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ENHANCEMENT OF POWER SYSTEM STABILITY IN THREE MACHINE SYSTEM BY USING SSSC

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ABSTRACT-This paper proposes the improvement of voltage stability using Static Synchronous Series Compensator (SSSC). The SSSC is a series voltage source. The increase demand in electric power system network has caused the system to be heavily loaded conditions leading to voltage instability. Under heavy loaded conditions there may be insufficient reactive power causing the voltages to drop. This drop may lead to drops in voltage at various buses. In SSSC the dc capacitor has been replaced by an energy storage device such as a high energy battery installation to allow active as well as reactive power exchanges with the ac system. Flexible AC transmission systems (FACTS) controllers have been mainly used for solving various power system stability control problems. In this study, a static synchronous series compensator (SSSC) is used to controlling active and reactive powers as well as damping power system oscillations in transient mode. To control overall system PI controller is used. The PI controller is used to tune the circuit and to provide the zero signal error. The dynamic performance of SSSC is presented by real time voltage and current waveforms using MATLAB software.

Keywords— Static Synchronous Series Compensator (SSSC), Superconducting Magnetic Energy Storage (SMES), multi area system, transient disturbances.

I. INTRODUCTION

In recent years, the demands have been placed on the transmission network and the increase in demands the power quality problems will be occurred. The power quality problems are voltage balancing, unbalancing and instability. Increasing demands, lack of long term planning, and the need to provide open access electricity market for Generating Companies and utility customers, all of them have created tendencies security and reduced quality of supply. The power could be a means to carry out this function without the systems of today, by and large, are mechanically controlled. There is a widespread use of microelectronics, computers and high-speed communications for control and protection of present transmission systems; however, when operating signals are sent to the power circuits, where the final power control action is taken, the switching devices are mechanical and there is little high-speed control. Another problem with mechanical devices is that control cannot be initiated frequently, because these mechanical devices tend to wear out very quickly compared to static devices. In effect, from the point of view of both dynamic and steady-state operation, the system is really uncontrolled. Power system planner, 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, as needed basis.

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.

The static synchronous series compensator (SSSC) FACTS controller is used to prove its performance in terms of stability improvement. A Static Synchronous Series Compensator (SSSC) is a member of F ACTS family which is connected in series with a power system. It consists of a solid state voltage source converter (VSC) which generates a controllable alternating current 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. While the primary purpose of a SSSC is to control power flow in steady state, it can also improve transient stability of a power system. Here PI controller is used to control the parameters of the power system. The Fig.l Shows a functional model of the SSSC [4] where 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.

II. OPERATION PRINCIPLE OF SSSC

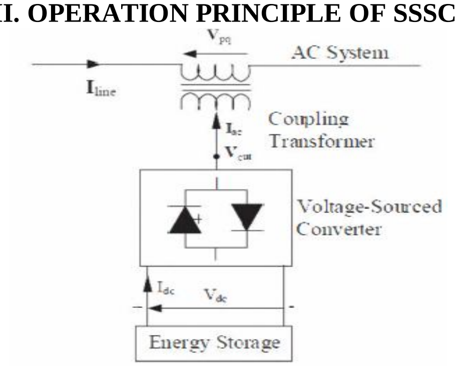

Fig (l): Functional Model of SSSC

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 Vpq, with respect to the transmission line current line I, determines the exchange of real and reactive power with the ac system

Control structure of sssc

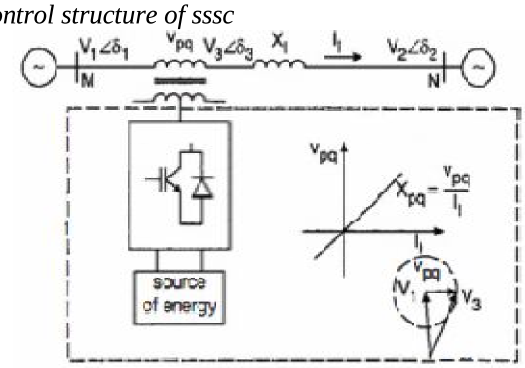

Fig (2): Single Line Diagram of Simple Transmission Line

Fig. 2 shows a single line diagram of a simple transmission line with an inductive reactance, XL, connecting a sending end voltage source, VS, and a receiving-end voltage source, Vr espectively [8].The real and reactive power (P and Q) flow at the receiving end voltage source are given by the expressions

(1)

(2)

Where V s and Vr are the magnitudes and 15s and Dr are the phase angles of the voltage sources Vs and Vr respectively. For simplicity, the voltage magnitudes are chosen such those Vs = Vr = V and the difference between the phase angles is:

(3)

An SSSC, limited by its voltage and current ratings, is capable of emulating a compensating reactance Xq (both inductive and capacitive) in series with the transmission line inductive reactance XL, Therefore, the expressions for power flow given in equation (l & 2) becomes

(4)

(5)

Where Xeff is the effective reactance of the transmission line between its two ends, including the emulated variable reactance inserted by the injected voltage source of the Static Synchronous Series Compensator (SSSC).

The compensating reactance Xq is defined to be negative when the SSSC is operated in an inductive mode and positive when the SSSC is operated in a capacitive mode.

III. THREE MACHINE MODELLING

The dynamic performance of SSSC is presented by real time voltage and current waveforms. Using MATLAB software the system shown in Fig. 3, has been obtained [1]. In the simulation one SSSC has been utilized to control the power flow in the 500 KV transmission systems.

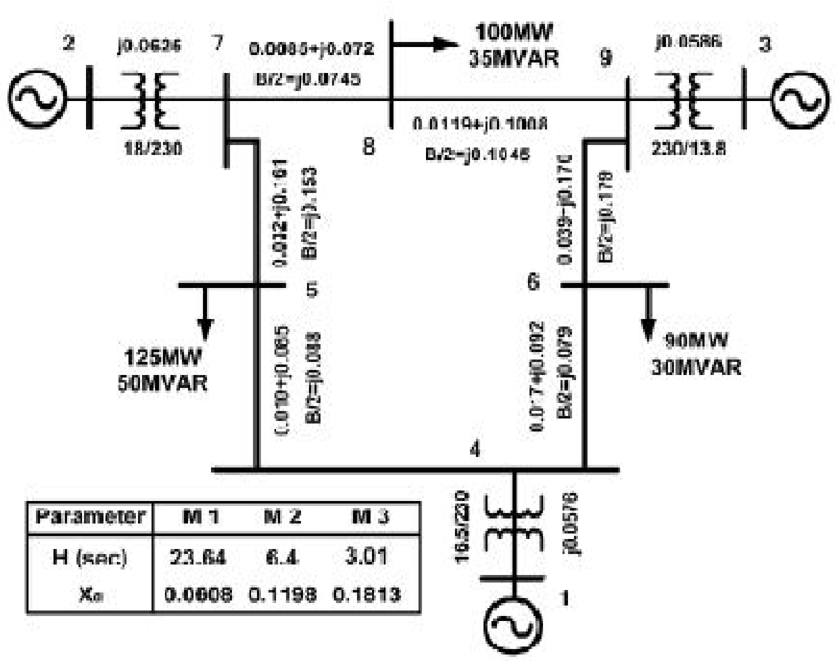

Fig (3): Three Machine System without SSSC

Table I. Simulation results without SSSC

BUS NO	VOLTAGE	CURRENT	P	Q
1	1.093	24.57	3.961e9	-7.31e8
2	1.002	33.5	4.951e9	-9.138e8
3	1.002	19.42	2.87e9	-5.296e8
4	0.9958	28.18	4.14e9	-7.641e8
5	0.9935	12.31	1.804e9	-3.328e8
6	1.001	22.49	3.323e9	-6.132e8
7	1.005	29.31	4.343e9	-8.015e8
8	0.9975	22.83	3.359e9	-6.199e8
9	0.9991	16.67	2.456e9	-4.533e8

Table II. SImulation results wIth SSSC

BUS NO	VOLTAGE	CURRENT	P	Q
1	1.093	24.57	3.961e9	-7.31e8
2	1.002	33.5	4.951e9	-9.318e8
3	1.002	19.42	2.87e9	-5.296e8
4	1.011	31.49	4.696e9	-8.667e8
5	1.008	13.73	2.041e9	-3.768e8
6	1.011	38.19	5.698e9	-1.052e8
7	1.01	35.31	5.258e9	-9.705e8
8	1.008	26.67	3.963e9	-7.315e8
9	1.009	16.83	2.506e9	-4.625e8

This system which has been made in ring mode consisting of4 buses (Bl 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 5 kIn respectively. System hasbeen supplied by three power plants with the phase-to-phase voltage equal to 13.8 Kv.

IV. SIMULATION RESULTS

A. Simulation results without sssc

In order to evaluate the stability, all possible fault cases should be considered. In this work, there are 12 cases. For example, there is a three-phase fault on line 4-6 near bus 4. For convenience, the situation involves a fault at bus 4, and line 4-6 is removed post-fault.

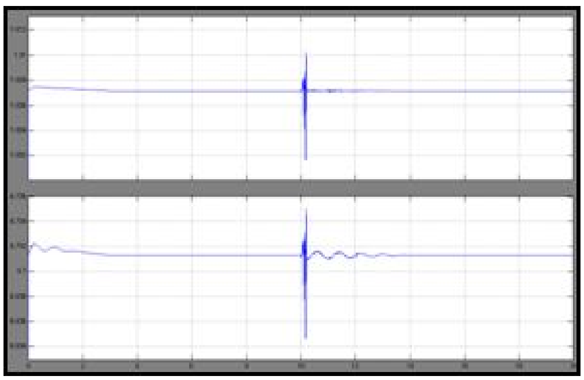

Fig (4): voltage and current rating of bus-4 without SSSC

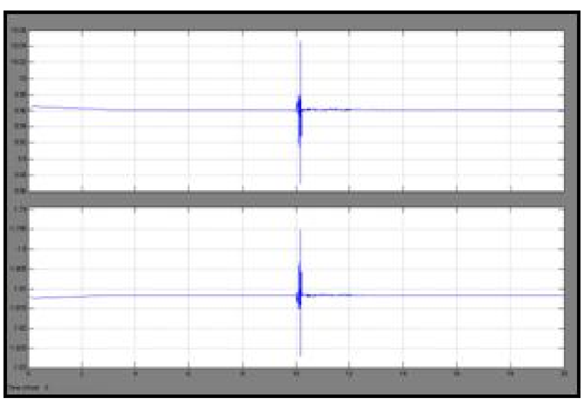

Fig (5): Real and reactive Power of bus-4 without SSSC

Bus-4 parameter 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-4 we want to keep constant the voltage value in 1per unit, hence the power flow is done in the presence of SSSC and the simulation results are as follows.

B. Simulation results with SSSC

Power system with two machines and four buses after incorporating SSSC has been simulated in MATLAB environment, and then powers and voltages in all buses have been obtained. The results have been given in Table 2

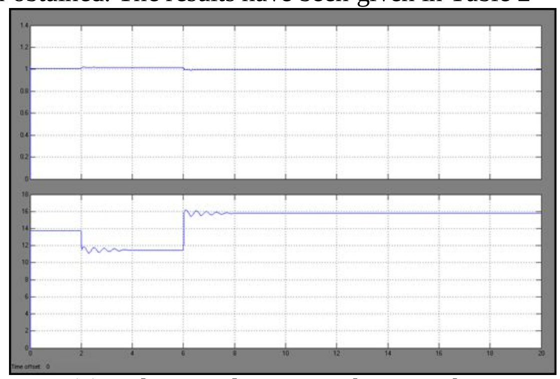

Fig (6): voltage and current at bus-4 with SSSC

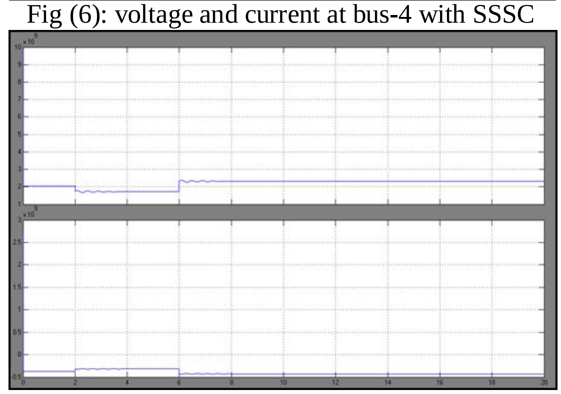

Fig (7): Real and reactive Power of bus-4 with SSSC

Obtained results of bus-4 had proven that the stability of power system parameters has been increased.

V. CONCLUSION

The dynamic performance of the SSSC with three machines system is analyzed. It has been found that the SSSC is capable of controlling the flow of power, voltage stability, active and reactive power at a desired point on the transmission line. It is also observed that the SSSC injects voltage in series with the line irrespective of the magnitude and phase of the line current. Based on obtained simulation results the performance of the SSSC has been examined in a three machine system, and applications of the SSSC will been extended in future to a complex system to investigate the problems related to the various modes of power oscillation in the power systems.

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