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POWER SYSTEM STABILITY ENHANCEMENT USING STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)

Ms. Priti Wamane[1], Prof. Hitesh Murkute[2]

[1]PG student, Electrical Engineering, GNIET. Assist. Prof.
[2]Professor, Electrical Engineering, GNIET

Abstract —The continuous demand in electric power system leads to voltage instability. There may be insufficient reactive power causing voltage drop. The enhancement of voltage stability using static synchronous series compensator (SSSC) improves the system performance such as increase in transmittable power, transmission angle, power factor improvement and decrease line series reactance. Static synchronous series compensator (SSSC) is used to investigate the effect of this device and will be controlling active and reactive power as well as power oscillation damping. The steady state performance of SSSC will be presented using MATLAB software.

Keywords-component;Active and reactive power, FACTS, Multi-bus system, Static synchronous series compensator(SSSC)

I. INTRODUCTION

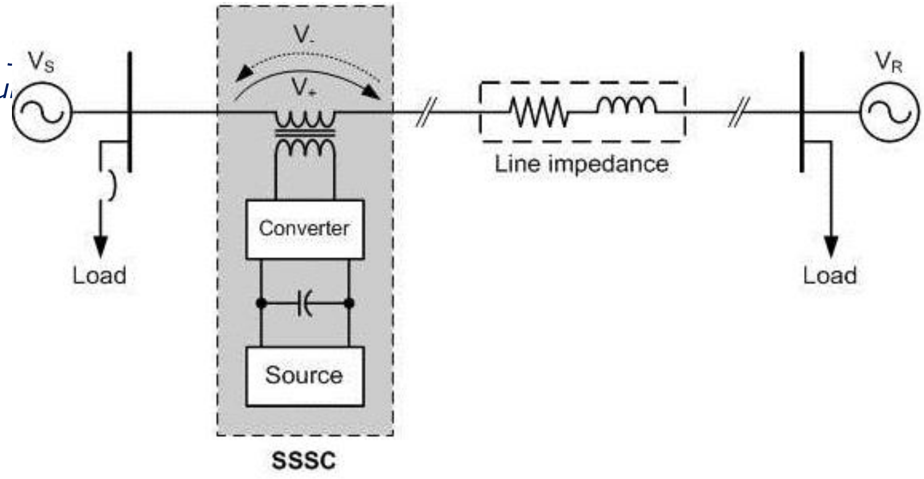
In the deregulated power environment, the loads and generations change rapidly, causing certain corridors to be loaded to thermal limits. Once a small disturbance occurs in the part of the system, if not controlled, can lead to catastrophic failure resulting in complete blackout. In case, a line is overloaded or a contingency has occurred such as loss of line, or loss of large generator, the balance of load and generation in the system is distributed causing some of the lines to be overloaded. Therefore, a secure, stable and reliable operation of power system has become a serious challenge in the emerging electricity market scenario. The continuous growth in power demand and supply along with the limited expansion of transmission network changes the power flow pattern in the power system in such a way that some of the lines are overloaded. The flexible AC Transmission systems (FACTS) controllers find their enhanced application areas to resolve some of the challenges to ensure the proper power flow control, voltage control and stability enhancement.

In essence, the SSSC can be considered to be controllable effective line impedance. Since SSSC has a VSC topology, the DC capacitor is used to maintain the DC voltage enabling the SSSC to increase or decrease the transmitted power across the line by a fixed fraction of maximum power. Since the SSSC has the ability of absorb or supply reactive power from or to the line, it makes the surrounding power system impervious to classical sub synchronous resonance (SSR) [6].

Fig. 1 shows the basic configuration of SSSC. The main component of SSSC is a Voltage Source Converter (VSC). It is equipped with an energy source to enhance the active and reactive power exchange with an AC system. The series connected SSSC inject an AC voltage in phase quadrature with line current, and thus the control of power flow through the transmission line is attained by adjusting the magnitude and phase angle of the injected voltage.
Basic equations representing the power flow through the transmission line is given by :

$Pq= V^2/Xeff *Sind$ (1) :
$Qq= V^2/Xeff *(1-cosd)$ (2)

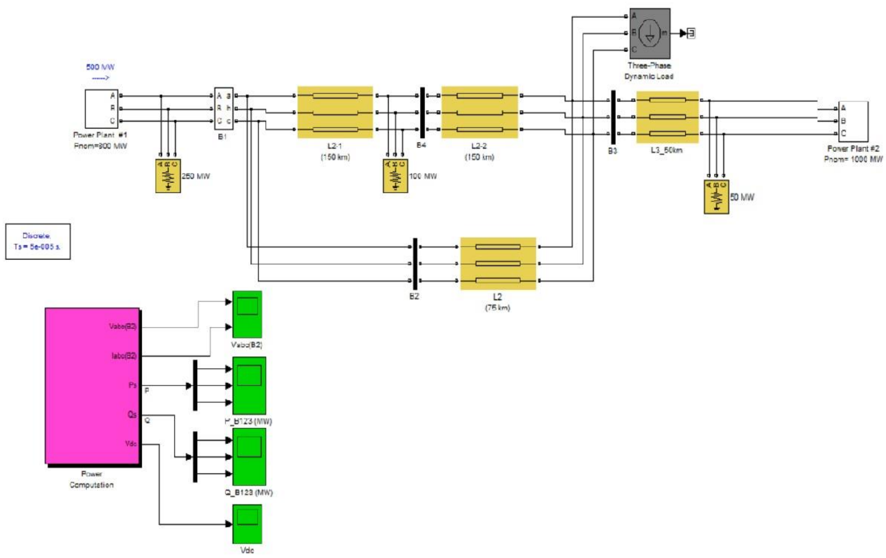
Where
: $Xeff= X_L (1-X/X_L)$ (3)
Xq is the capacitive reactance due to injected voltage.
XL is the inductive reactance of the transmission line.
V is the voltage magnitude
(Vs. = Vr =V)
: d=ds-d- (4)



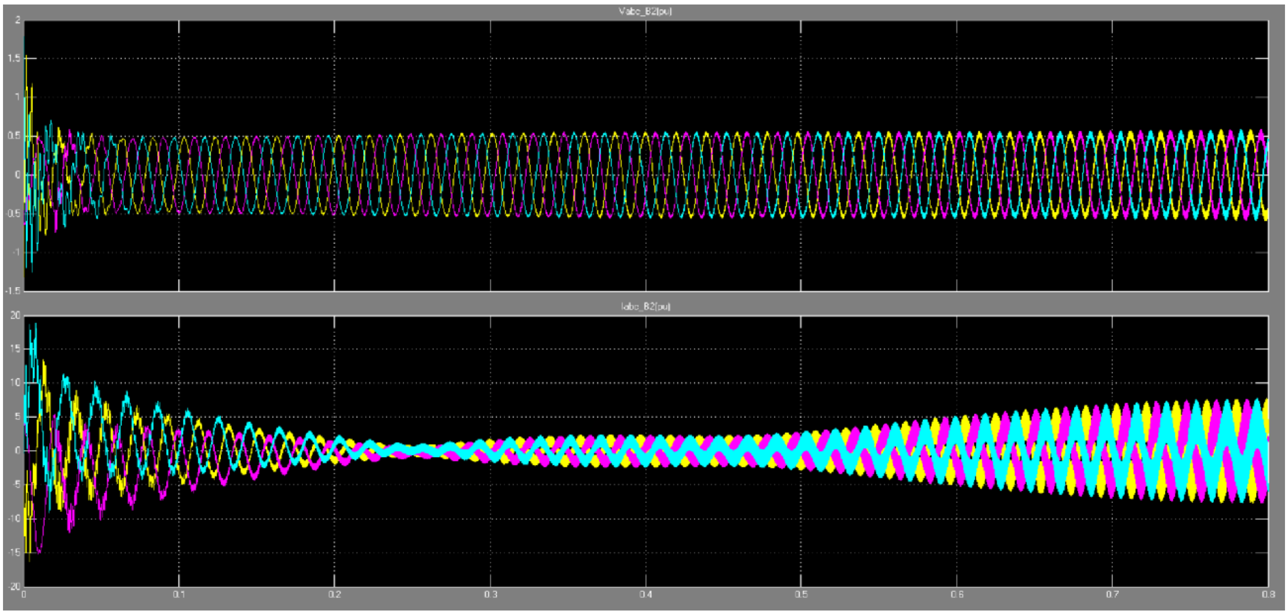
"Figure 1. Basic configration of SSSC"

II. MODELLING OF THE PROPOSED FOUR BUS SYSTEM

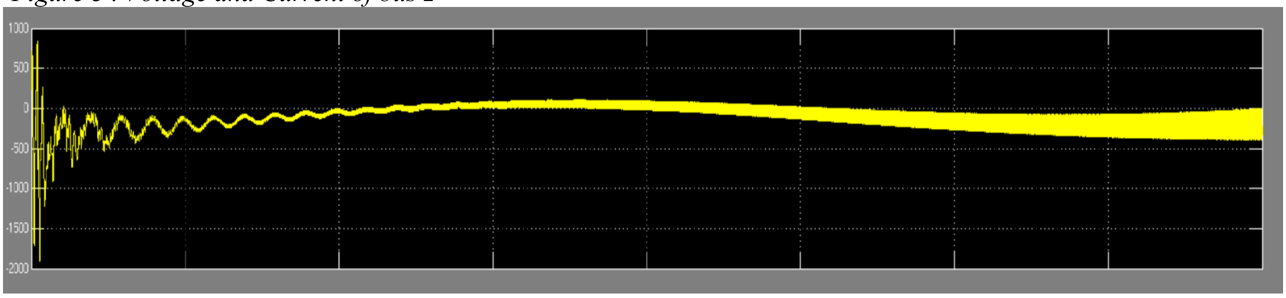
The dynamic performance of the SSSC is presented by real time voltage and current waveforms obtained after simulation. The simulation diagram for a two machine four bus system is given below. In this system SSSC is used for controlling the power flow through a 500KV transmission system. The system which has been made in ring mode consisting of four buses(B1-B4),connecting each other by transmission lines L2-1,L2-2, L2 and L3 having length 150KM,150KM, 75KM and 50KM respectively. The system has been supplied by two power plants with phase to phase voltage 13.8 KV. The simulation results obtained for bus 2 is given below. The SSSC has been connected to a bus that shows more variations in real and reactive power values.



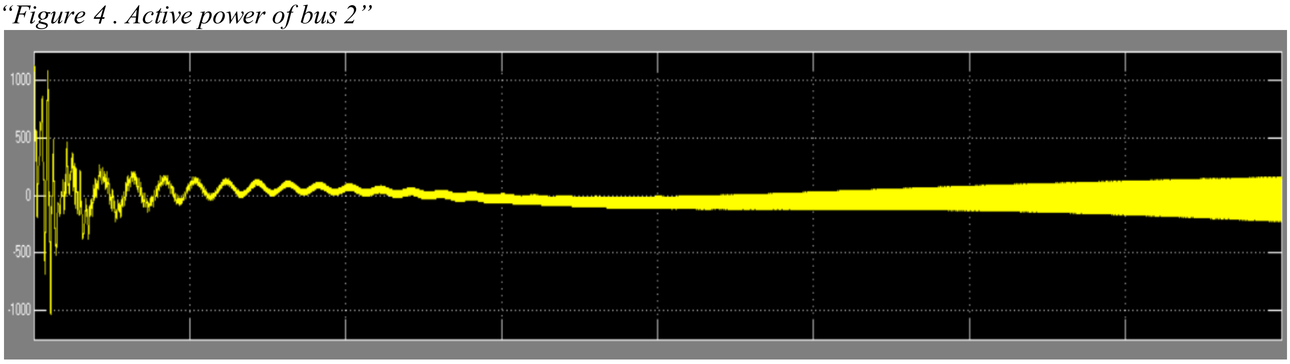
"Figure 2 . Two machine four bus system without SSSC"



"Figure 3 . Voltage and Current of bus 2"



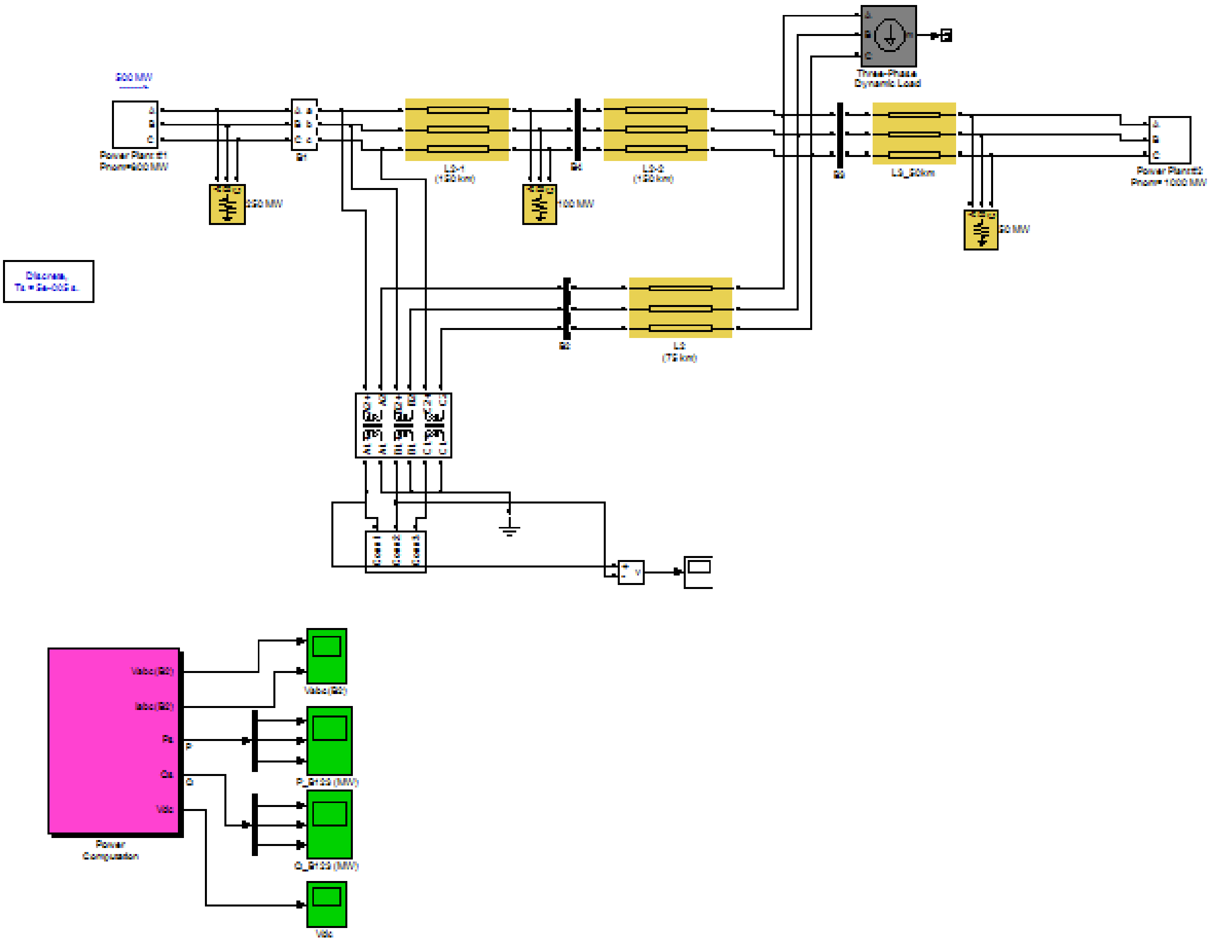
"Figure 4 . Active power of bus 2"



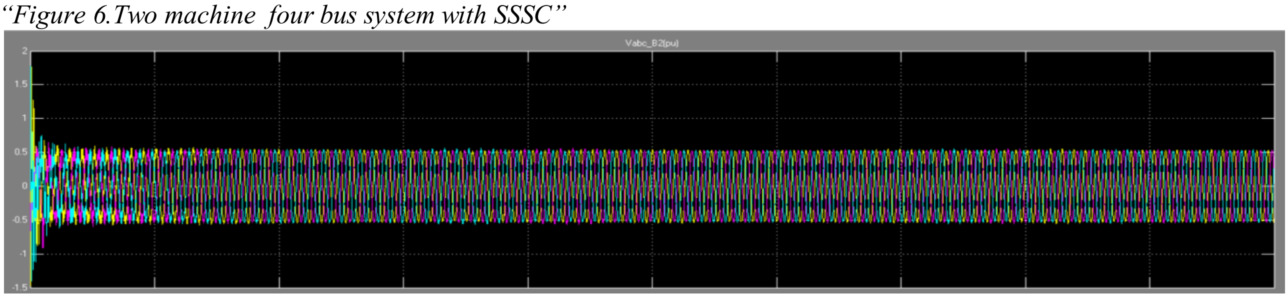
"Figure 5. Reactive power of bus 2"

III. TWO MACHINES FOUR BUS SYSTEM WITH SSSC

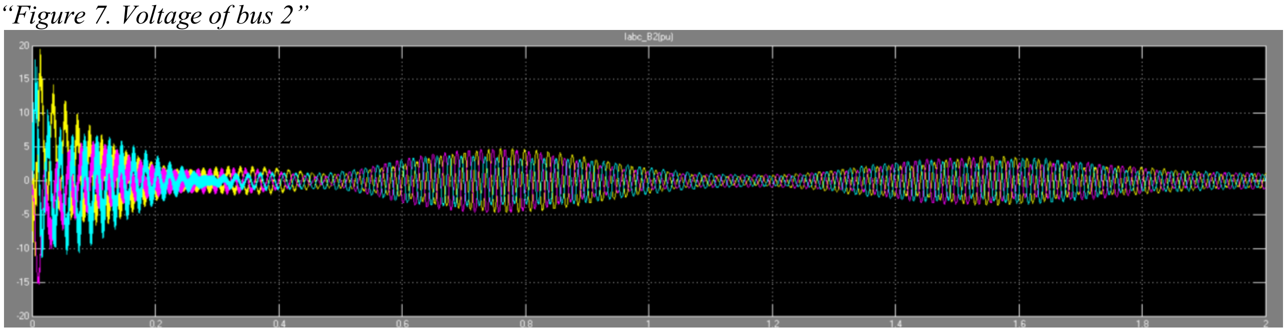
SSSC is controlling the active and reactive powers; beside these SSSC could fairly improve the transient oscillations of system. After the installation of SSSC, besides controlling the power flow in bus-2 we want to keep constant the voltage value in 1 per unit, hence the power flow is done in the presence of SSSC . According to the Fig., by installing the SSSC, active power damping time will be less than the mode without SSSC and it will be damped faster. Also as shown in Fig, reactive power damping time will be decreased and system will follow the references value with acceptable error.



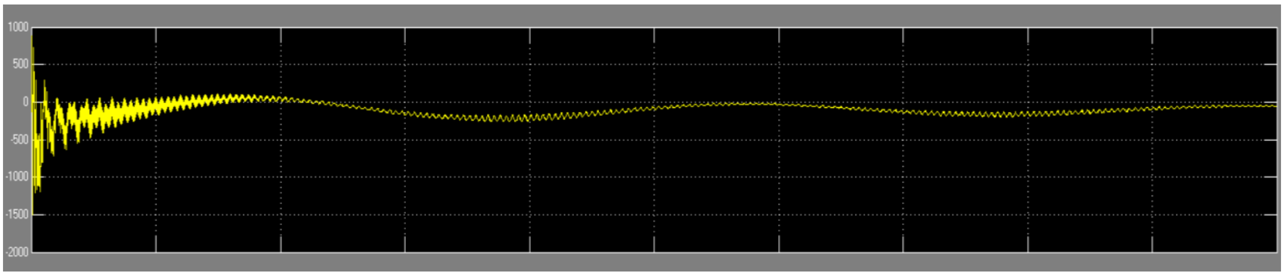
"Figure 6.Two machine four bus system with SSSC"



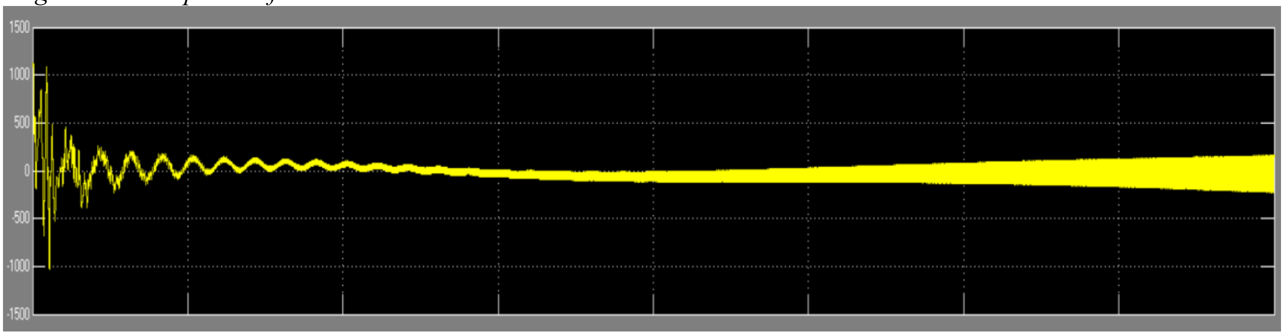
"Figure 7. Voltage of bus 2"



"Figure 8. Current of bus 2"



"Figure 9.Active power of bus 2"



"Figure 10. Reactive power of bus 2"

III. BUS-2 PARAMETER WITHOUT AND WITH SSSC

After simulation we have been obtained the real time voltage, current, power variations at bus 2. The active and reactive powers at bus 2 got oscillated due to large loads of the system and which keep continuing for almost 3 sec. Because of the ohmic loads the active power oscillations are more compared to reactive power oscillations. The preliminary controlling systems such as governor, PSS are used for damping these oscillations. According to the figures it is also clear that the voltage and current waveforms are closer to sinusoidal waveform. The voltage amplitude is 1 per unit and the current amplitude is 6.7 per unit.

SSSC is mainly used for controlling the active and reactive power flow through the transmission system and also to improve the transient stability of the system. Form the simulation result it is clear that after the installation of SSSC the active power oscillation damping time will be less than the mode without SSSC. Also it will decrease the reactive power damping time.

1. CONCLUSION

Static synchronous series compensator is capable of enhancing the power flow through the transmission system by injecting a fast changing voltage in series with the line. It is also observe that the SSSC injected voltage is in quadrature with line current. Based on obtained simulation result the performance of SSSC has been examined in multi- machine system. Here the performance of SSSC is presented by the real time voltage and current waveforms obtained after the simulation of a four bus system. The application of this can be extended to a multi machine multi-bus system to investigate the problems related to stability.

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