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Control of Active And reactive power flow in transmission line and power Oscillation damping by using Static Synchronous series compensator (SSSC).

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Abstract— the continuous demand in electric power system network has caused the system to be heavily loaded leading to voltage instability. This paper describe the active approach to series line compensation, in which static voltage sourced converter, is used to provide controllable series compensation. This compensator is called as Static synchronous series compensator (SSSC). It injects the compensating voltage in phase quadrature with line current, it can emulate as inductive or capacitive reactance so as to influence the power flow in the line. With DC power supply it can also compensate the voltage drop across the resistive component of the line impedance. In addition, the series reactive compensation can greatly increase the power oscillation damping.

Simulations have been done in MATLAB SIMULINK. Simulation results obtained for selected bus-2 in two machine power system. From the result we can investigate the effect of this device in controlling active and reactive power as well as damping power system oscillations in transient mode.

Keywords— Static synchronous series compensator (SSSC), Two machine power system, active and reactive power, power oscillation Damping.

I. INTRODUCTION

Nowadays, the need for flexible and fast power flow control in the transmission system is anticipated to increase in the future in view of utility deregulation and power wheeling requirement. The utilities need to operate their power transmission system much more effectively, increasing their utilization degree. Reducing the effective reactance of lines by series compensation is a direct approach to increase transmission capability. However, power transfer capability of long transmission lines is limited by stability considerations. [1] Power system planers, operators, and engineers have learned to live with this limitation by using a variety of ingenious techniques to make the system work effectively, but at a price of providing greater operating margins and redundancies. These represent an asset that can be effectively utilized with prudent use of FACTS technology on a selective, a needed basis. i.e. Proportional Integral Controller, Real and Reactive Power Flow, Voltage Stability. The FACTS devices (Flexible AC Transmission Systems) could be a means to carry out this function without the drawbacks of the electromechanical devices such as slowness and wear. FACTS can improve the stability of network, such as the transient and the small signal stability, and can reduce the flow of heavily loaded lines and support voltages by controlling their parameters including series impedance, shunt impedance, current, and voltage and phase angle. Controlling the power flows in the network leads to reduce the flow of heavily loaded lines, increased system load ability, less system loss and improved security of the system. [2] A Static Synchronous Series Compensator (SSSC) is a member of FACTS family which is connected in series with a power system. It consists of a solid state voltage source converter (VSC) which generates a controllable AC voltage at fundamental frequency. When the injected voltage is kept in quadrature with the line current, it can emulate as inductive or capacitive reactance so as to influence the power flow through the transmission line [2, 3].

II. BASIC SSSC CONFIGURATION.

The basic Configuration of the SSSC is shown in Fig. 1. The compensator is equipped with a source of energy, which helps in supplying or absorbing active power to or from the transmission line along with the control of reactive power flow. The dc capacitor has been replaced by an energy storage device such as a high energy battery installation to allow active as well as reactive power exchanges with the ac system. The SSSC's output voltage magnitude and phase angle can be varied in a controlled manner to influence power flows in a transmission line. The phase displacement of the inserted voltage, with respect to the transmission line current, determines the exchange of real and reactive power with the ac system [3]

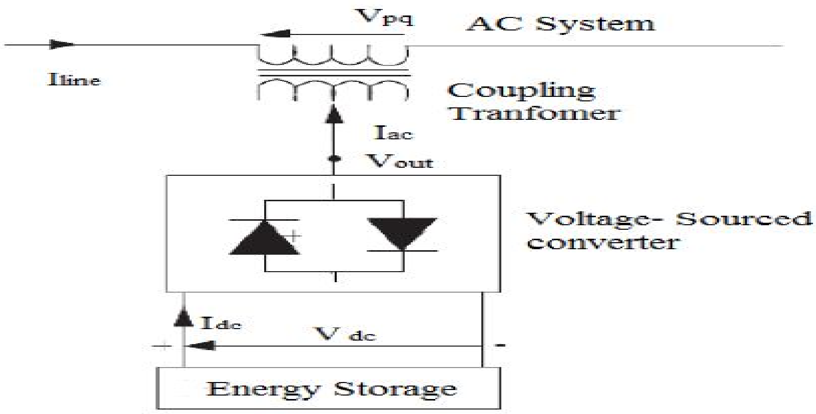

Fig.1 Static synchronous series compensator.

III. CONTROL SCHEME OF SSSC

SSSC is similar to the variable reactance because the injected voltage and current to the circuit by this device are changing depend upon to the system conditions and the loads entering/getting out. For responding to the dynamic and transient changes created in system, SSSC utilizes the series converter. One side of the converter is connected to the AC system and the other side is connected to a capacitor and battery which in the system we assume DC source as battery. If a dynamic change in system will be occurred, the energy of battery will be converted to the ac form by converter and then injecting this voltage to the circuit the changes will be damped appropriately. To control the active and reactive powers of bus-2, the control circuit as shown in Fig. 2 is utilized. For controlling the powers, first, sampling from the voltage and current is done and transformed to the dq0 values. Active and reactive powers of bus-2 are calculated using their voltage and current in dq0 references and compared with the determined reference and the produced error signal is given to the PI controllers. Adjusting parameters of the PI controllers, we are trying to achieve the zero signal error, such that powers can follow the reference powers precisely. Then, the output of the controllers are transformed to the abc reference and given to the PWM.

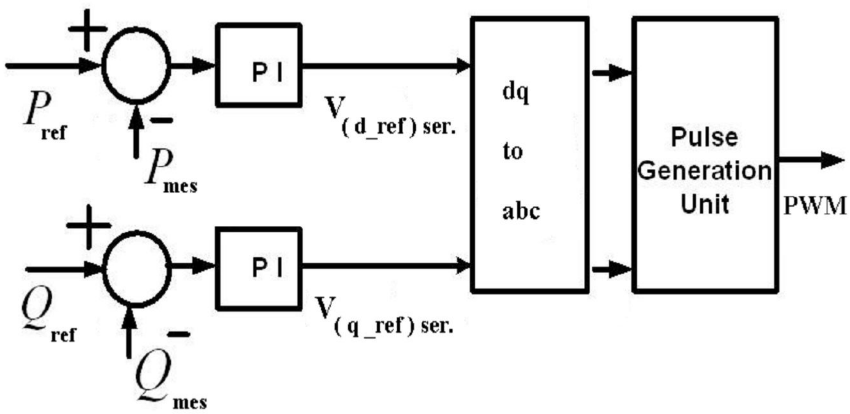

Fig .2 Control Scheme for SSSC.

IV. TWO MACHINE POWER YSTEM MODEL.

The system shown in fig.3 is simulated in MATLAB SIMULINK, to analyze the dynamic performance of SSSC in real time current and voltage waveforms. Which has been made in ring mode consisting of 4 buses (B1 to B4) connected to each other through three phase transmission lines L1, L2-1, L2-2 and L3 with the length of 280, 150, 150 and 50 km respectively. System has been supplied by two power plants with the phase-to-phase voltage equal to 13.8 kv Active and reactive powers injected by power plants 1 and 2 to the power system are presented in per unit by using base parameters Sb=100MVA and Vb=500KV, which active and reactive powers of power plants 1 and 2 are (24-j3.8) and (15.6-j0.5) in per unit, respectively.

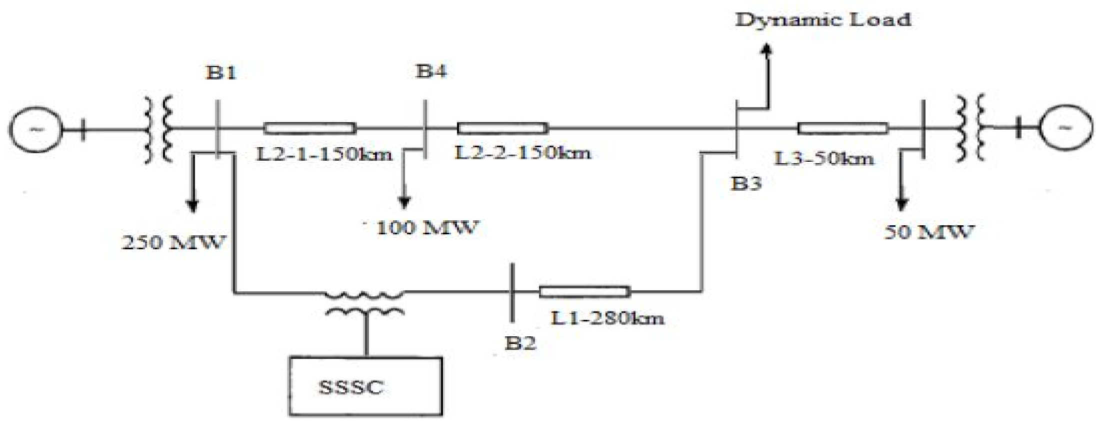

Fig.3 Single line diagram for tow machine system with SSSC.

V. SIMULATION RESULTS IN MATLAB SIMULINK

The power system with two machines and four buses has been simulated in MATLAB environment, and then active and reactive powers and voltages in all buses have been obtained. The bus 2 is at the middle of the transmission line so that it was selected as candidate bus to connect the SSSC Therefore, the simulation results have been focused on bus-2.

A. Bus -2 Parameter s without SSSC

Changes in current, voltage, active and reactive powers of bus-2 have been obtained in real time. The Figure. 4 shows the simulink model without SSSC .at first, due to the large loads of the system active power of bus-2 got oscillations which keep continuing for 3 seconds.

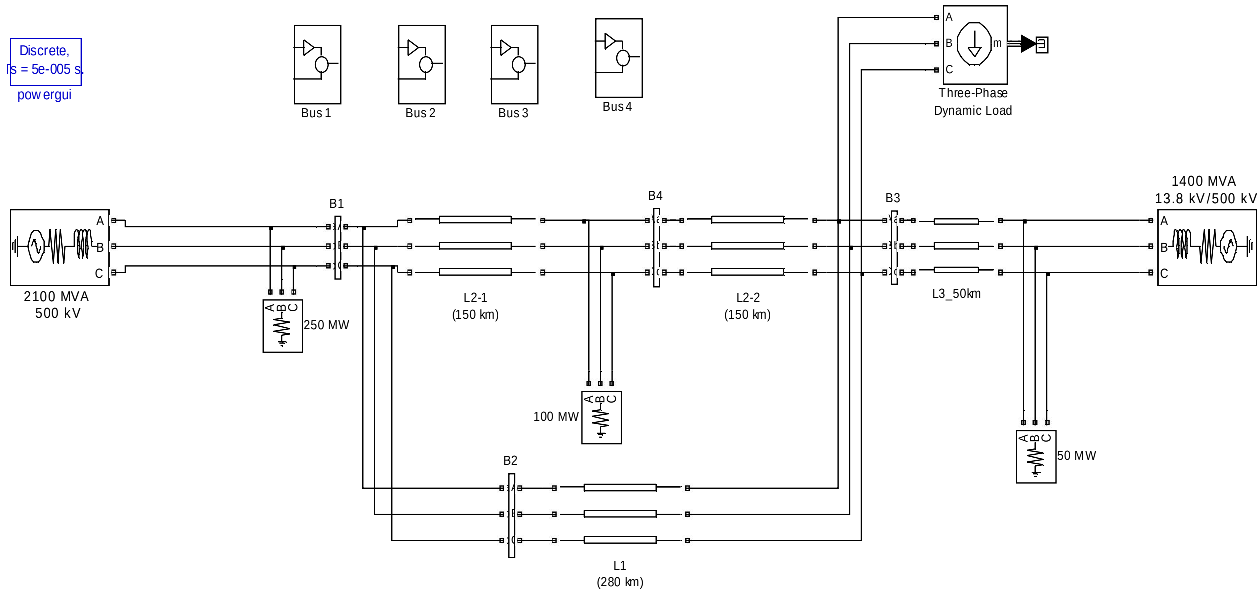

Fig.4 Simulink model of two machine system without SSS.

According to fig 5 and fig. 6 active and reactive power of bus -2 got oscillations and then damped properly by controlling systems in plants 1 and 2 such as governor, PSS and other stabilizing devices.

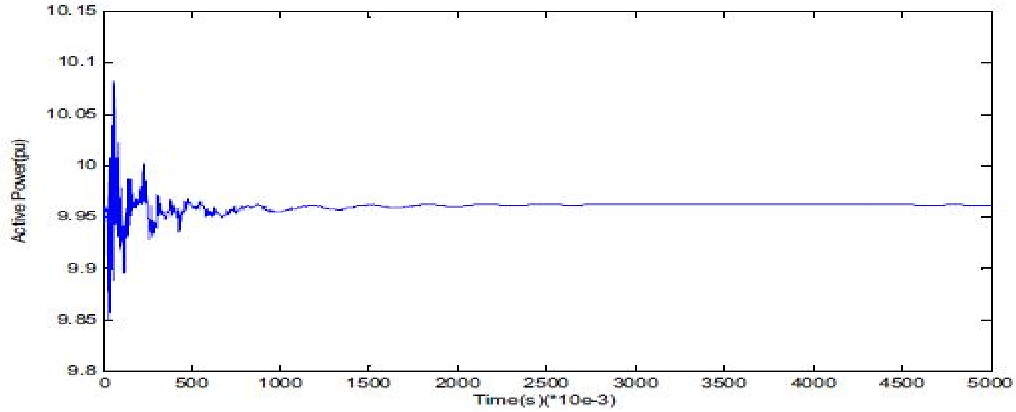

Fig. 5 Active power of bus-2 without SSSC

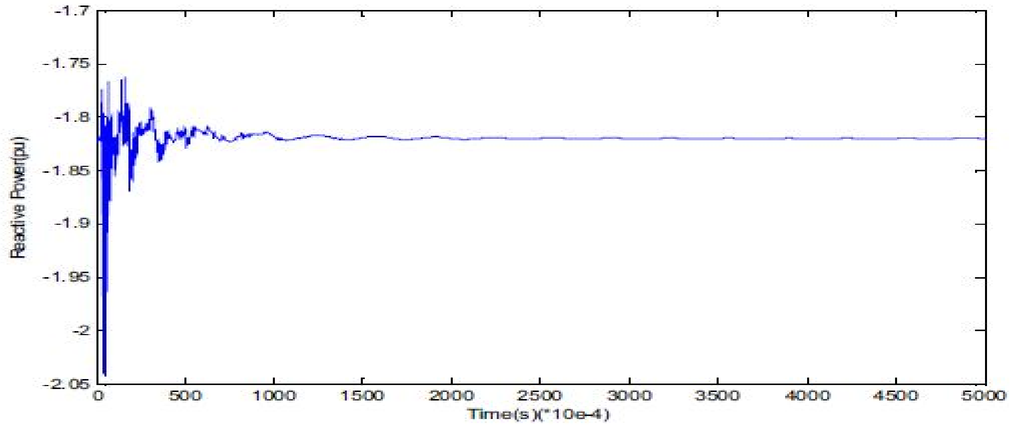

Fig. 6 Reactive power of bus-2 without SSSC

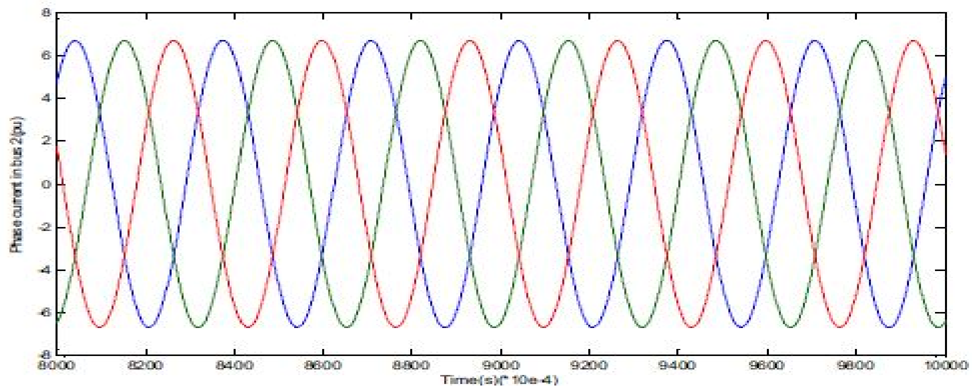

Fig.7 Phase current of bus-2 without SSSC.

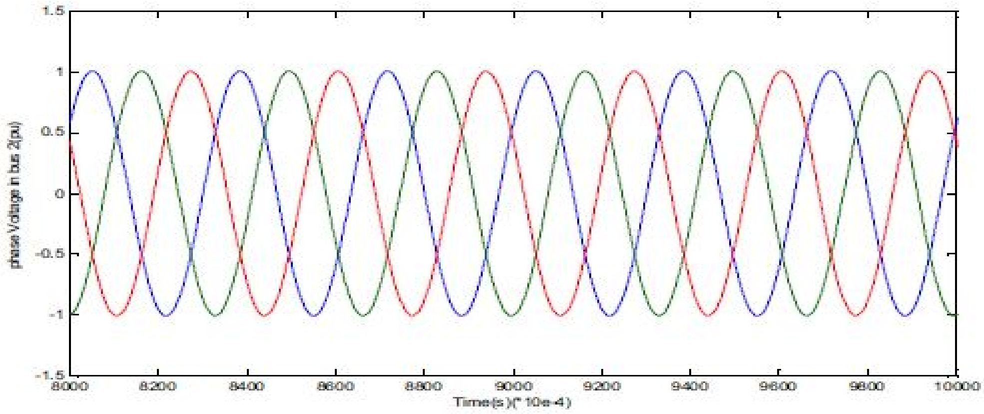

Fig. 8 Voltage of bus-2 without SSSC.

B. Bus-2 Parameters with SSSC

As shown in Figure. 9, SSSC has been placed between bus-1 and bus-2 and the aim is achieving the following active and reactive powers: P_{ref} = 4 pu Q_{ref}.= -1 pu

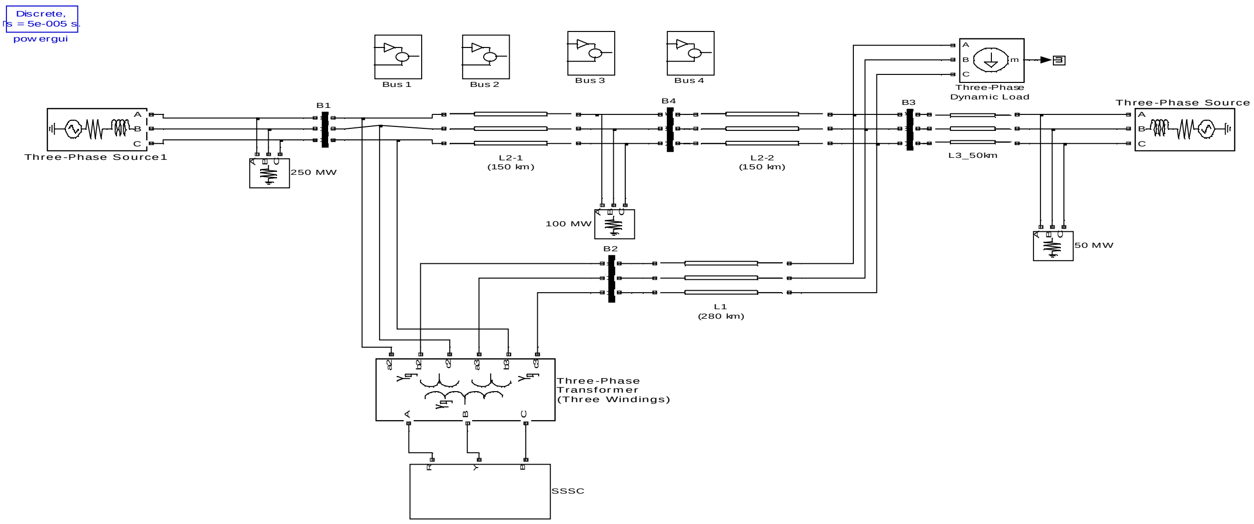

Fig. 9 Simulink model of two machine system with SSSC

The main role of 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 and the simulation results are as follows.

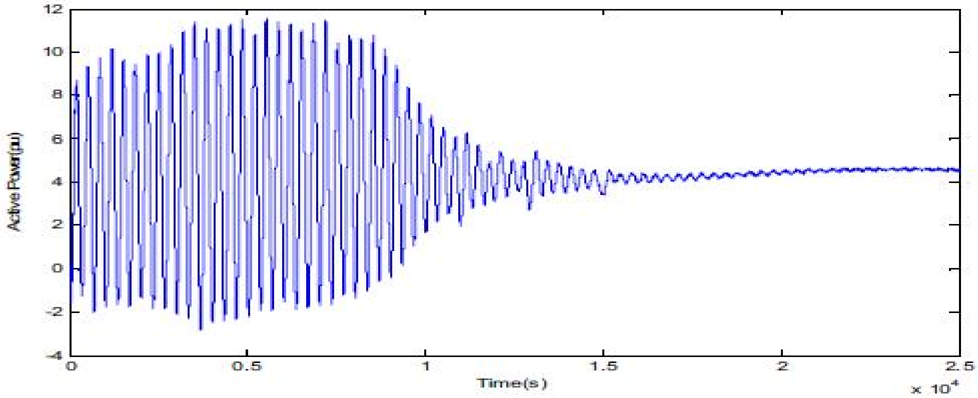

Fig. 10 Active power of bus-2 without SSSC

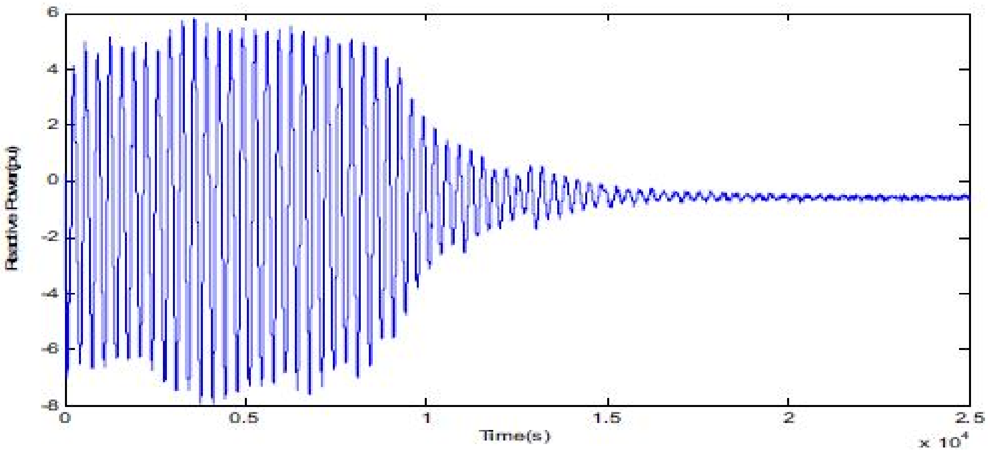

Fig. 11 Reactive power of bus-2 without SSSC

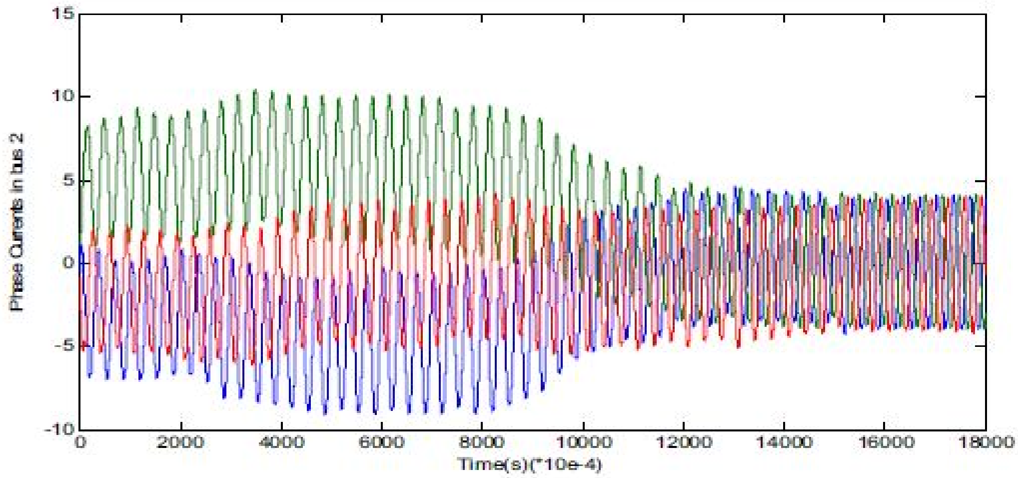

Fig. 12 Current of bus-2 with SSSC

VI. Conclusion

From the simulation result it is clear that SSSC is capable of controlling active and reactive power flow in the power system at desired point. From the simulation results the performance of SSSC has been examined in simple two machine system, and applications of SSSC can be extended to complex and multi machine system.

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