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TCSC WITH PSS CONTROLLER FOR DAMPING LOW FREQUENCY OSCILLATION IN POWER SYSTEM

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ABSTRACT

This paper proposes an analytical approach for control designing of Thyristor controlled switched capacitor Controller (TCSC) for damping low frequency oscillation in a power system. Power System Stabilizer (PSS) detects changes in the generator output power and by controlling the excitation value it reduces the power swings in the system. PSS can't provide sufficient damping for inter-area oscillations in the multi-machine power system. We can overcome this problem by providing proper Co-ordination of PSS and TCSC. The proposed controller provides an efficient damping when compared to conventional controller. The simulations are performed in MATLAB/SIMULINK software.

KEYWORDS: *Damping controller, PSS controller, SMIB ,TCSC.*

I.INTRODUCTION

The Flexible AC Transmission System (FACTS) Technology, introduced in 1988 by Hingorani in an enabling technology and provides added flexibility and can enable a line to transfer power to the thermal rating. .Therefore, it can be used not only for power flow but also for the power stabilizing control. Thyristor controlled switched Capacitor (TCSC) is one of the most commonly used FACTS devices that provides the most important performance in damping low frequency oscillations in interconnected power system .

A comprehensive and analytical approach for mathematical modeling of TCSC for steady state and linearised dynamic stability has been proposed. Several years the power system stabilizer act as a common control approach to damp the system oscillations. However, in some operating conditions, the PSS may fail to stabilize the power system, especially in low frequency oscillations. It is proved that the FACTS devices are very much effective in power flow control as well as damping out the swing of the system during fault. Among all FACTS devices the TCSC is the most popular controller for effective damping.

II. SMIB SYSTEM WITHOUT TCSC CONSIDERING FAULT

A single machine infinite bus system installed without TCSC is considered.

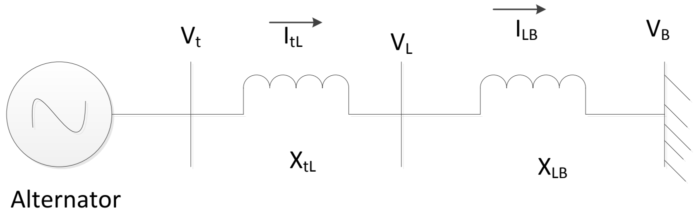


Fig.1 A single machine infinite bus system (SMIB)

$$\Delta\dot{\delta} = \omega_b \Delta\omega$$

$$\Delta\dot{\omega} = \left(-\frac{k_1}{M}\right)\Delta\delta + \left(-\frac{k_2}{M}\right)\Delta E'_q + \left(-\frac{D}{M}\right)\Delta\omega$$

$$\Delta\dot{E}'_q = \left(-\frac{k_3}{T'_{d0}}\right)\Delta\delta + \left(-\frac{k_4}{T'_{d0}}\right)\Delta E'_q + \left(\frac{1}{T'_{d0}}\right)\Delta E_{fd}$$

$$\Delta\dot{E}_{fd} = \left(-\frac{k_5 k_a}{T_a}\right)\Delta\delta + \frac{k_a}{T_a}\Delta\omega + \left(-\frac{k_6 k_a}{T_a}\right)\Delta E'_q + \left(-\frac{1}{T_a}\right)\Delta E_{fd} + \left(\frac{k_a}{T_a}\right)\Delta V_{ref}$$

With the help of these linearised equation of SMIB, we obtained a simulation model of SMIB without TCSC considering fault.

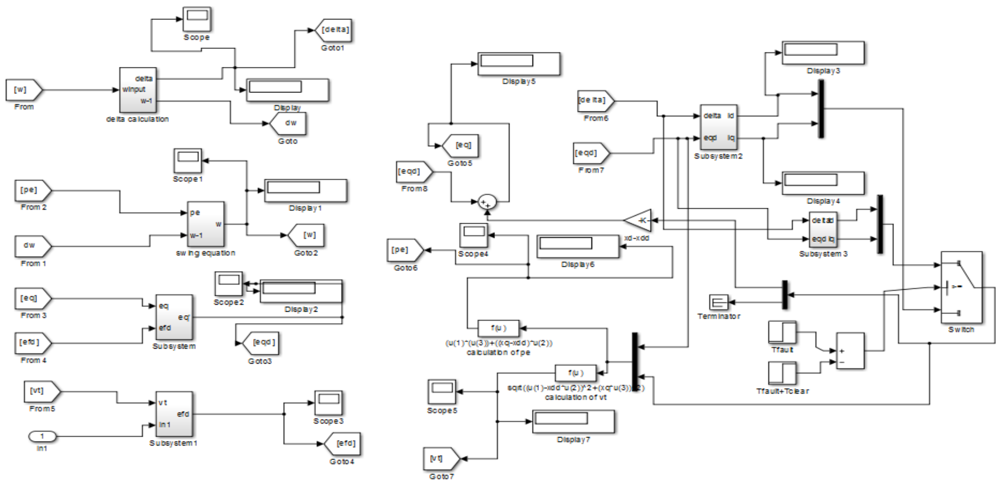
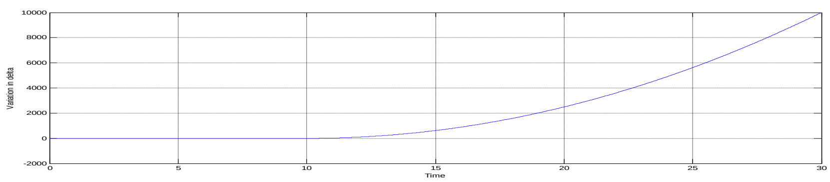


Fig.2 Simulation model of SMIB system without TCSC

The output of this simulation is taken as angle deviation, electrical power and terminal voltage .Simulation process is carried out for duration of 30 seconds.



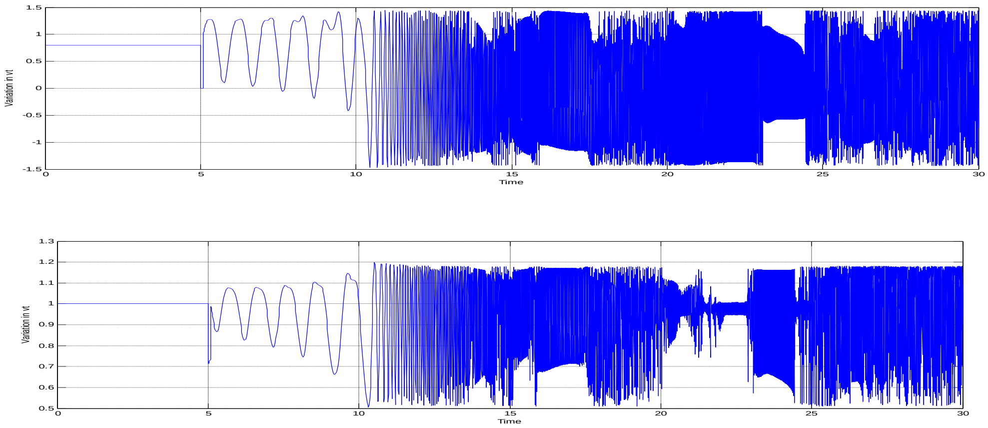


Fig.3 Response of SMIB system in Variation of load angle, electrical power , terminal voltage at 80 % loading considering fault

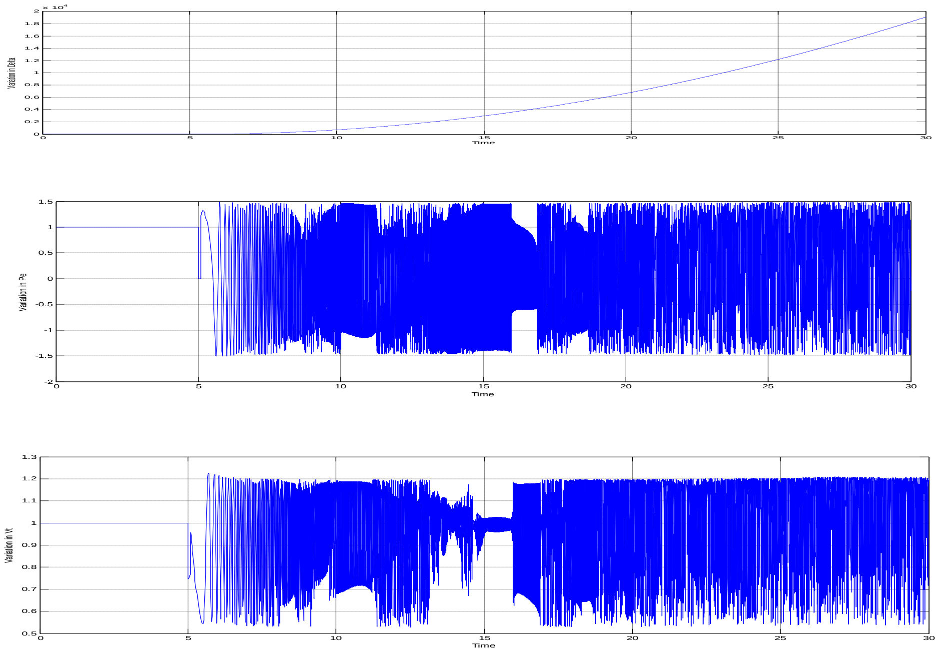


Fig.4 Response of SMIB system in Variation of load angle, electrical power , terminal voltage at 100 % loading considering fault

III. SMIB SYSTEM WITH TCSC

A TCSC is a capacitive reactance compensator which consists of a series capacitor bank shunted by a thyristor-controlled reactor in order to provide a smoothly variable series capacitive reactance

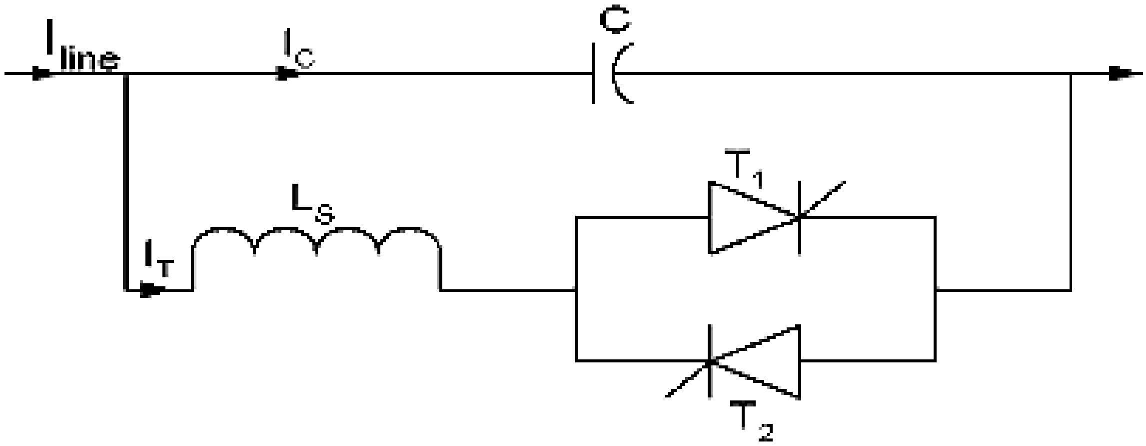


Fig.5 TCSC Controller

Fig.5 shows the basic diagram of TCSC controller encloses a series capacitor depository, shoved with a Thyristor Controlled Reactor (TCR) which provide variable series capacitive reactance. When the TCR firing angle is 180 degrees, the reactor becomes non conducting and the series capacitor has its normal impedance. As the firing angle is advanced from 180 degrees to less than 180 degrees, the capacitive impedance increases. At the other end, when the TCR firing angle is 90 degrees, the reactor becomes fully conducting, and the total impedance becomes inductive, because the reactor impedance is designed to be much lower than the series capacitor impedance. With 90 degrees firing angle, the TCSC helps in limiting fault current.

A linear dynamic model is obtained by linearizing the nonlinear model

$$\Delta\dot{\delta} = w_0 \Delta w$$

$$\Delta\dot{w} = \frac{-\Delta P_e - D\Delta w}{M}$$

$$\Delta E^{'} = (-\Delta E_q + \Delta E_{fd})/T'_{d0}$$

$$\Delta\dot{E}_{fd} = -\frac{\Delta E_{fd}}{T_a} + \frac{K_a}{T_a}(\Delta V_{ref} - \Delta V_t)$$

$$\Delta E_q^{'} = K_4\Delta\delta + K_3\Delta E_q^{'} + K_{vd}\Delta V_{dc} + K_{qe}\Delta m_E + K_{q\delta e}\Delta\delta_E + K_{qb}\Delta m_B + K_{q\delta b}\Delta\delta_B$$

$$\Delta V_t = K_5\Delta\delta + K_6\Delta E_q^{'} + K_{vd}\Delta V_{dc} + K_{ve}\Delta m_E + K_{v\delta e}\Delta\delta_E + K_{vb}\Delta m_B + K_{v\delta b}\Delta\delta_B$$

$$\Delta\dot{X}_{tcsc} = k_1 k_{11}\Delta\delta + Dk_{11}\Delta\omega + k_2 k_{11}\Delta E'_q + \frac{\Delta X_{tcsc}}{T_s}\Delta X_{tcsc0}$$

With the help of these linearised equation of SMIB with TCSC, we obtained a simulation model of SMIB with TCSC considering fault.

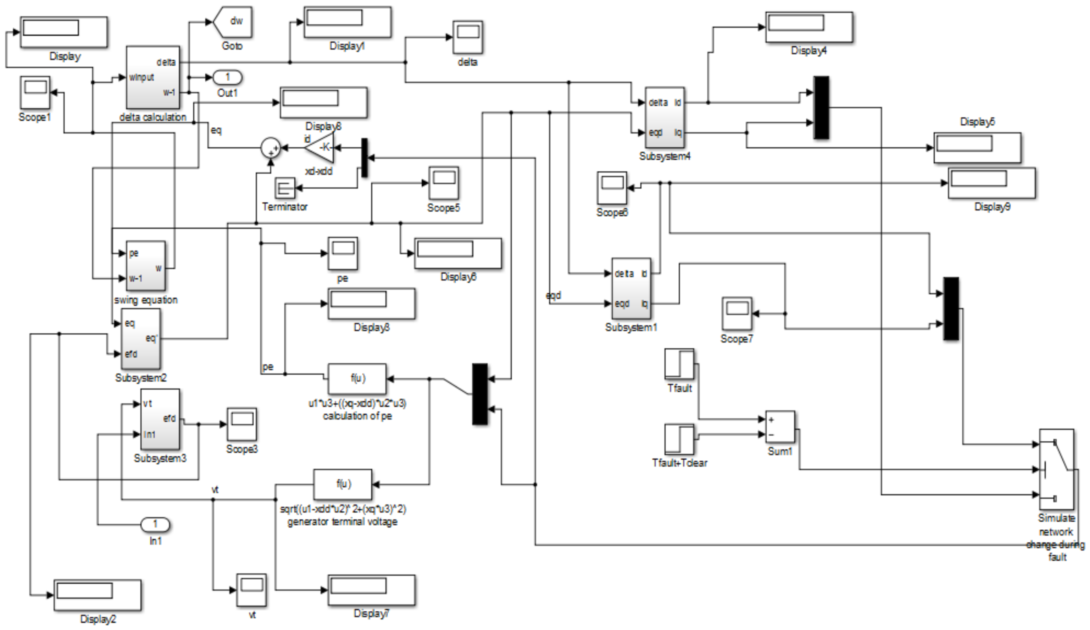


Fig.6 Simulation model of SMIB system with TCSC

The output of this simulation is taken as angle deviation, electrical power and terminal voltage .Simulation process is carried out for duration of 30 seconds.

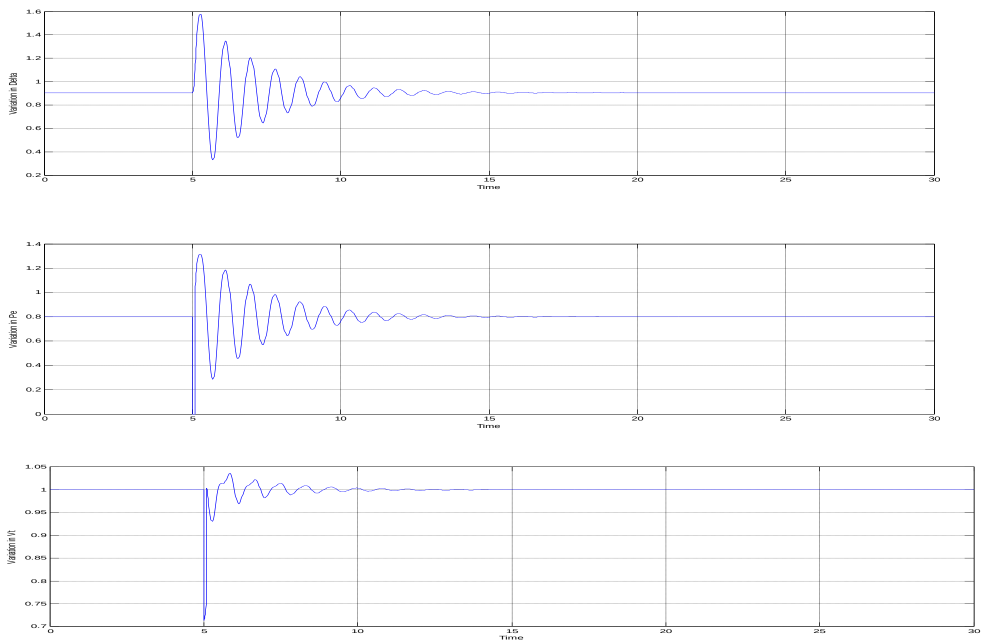


Fig.7 Response of SMIB system with TCSC in Variation of load angle, electrical power , terminal voltage at 80 % loading.

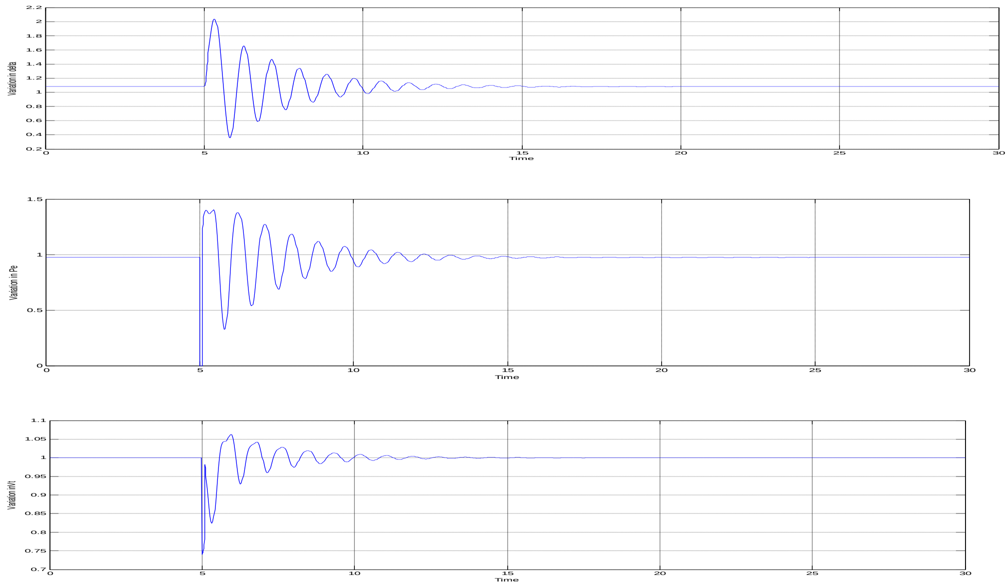


Fig.8 Response of SMIB system with TCSC in Variation of load angle, electrical power , terminal voltage at 100 % loading.

IV. SMIB SYSTEM WITH PROPOSED PSS CONTROLLER WITH TCSC

The single-machine infinite-bus power system with PSS and TCSC shown in Fig.6.1 is considered in this study. The generator is equipped with a PSS and the system has a TCSC installed in transmission line. In the figure XT and XL represent the reactance of the transformer and the transmission line respectively, VT and VB are the generator terminal and infinite bus voltage respectively.

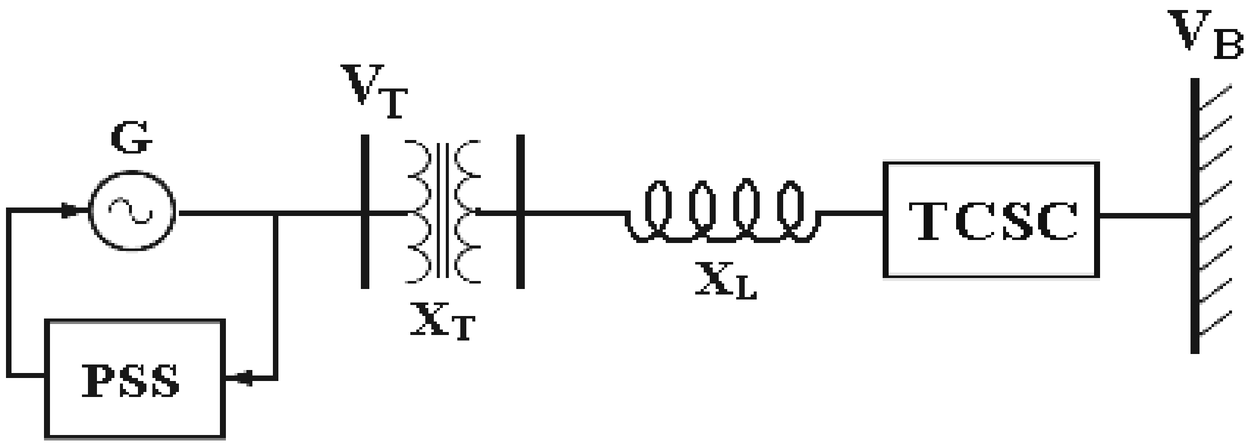


Fig.9 Structure of PSS with TCSC equipped in SMIB System

The simulation model of SMIB with proposed TCSC with PSS controller as shown in figure

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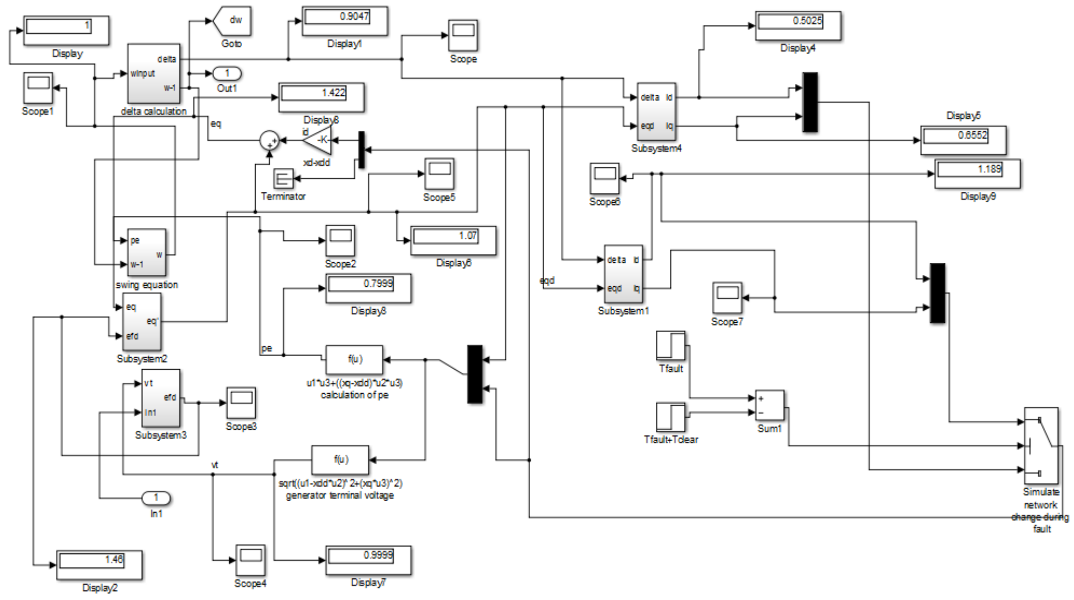


Fig.10 Simulation model of SMIB with proposed TCSC with PSS controller

The output of this simulation is taken as angle deviation, electrical power and terminal voltage .Simulation process is carried out for duration of 30 seconds.

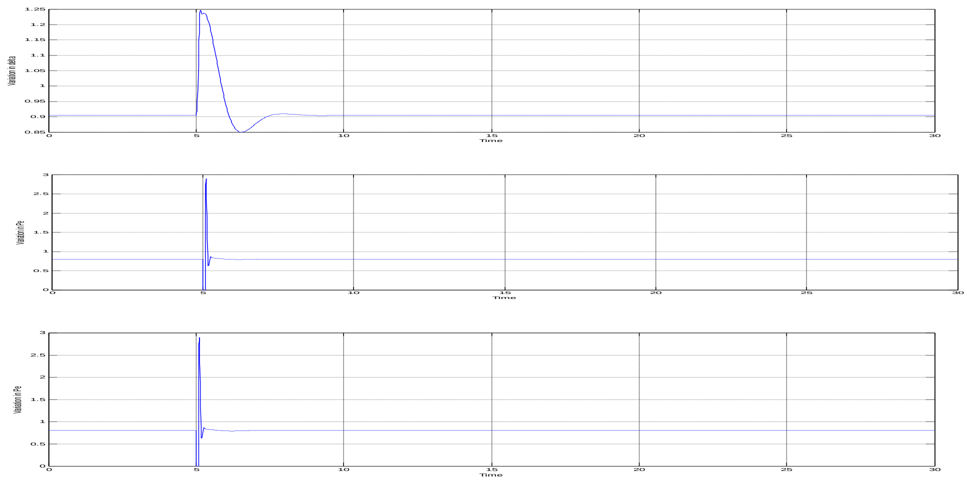
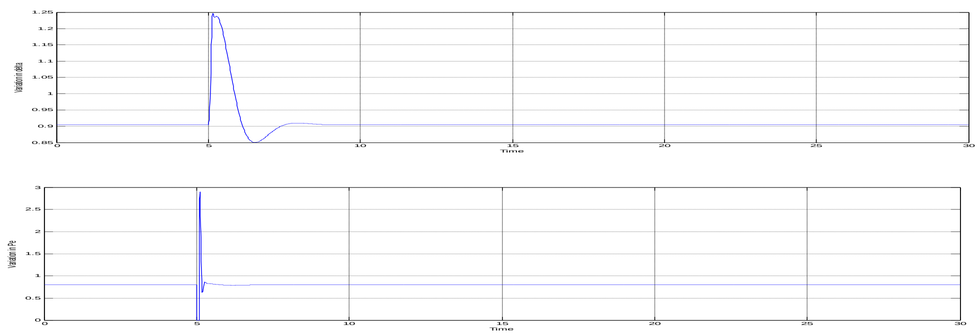


Fig.11 Response of SMIB system with proposed TCSC with PSS controller in Variation of load angle, electrical power , terminal voltage at 80 % loading.



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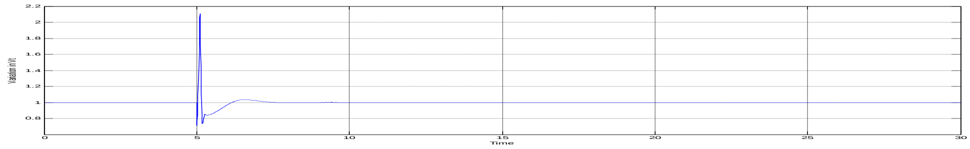

Fig.12 Response of SMIB system with proposed TCSC with PSS controller in Variation of load angle, electrical power , terminal voltage at 100 % loading.

V.CONCLUSION

Objective of this work is damp the oscillation of power system using different controller. In this paper, MATLAB/SIMULINK model of a single machine infinite bus (SMIB) system with a TCSC controller presented .With the help of this controller power system oscillation will damped out. But still system having the oscillation. Then we will incorporate PSS controller with TCSC. The simulation results show that TCSC with PSS controller has better performance for damped out the oscillation in power system.

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APPENDIX

The value of parameter used in simulation are

Generator:

M=2H=8.0,D=0, $T_{do'}$ =5.044, Xd=1.0,Xq=0.6,Xd'=0.3

Excitation System:

K_A=100,T_A=0.01

Transformer:

X_{tE}=0.1 p.u., X_E=0.1 p.u., X_B=0.1 p.u.

Transmission Line:

X_{Bv}=0.3, Xe=0.5

Operating conditions:

Pe=0.8, Vt=1.0 p.u.

Vb=1.0 p.u.