ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

# Enhancement of Power System Dynamics Using TCSC Based Hybride Series Capacitive Compensation

**Madupu Renuka*, Nomula Ganesh, Nagalla Bhargavi**
*Student of EEE department at Siddhartha Institute of Technology & Science, Hyderabad, India
Associate Professor of EEE department Siddhartha Institute of Technology & Science, Hyderabad, India
Assistant Professor of EEE department Siddhartha Institute of Technology & Science, Hyderabad, India

## Abstracts

This paper demonstrate phase imbalanced series capacitive compensation to enhancing power system dynamics as it has the potential of damping power swing as well as subsynchronous resonance oscillations. In this paper, the effectiveness of a "hybrid" series capacitive compensation scheme in single line and double line to damping power system oscillations is computed. A hybrid concept is a series capacitive compensation scheme, in one case two phases are compensated by fixed series capacitor (Cs) and the third phase is compensated by a TCSC in series with a fixed capacitor (Cc) in singe line scheme. In second case one phase is compensated by fixed series capacitor (Cs) and the other phase are compensated by a TCSC in series with a fixed capacitor (Cc) in double line scheme

The performance of the scheme in damping power system oscillations for various network conditions like fault and without fault are evaluated using the MATLAB simulation.

**Keywords**: FACTS Controllers, phase imbalance, series compensation, SVR Controller thyristor controlled series capacitor.PLL.

## Introduction

FACTS controllers play a significant role in controlling the power flow in a AC Network which control the active and reactive power result in an excellent capability for improving the power system Transient stability[1]. Today's Power system is a complex network. Power generation usually does not locate near the load center and different generating stations are connected through a grid. The Integrated power system result into a low-frequency "inter-area" oscillations[2], when the balancing between generation, load in each system and disturbance in transmission line. Such disturbance may be due to loss of excitation, loss of prime mover, failure of transmission line, fault in transmission and sudden change in load. These oscillations can also lead to voltage collapse and frequency collapse. Facts devices can be used to provide the damping in the power system, Thyristor Controlled Series Capacitor (TCSC), and Static Synchronous Series Compensator (SSSC) have been used to enhancing power system dynamics[3]-[5]. The recently proposed phase imbalanced series capacitive compensation concept has been shown to be effective in enhancing power system dynamics as it has the potential of damping power swing as well as subsynchronous resonance oscillations [6]. In *hybrid* capacitive compensation scheme, in one case two phases are compensated by fixed series capacitor (Cs) and the third phase is compensated by a TCSC in series with a fixed capacitor ($C_c$) in singe line scheme. In second case one phase is compensated by fixed series capacitor (Cs) and the other phase are compensated by a TCSC in series with a fixed capacitor ($C_c$) in double line scheme. The TCSC control is initially set to equivalent compensations at the power frequency combined with the fixed capacitor yield a resultant compensation equal to the other two phases in single line compensation, equal to the other phases in double line compensation. Thus, the phase balance is maintained at the power frequency while at any other frequency, a phase imbalance is created. To further improve power oscillations damping, the TCSC is operated with a supplementary controller.

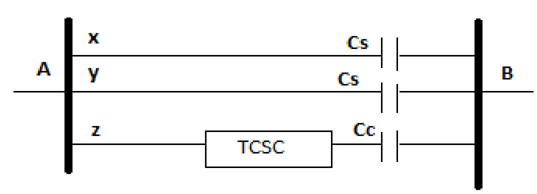


*Fig. 1. A schematic diagram of the hybrid series compensation scheme in single Line.*

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

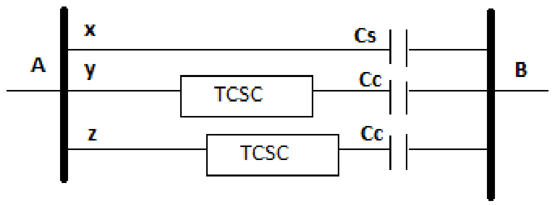


***Fig. 2. A schematic diagram of the hybrid series compensation scheme in Double Line.***

The phase imbalance of Scheme can be explained mathematically as follows.

At the power frequency, the series reactances between buses A and B in Fig. 1 in phases x,y,z are given by

$$X_x = X_y = 1/j\omega_o C_s \quad (1)$$

$$X_z = \frac{1}{j\omega_o C_c} - jX_{TCSCO} \quad (2)$$

Where $X_{TCSCO}$ is reactance offered by TCSC.

At any other frequency fc

$$X_z = \frac{1}{j\omega_o C_c} - jX_{TCSCo} - j\Delta X_{TCSC} \quad (3)$$

Where $\Delta X_{TCSC}$ is change in reactance.

This paper evaluate the performance of the damping power system oscillations for various network conditions like fault and without fault using the MATLAB simulation.

## Implementation of the single-phase TCSC in matlab

The single-phase TCSC is modeled using an ideal thyristor pair and an RC snubber circuit. A Phase Locked Loop (PLL) is used to extract phase information of the fundamental frequency line current, it is used to synchronize TCSC operation. The thyristor Firing control is based on the Synchronous Voltage Reversal (SVR) technique [9] - [11]. The impedance of TCSC is measured in terms of a boost factor *kB*, which is the ratio of the apparent reactance of the line to the physical reactance of the TCSC capacitor bank. A positive value of *kB* is considered for capacitive operation. A boost measurement block performs complex impedance calculations for the boost factor of the TCSC as *kB*.

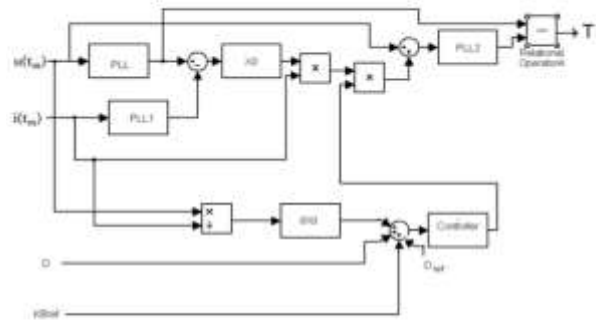


***Fig. 3. Block Diagram of TCSC Controller***

D(t) is a supplemental signal generated from an *m*-stage lead-lag compensation based controller. As the real power flow in the transmission line is proportional to the inverse of the total line reactance, the power swing damping can be achieved by properly odulating the apparent TCSC reactance through this controller.

## Test study

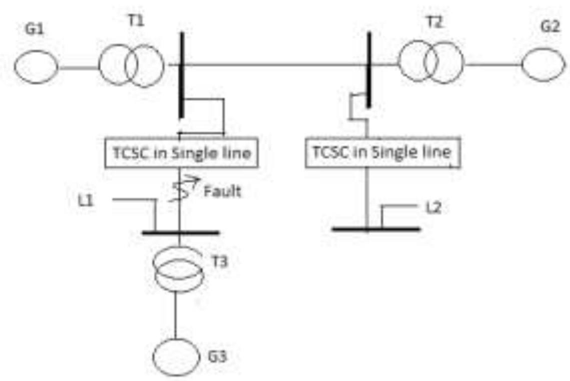


***Fig 4. Schematic diagram of the hybrid series compensation scheme in single Line.***

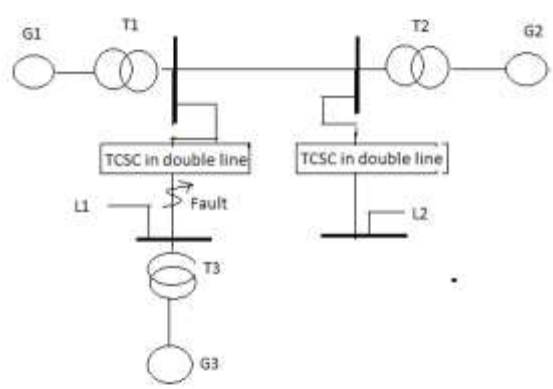


***Fig. 5. Schematic diagram of the hybrid series compensation scheme in Double Line.***

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

To demonstrate the effectiveness of the proposed scheme in power system oscillations damping, the system shown in Fig. 3 & Fig 4 is adopted as a test System. It consists of three large generating stations ($G_1$, $G_2$ and $G_3$) supplying two load centers ($L_1$ and $L_2$) through five 600 kV transmission lines. The two transmission lines are compensated with Hybride series capacitive compensation in single line and in double line.

The total installed capacity and peak load of the system are 4500 MVA and 3833 MVA respectively. $L_1$ = 1400 + j200 MVA and $L_2$ = 2400 + j300 MVA.

## Matlab simulation study

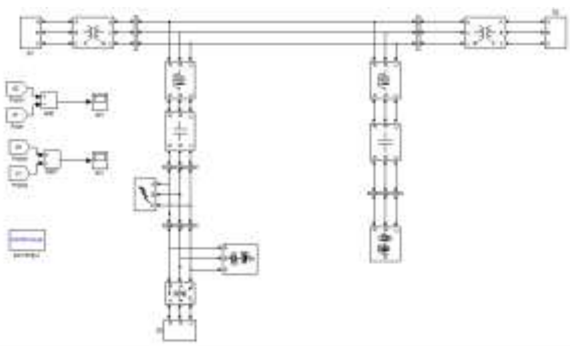

*Fig 6. Simulation diagram of Fixed Compensatin.*

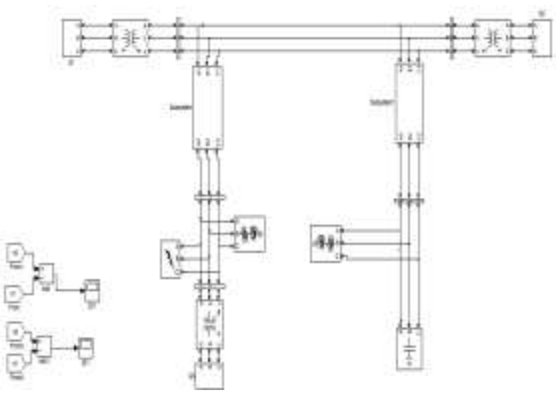

*Fig 7. Simulation diagram of the hybrid series compensation scheme in single Line.*

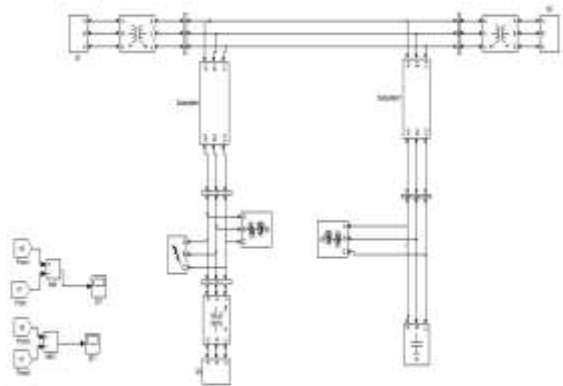

*Fig. 8. Simulation diagram of the hybrid series compensation scheme in Double Line.*

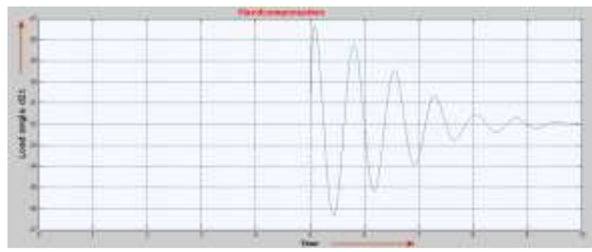

*Fig. 9. Generator load angle $d_{21}$, during and after clearing a three-phase fault with fixed compensation.*

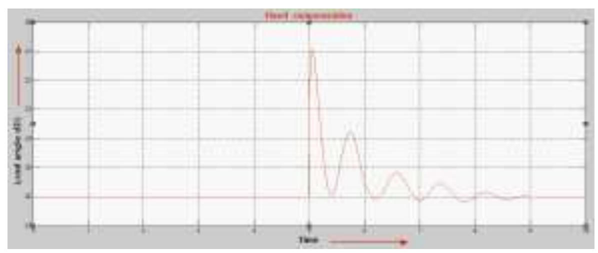

*Fig. 10. Generator load angle $d_{31}$, during and after clearing a three-phase fault with fixed compensation.*

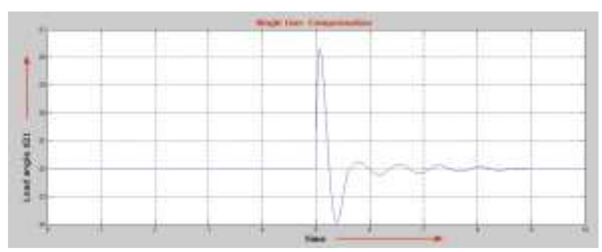

*Fig.11. Generator load angle $d_{21}$, during and after clearing a three-phase fault with Single Line compensation.*

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

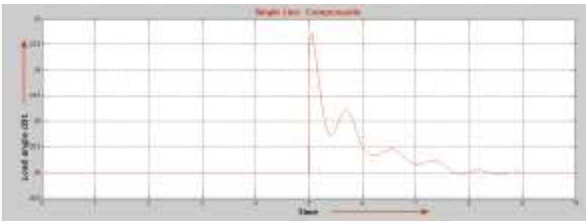

***Fig.12. Generator load angle $d_{31}$, during and after clearing a three-phase fault with Single Line compensation.***

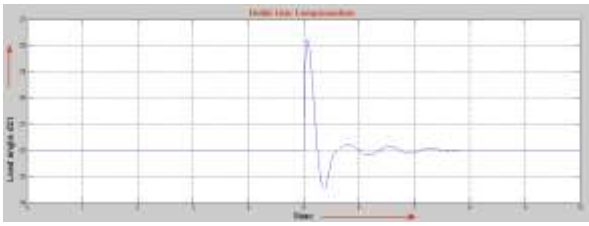

***Fig.13. Generator load angle $d_{21}$, during and after clearing a three-phase fault with Double Line compensation.***

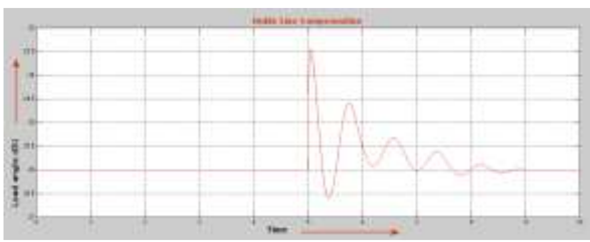

***Fig.14. Generator load angle $d_{31}$, during and after clearing a three-phase fault with Double Line compensation.***

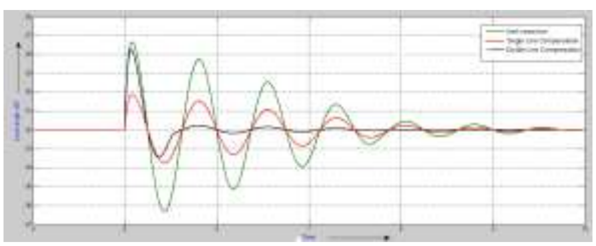

***Fig.15. Generator load angle $d_{21}$, during and after clearing a three-phase fault with Fixed Compensation ,Single Line Compensation & Double Line compensation.***

## Conclusions

It has been shown in the paper that the double line hybrid series capacitive compensation damping power system oscillations much faster rate. The performance of scheme in damping these oscillations is demonstrated through simulations with a Test system. The presented hybrid series capacitive compensation scheme improve the Transient Stability.

## References

1. Narain G. Hingorani and Laszlo Gyugyi, "Understanding FACTS, Concepts and Technology of Flexible AC Transmission Systems," IEEE Press, 2000.
2. M. Klein, G.J. Rogers and P. Kundur, "A Fundamental Study of Inter-Area Oscillations in Power Systems," IEEE Transactions on Power Systems, Vol. 6, No. 3, 1991, pp. 914-921.
3. E.V. Larsen, J.J. Sanchez-Gasca and J.H. Chow, "Concepts for Designof FACTS Controllers to Damp Power Swings," IEEE Transactions on Power Systems, Vol. 10, No. 2, May 1995, pp. 948-956.
4. B. Chaudhuri, B. Pal, A. C. Zolotas, I. M. Jaimoukha, and T. C. Green,"Mixed-sensitivity Approach to H Control of Power System Oscillations Employing Multiple FACTS Devices," IEEE Transactions on Power System, Vol. 18, No. 3, August 2003, pp. 1149–1156.
5. B. Chaudhuri and B. Pal, "Robust Damping of Multiple Swing Modes Employing Global Stabilizing Signals with a TCSC," IEEE Transactions on Power System, Vol. 19, No. 1, February 2004, pp. 499–506.
6. D. Rai, G. Ramakrishna, S.O. Faried and A. Edris," Enhancement of Power System Dynamics Using a Phase Imbalanced Series Compensation Scheme," IEEE Transactions on Power Systems, Vol. 25,No. 2, May 2010, pp. 966-974.