

## POWER SYSTEM STABILITY OF MULTI MACHINE BY USING STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)

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### ABSTRACT

In this paper the problem of modeling and simulation of voltage stability is improved using Static Synchronous Series Compensator (SSSC). Due to the continuous demand in electric power system, the system is heavily loaded, this causes to voltage instability. In this work, a static synchronous series compensator (SSSC) is used to minimize the effect of this device in controlling active and reactive powers as well as damping power system oscillations in transient mode. The PI controller is used to achieve the zero signal error. The result is obtained from simulation using MATLAB. In short when any disturbances occur in transmission line, if SSSC is connected then disturbance in the system is minimized & system will reach the steady state condition very quickly.

**KEYWORDS-** Static Synchronous Series Compensator (SSSC), Voltage Stability, PI controller (Proportional Integral).

### INTRODUCTION

A network which contains electrical component to supply, generation, transmission and use of electrical power is called as electrical power system. Now in power system all areas are connected with each other which we called interconnected power system. Electric power system is combination of generation, transmission and distribution. So due to use of large system there is different types of disturbances are produced which may lead to unwanted effects on the network, such as loss of synchronism in generators. Solving the problems of transient stability determine the behavior of a power system for as much as more seconds following a power disturbance. SSSC has been used at in series the transmission line for damping and compensation for the improvement in the power transfer capability. The static synchronous series compensator (SSSC) is a series device of the Flexible AC Transmission system.

Systems (FACTS) family device are used to control power flow and improve transient stability on power grids. The SSSC controls voltage at its terminals by controlling the amount

of reactive power injected into or absorbed from the power system. Here in this paper a concept is introduced with simultaneous operation of multi machine system with SSSC converter. The SSSC is connected at bus-3 of the transmission line. The multi machine power systems are simulated using MATLAB and the effect of with and without SSSC on system and in fault condition are simulated. 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, 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.

## STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)

The voltage-sourced convertor-based series compensator, called Static Synchronous Series Compensator [3]. The Figure 1, [1] [2][4] shows a functional model of the SSSC 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. 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  $V_{pq}$ , with respect to the transmission line current  $I$ , determines the exchange of real and reactive power with the ac system.

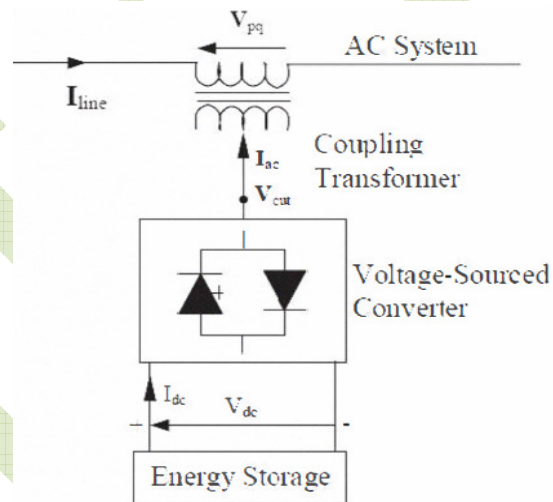
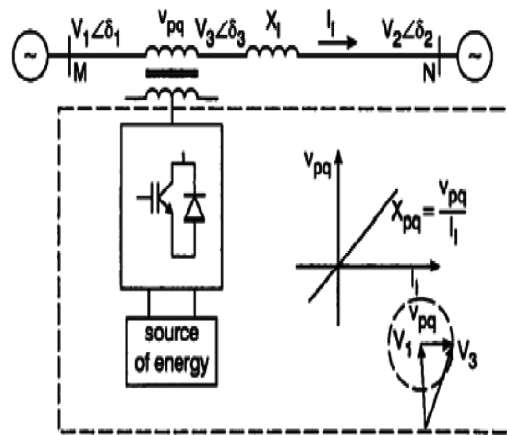


Fig.1: Functional Model of SSSC

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.

## SSSC CONFIGURATION



**Figure.2 Single Line Diagram of Simple Transmission Line**

The basic scheme of the SSSC is shown in Fig.2 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 [5]. The real and reactive power ( $P$  and  $Q$ ) flow at the receiving end voltage source are given by the expressions

$$P = \frac{V_s V_r}{X_L} \sin(\delta_s - \delta_r) = \frac{V^2}{X_L} \sin\delta \quad (1)$$

$$Q = \frac{V_s V_r}{X_L} (1 - \cos(\delta_s - \delta_r)) = \frac{V^2}{X_L} (1 - \cos\delta) \quad (2)$$

Where  $V_s$  and  $V_r$  are the magnitudes and  $\delta_s$  and  $\delta_r$  are the phase angles of the voltage sources  $V_s$  and  $V_r$  respectively. For simplicity, the voltage magnitudes are chosen such those  $V_s = V_r = V$  and the difference between the phase angles is:

$$\delta = \delta_s - \delta_r \quad (3)$$

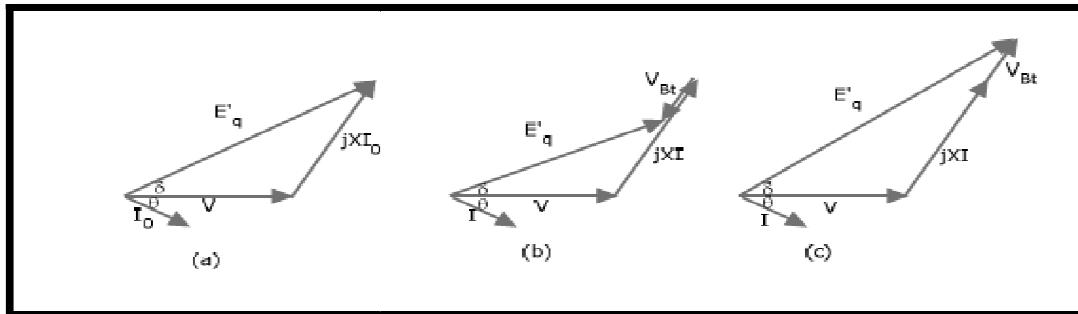
An SSSC, limited by its voltage and current ratings, is capable of emulating a compensating reactance  $X_q$  (both inductive and capacitive) in series with the transmission line inductive reactance  $X_L$ . Therefore, the expressions for power flow given in equation (1 & 2) becomes

$$P_q = \frac{V^2}{X_{eff}} \sin\delta = \frac{V^2}{X_L(1-X_q/X_L)} \sin\delta \quad (4)$$

$$Q_q = \frac{V^2}{X_{eff}} (1 - \cos\delta) = \frac{V^2}{X_L(1-X_q/X_L)} (1 - \cos\delta) \quad (5)$$

Where  $X_{eff}$  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  $X_q$  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 [1].



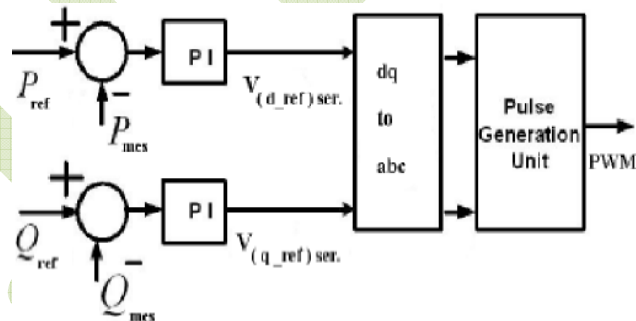
**Figure.3 Phasor diagram:**

- (a) When  $V_{Bt} = 00$ ;
- (b) When  $V_{Bt}$  lags  $I$  by  $90^\circ$ ;
- (c) When  $V_{Bt}$  leads  $I$  by  $90^\circ$ .

A variable synchronous voltage source  $V_{Bt}$  represents the SSSC. Fig.3 shows the phasor diagram of the system for SSSC's various operating conditions. Note that, the SSSC voltage  $V_{Bt}$ , changes the magnitude of the current for a given  $V_t$  and  $V$ , and not its angle [5].

### NEW TECHNOLOGY

I am going to improve the previous technology using PI-controller with SSSC. By using PI-controller we control the parameter with respective reference values of voltage & current [4].



**Figure.4 the Control Circuit of SSSC**

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 PWM is given to the SSSC.

## TWO MACHINE POWER SYSTEM MODELING

The dynamic performance of SSSC is presented by real time voltage and current waveforms. Using MATLAB software the system shown in Fig.5, has been obtained [4]. In the simulation one SSSC has been utilized to control the power flow in the transmission systems. This system 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 5 km respectively [1][5].

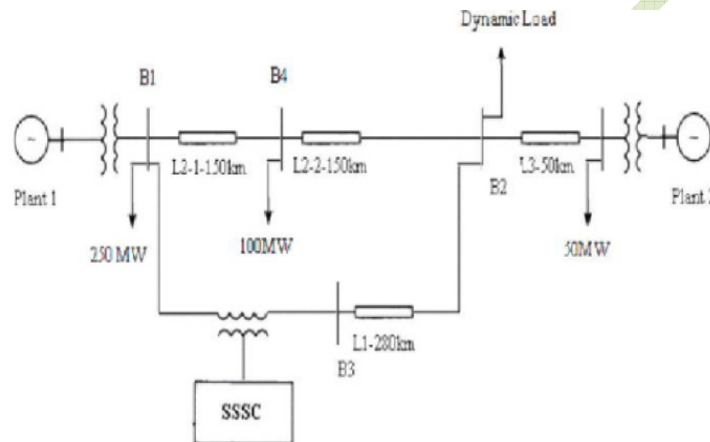


Figure no.5 test system

## CONCLUSIONS

It can be found that the SSSC is capable of controlling the flow of power at a desired point on the transmission line. By studying it know that, the SSSC injects a fast changing voltage in series with the line irrespective of the magnitude and phase of the line current. This paper presents a systematic procedure for modeling, simulation and optimal tuning of SSSC controller in a multi- machine system for enhancing power system stability. For the SSSC controller design problem, a parameter-constrained, time-domain based, objective function, is developed to improve the performance of power system subjected to a disturbance.

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*International Journal of Modern Engineering Research (IJMER) www.ijmer.com Vol. 3, Issue. 4, Jul - Aug. 2013 pp 2530-2536*

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