Voltage Stability Improvement using Thyristor Controlled Series Capacitor

Dhanush Patel[1], Kashyap Detroja[2], Mohit Patel[3], Krunal Rana[4], Praful Chudasama[5]
Electrical Engineering, Shroff S.R. Rotary Institute of Chemical Technology, Ankleshwar, India-393010

Abstract :
In the last 20 year the power demand has increased rapidly. As the demand in power is increased, the expansion of the transmission line and generation facility is been severely limited. Due to this the transmission line are loaded heavily and the voltage stability become power transfer limiting factor. So to solve the various power system problem the flexible AC transmission system (FACTS) is been mainly used now a day. In this paper we have aimed towards the benefits of using the Thyristor controlled series capacitor (TCSC) controller and how it improve the operation of an electrical transmission line. Mathematical model, performance, operation and application of TCSC controller has been discussed in this paper. Simulation of the MATLAB circuit without and with TCSC controller has been done using MATLAB software.

Keywords— *Voltage stability, Thyristor controlled series capacitor (TCSC), Voltage Sag, Voltage Swell and MATLAB.*

I. INTRODUCTION

The power system grid is facing many challenges, because of increasing complexity in their operation. Voltage stability is one of the major problems in the recent years. The power demand has increased in recent years and there is lack of power generation and transmission facilities. The power demand rate is constantly increasing at a very rapid rate due to industrial development. To meet this demand the power which is transmitted through transmission line facilities should be improved. Flexible AC transmission system (FACTS) devices are used to solve the various power system problems. Voltage stability improvement is most concerned area of power system these days. We have many flexible AC transmission system (FACTS) devices but we are mainly focusing on TCSC controller. TCSC device deals with steady state and dynamic control application independently. There is a wide range of a system responses and a hierarchical control scheme should be preferably considered for the controller. In this paper our main aim is to analyze the design of a hierarchical TCSC controller for the voltage stability enhancement. The main aim is to analyze the design of TCSC controller for voltage stability improvement. In this paper our objective is to analyze the voltage profile at receiving end in MATALB simulation.

Simulation is done for 33kv, 110km medium transmission PI-section line for the analysis of voltage sag and voltage swell. The simulation work for sag and swell is done for with and without Thyristor controlled series capacitor. TCSC is used as series compensator

II. THYRISTOR CONTROLLED SERIES CAPACITOR(TCSC)

The TCSC controller consists of series compensating capacitor should by a Thyristor controller reactor (TCR). In a practical application, several such basic compensators nay be connected in series to obtain the desired voltage rating and capacitive reactance compensator which consists of a series capacitor bank shunted by a TCR in order to provide a smooth variable series capacitive reactance. The high speed switching property of TCSC provides a mechanism for controlling line power flow. The use of TCSC permits increased loading of existing transmission line, and also allows for rapid readjustment of line power flow in response to various issues.
The control and protection is located on ground potential along with other auxiliary systems.

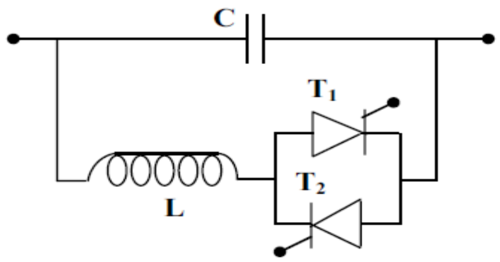

Fig.1:- Basic Thyristor Controlled Series Capacitor

The TCSC helps in tunable parallel LC circuit to the line current that is substantially a constant alternating current source. As the impedance of the controlled reactor, XL(α), is varied from its maximum (infinity) toward its minimum (ωL), the TCSC increases its minimum capacitive impedance, XTCSC.min = XC = 1/ωC, (and thereby the degree of series capacitive compensation) until parallel resonance at XC = XL(α) is established and XTCSC.max theoretically becomes infinite. Decreasing XL(α) further, the impedance of the TCSC, XTCSC(α) becomes inductive, reaching its minimum value of XL XC / (XL - XC) at α = 0, where the capacitor is in effect bypassed by the TCR. Therefore, with the usual TCSC arrangement in which the impedance of the TCR reactor, XL, is smaller than that of the capacitor, XC, the TCSC has two operating ranges around its internal circuit resonance: one is the αClim ≤ α ≤ π/2 range, where XTCSC (α) is capacitive, and the other is the 0 ≤ α ≤ αClim ≤ π/2 range, where XTCSC (α) is inductive. Capacitor value is chosen by a degree of series compensation. Choice of inductor depends on the length of operating area required for inductive and capacitive region. Hence the TCSC working is described.

III. PROBLEMS AND ITS SIMULATION

A three phase 33kv, 110km long transmission is considered as a case study for improving the voltage profile at receiving end and hence improving the power transfer capability. Our aim is to analyze the voltage sag and voltage swell at receiving end with and without TCSC. First the simulation results are obtained for the MATLAB system without TCSC, and then for a MATLAB system with TCSC implemented in the circuit. Voltage sag and voltage swell are described here. The complete simulation model is shown in fig.2. First the simulation results are obtained for system without TCSC, and then for a system with TCSC controller implemented.

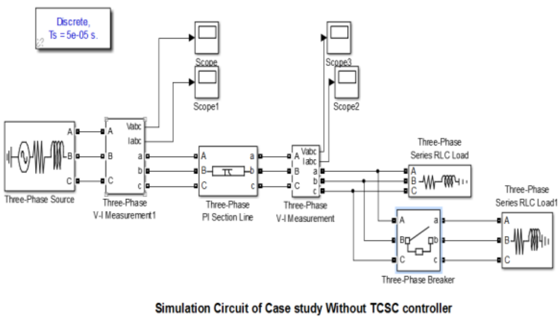

Fig. 2: Simulation Circuit Without TCSC Device

Voltage Profile Analysis:

i. A 33kv, 110km long transmission line is taken, and at receiving end we obtain voltage sag during switching of heavy loads or during fault condition at receiving side and voltage swell when there is a sudden removal of heavy load. Due to light loading the voltage swell is generated.

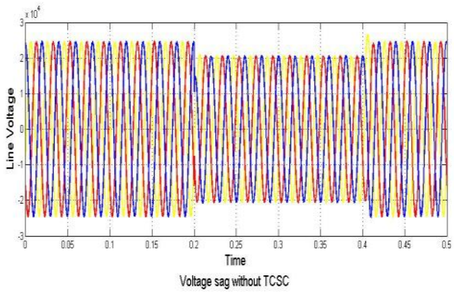

Fig. 3: Three Phase Voltage Sag Waveform Without TCSC Device

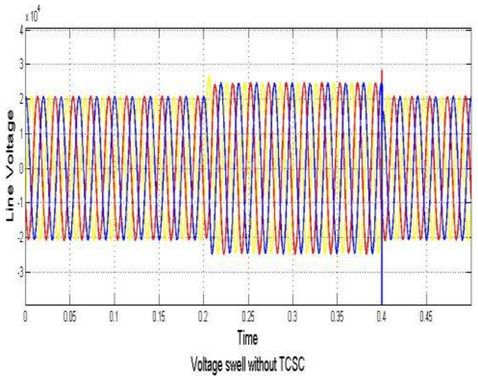

Fig. 4: Three Phase Voltage Swell Waveform Without TCSC Device

As shown in fig. 3 and fig.4 X axis shows the time and Y axis shows the line voltage.

ii. This simulation model is for the circuit with TCSC. The TCSC device is been connected in the transmission line to improve the voltage profile at the receiving side.

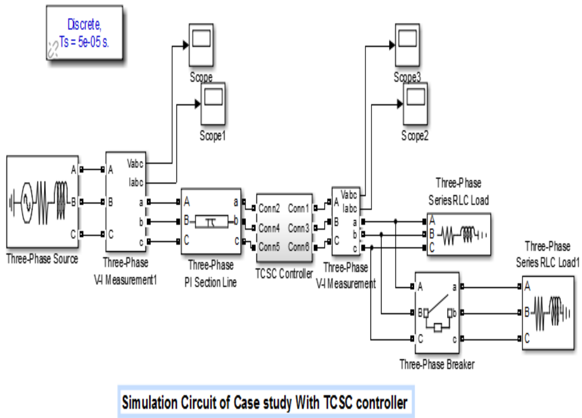

Fig. 5: Simulation Circuit With TCSC Device

This waveform shown below is for the voltage sag and voltage swell with TCSC. By implementing the TCSC device in the circuit the voltage compensation is achieved.

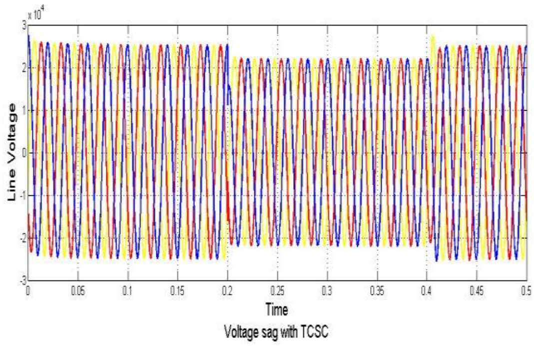

Fig. 6: Three Phase Voltage Sag Waveform With TCSC Device

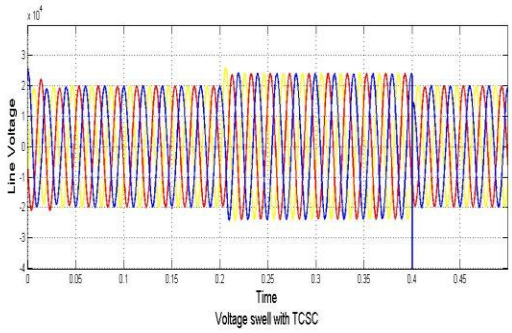

Fig. 7: Three Phase Voltage Swell Waveform With TCSC Device

All the simulation results has been carried in MATLAB/SIMULINK software. The result of simulation circuit, with and without TCSC is shown in Table.1

Sr no	Sending End Voltage	Profile Distortion	Voltage Without TCSC	Voltage With TCSC
1	33 kV	Voltage sag	31.71 %	25.20 %
2	33 kV	Voltage swell	40%	33.71 %

Table 1:- Output Result of Without and With TCSC

IV. CONCLUSION

The MATLAB simulation has been done for 33kv, 110km transmission line. Firstly the voltage drop and sending to receiving end losses are generated, and our objective is to minimize that drop and improve the voltage stability. The paper shows us the voltage sag due to switching of heavy loads, without TCSC and also shows voltage swell on the sudden removal of heavy load. Then the voltage sag and swell is been compensated with the help of TCSC device. From above Case study and its calculation, obtained compensation by TCSC controller for sag is 6.51 % & for swell is 6.29 % which means that voltage profile gets compensate while load fluctuation period. At the end we concluded that with the use of series compensator TCSC, the sag and swell can be compensated and the voltage stability in the transmission line is been improved.

REFERENCES

[1] N. G. Hingorani and L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems. New York: IEEE Press, 2000.

[2] Siti Amely Jumaat, Ismail Musirin, Muhammad Murtadha Othman and Hazlie Mokhlis "Placement And Sizing Of Thyristor Controlled Series Compensator Using PSO Based Technique For Loss Minimization", 2012 IEEE International Power Engineering and Optimization Conference (PEOCO2012), Melaka, Malaysia: 6-7June 2012, PP285-290.

[3] Claudio A. Ca~nizares, Zeno T. Faur "Analysis of SVC and TCSC Controllers in Voltage Collapse", IEEE Trans. Power Systems, Vol. 14, No. 1, February 1999, pp. 158-165.

[4] Nagendrababu, Sreekanth G, Narender Reddy Narra, Dr. Srujana, "Series Compensation Technique for Voltage Sag Mitigation", IOSR Journal of Engineering(IOSRJEN) ISSN: 2250-3021 Volume 2, Issue 8 (August 2012), PP 14-24.

[5] G. V. T. Prudhvira, Raghu, S. Meikandasivam and D. Vijayakumar, "Implementing TCSC Device in Kalpakam Khammam Line for Power Flow Enhancement", 2013 IEEE International Conference on Circuits, Power and Computing Technologies 978-1-4673-4922-2/13, PP138-141.