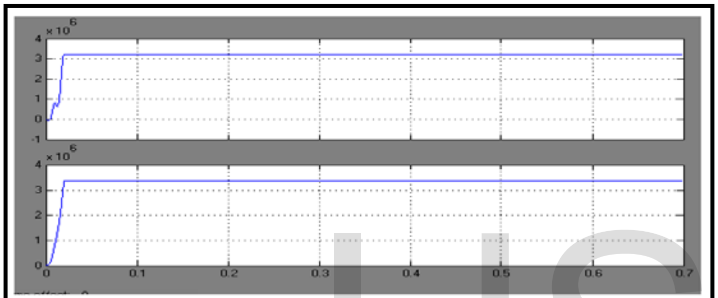
Bus 3 real and reactive power



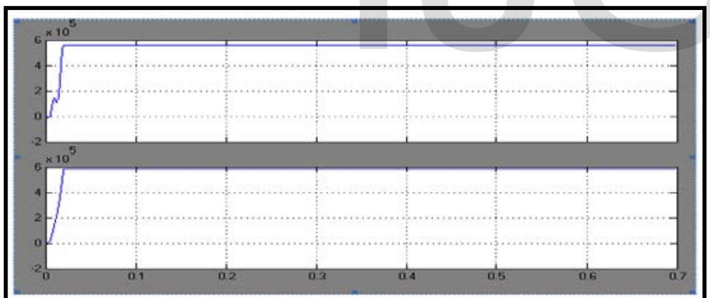
Bus4 real and reactive power



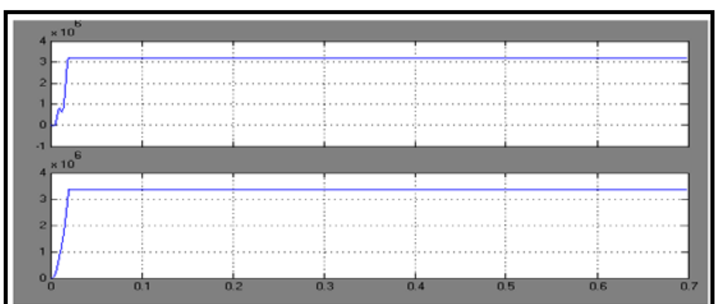
Bus 6 real and reactive power



Bus 8 real and reactive power



Bus 10 real and reactive power



Bus 14 real and reactive power

Above results repragents Real and Reactive power at various Buses.

Table:1 shows Real and Reactive power magnitudes for without FACTS controller [TCSC] .

Power flow profile of the system for each each bus is presented below.

BUS NO	REAL POWER (MW) WITHOUT controller	REACTIVE POWER (MVAR) WITHOUT CONTROLLER
BUS-1	0.022	0.023
BUS-2	0.556	0.582
BUS-3	0.419	0.433
BUS-4	0.017	0.027
BUS-5	0.024	0.025
BUS-6	0.021	0.022
BUS-7	0.019	0.020
BUS-8	3.206	3.357
BUS-9	0.022	0.023
BUS-10	0.556	0.558
BUS-11	3.205	3.356
BUS-12	3.202	3.342
BUS-13	3.210	3.362
BUS-14	3.223	3.372

Table:1Real and Reactive Power at each Bus With out TCSC

Lines	From bus	To bus	Sensitivity Index
1	1	2	**-1.0834**
2	1	5	-0.3068
3	2	3	-0.2935
4	2	4	-0.1725
5	2	5	-0.0943
6	3	4	-0.0225
7	4	5	-0.2611
8	4	7	-0.0595
9	4	9	-0.0188
10	5	6	-0.1297
11	6	11	-0.0054
12	6	12	-0.0035
13	6	13	-0.0171
14	7	8	-0.0135
15	7	9	-0.0729
16	9	10	-0.0015
17	9	14	-0.0059
18	10	11	-0.0008
19	12	13	**-0.0000**
20	13	14	-0.0020

Table:2 Sensitivity index values

From table:2, the line 1-5 has the most positive sensitivity fact or. So this is the best location for placement of Thyristor Controlled Switched Capacitor [TCSC] to relieve congestion in the network.By placing the TCSC in the line 1-5, the congestion in the network is relieved.

5.2 TCSC modeling Using Simulink

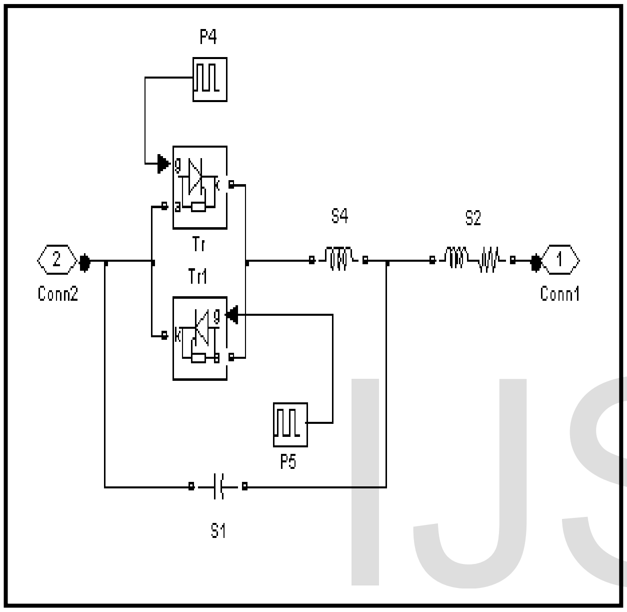


Figure:5 TCSC model

The complte system has been repragented in terms of Simulink blocks in a single integral model.

5.2 Simulation results on IEEE 14-bus system with TCSC

In this section IEEE 14 –buspractcal system has been presented to numerically demonstrate its performance.It has been used to show quantitatively, how the TSCS performs.The original network is modified to include the TCSC.This compensates the line between any of the buses.The TCSC is used to regulate the Active and Reactive power flowing in the line at a prespecified value.The MATLAB-SIMULINK model is used to find control settings of TCSC for the prespecified Real and Reactive power flow between any buses and the power flow between the lines are observed the effects of TCSC. The FACTS device placement method known as sensitivity index has been tested on IEEE 14- bus system. After incorparating TCSC the Active and Reactive Power flow can be improved which is shown in Table:3

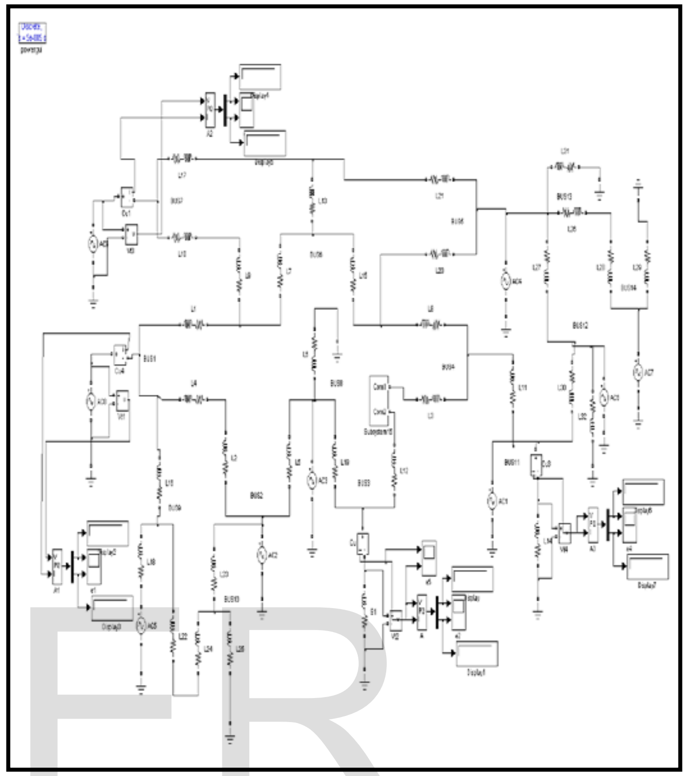
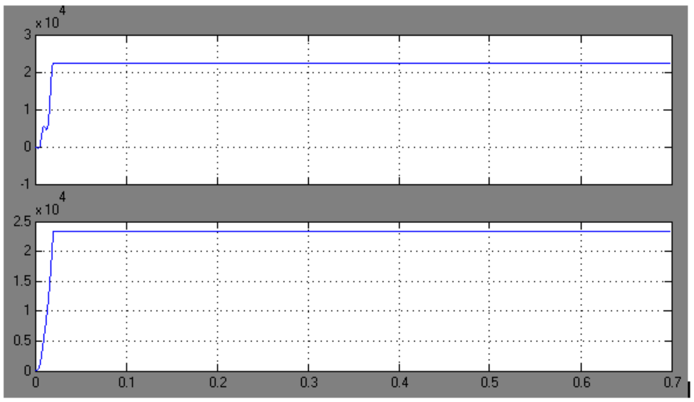


Figure:6 shows Matlab simulink model for modified IEEE-14 bus line model by incorporating TCSC in the line.

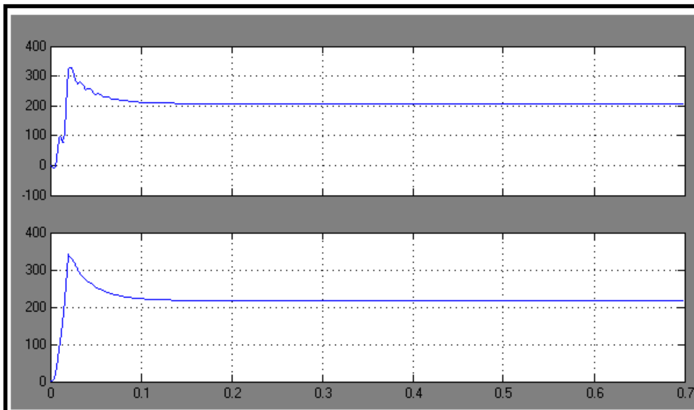
BUS NO	REAL POWER (MW)WITH tcsc controller	REACTIVE POWER (MVAR) WITH tcsc CONTROLLER
BUS-1	0.023	0.024
BUS-2	0.565	0.592
BUS-3	0.421	0.448
BUS-4	0.243	0.319
BUS-5	0.024	0.025
BUS-6	0.021	0.023
BUS-7	0.019	0.021
BUS-8	3.215	3.365
BUS-9	0.023	0.028
BUS-10	0.569	0.572
BUS-11	3.232	3.365
BUS-12	3.213	3.349
BUS-13	3.218	3.379
BUS-14	3.228	3.372

Table:3Real and Reactive Power at each Bus With TCSC

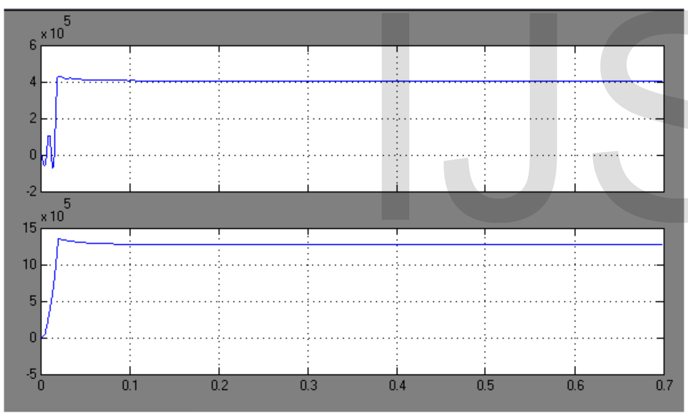
5.2.1Graphs for witht incorporation of TCSC



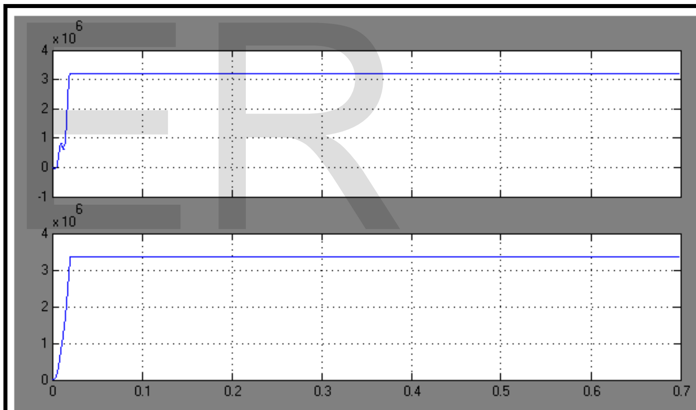
Bus1 real and reactive power



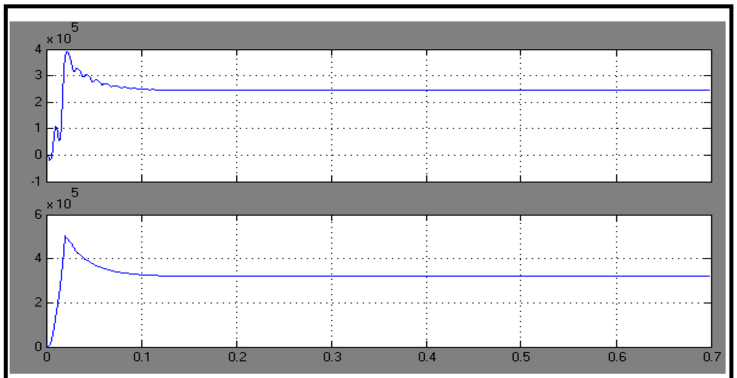
Bus 6 real and reactive power



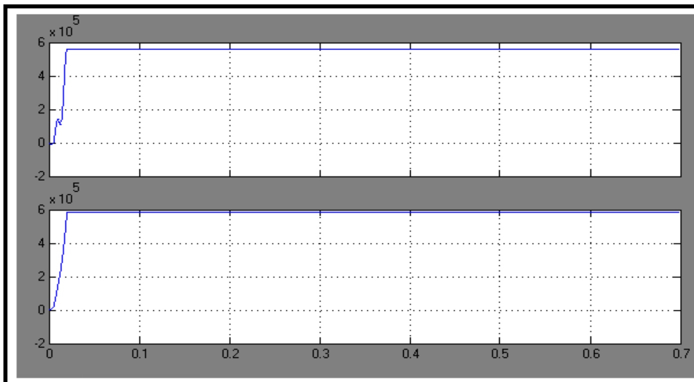
Bus 3 real and reactive power



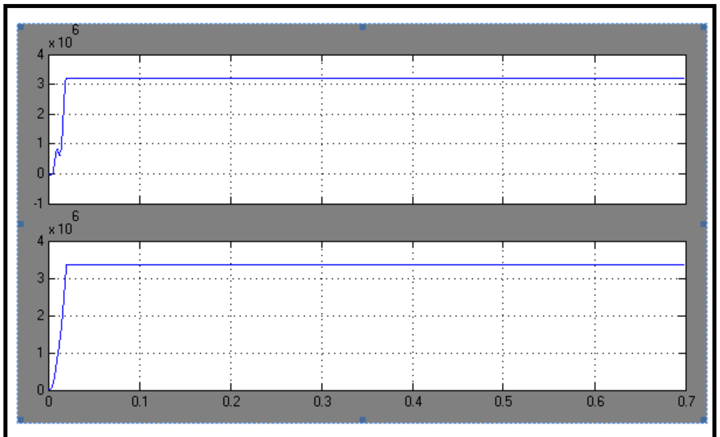
Bus 8 real and reactive power



Bus4 real and reactive power



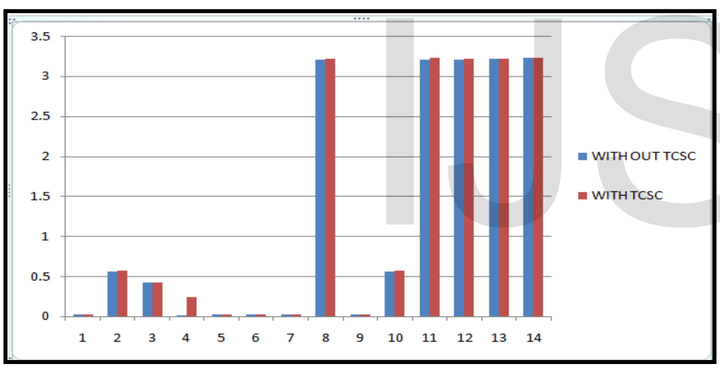
Bus 10 real and reactive power



Bus 14 real and reactive power

Above results repragents Real and Reactive power at various Buses.

Chart1:comprision of Real power flows(MW) with and without TCSC



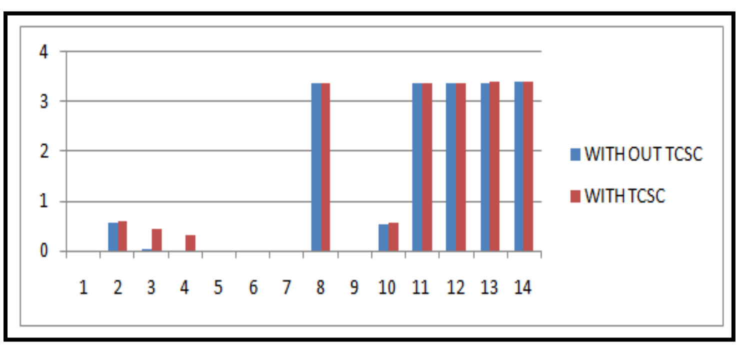


Chart2:comprision of Reactive power flows(MW) with and without TCSC

6 Conclusions:

The contribution of TCSC towards the improvement of Power flow(Active and Reactive) been tested on IEEE 14 bus system.The FACTS device (TCSC) located at optimal locations is observed to have a better voltage profile and power loss. FACTS devices such as TCSC by controlling the power flow in the network can help to reduce flows in overloaded lines. Because of the considerable costs of FACTS devices, It is important to obtain optimal location for placement of these devices. The results presented in this paper show that sensitivity index along with TCSC. So, it can ccluded that after the incorparation of TCSC the power flow between the lines can be improved.

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He is currently working as Associate Professor and Head of the department in Electrical & Electronics Engineering at NRI Institute of Technology, Agiripalli, India. He **got *"Best Achiever award of Andhra Pradesh "By NCERT, New Delhi, India.*** His Areas of interest include Electrical Machines, control Systems and power System Protection