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Improvement of Power system transient stability using static synchronous series compensator

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Abstract- **The power system industry is a field where there are constant changes occurs. Economic and environmental pressures force electric companies to enhance the power transfer capability of the existing transmission lines instead of constructing new ones. Besides allowing a better utilization of existing power systems capacity, FACTS controllers can control network parameters, such as magnitude of sending-end and receiving-end voltage, and active-reactive power, to improve both the transient stability performance of the system. In thesis work describe the Static synchronous series compensator device, that controls the power flow of the transmission line during sever disturbances. Basics of Static synchronous series compensator is that it does not contains bulky component like reactor and inductor so this device is more economical compare to conventional devices. And characteristic of Static synchronous series compensator is that injects or absorbs the reactance in the system and control the power. In thesis work two machine bus system with and without discrete PI controller and SSSC converter simulated in MATLAB .Simulation result obtained for selected Bus-3 in two machine power system shows that with SSSC the active-reactive powers, voltage - current compensation and damping out oscillation appropriately. In short in the power system when any disturbance occurs at that time if Static synchronous series compensator controller is connected at there so any disturbance occurs on the system may reach steady state condition very quick.**

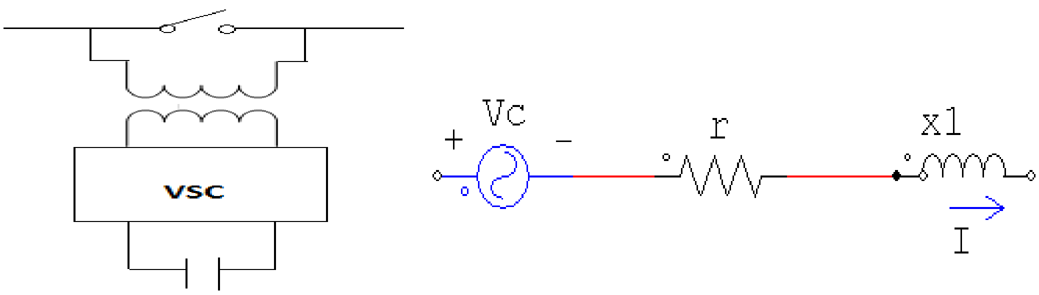
Index Terms-**Static synchronous series compensator, PI Controller, FACTS, Transient Stability**

I. INTRODUCTION

A network which contains or possess electrical component to supply, generation. Transmit and use electrical power is called as electrical power system. Now currently in power system all areas are connected with each other which we called interconnected power system. Electric power system is combination in which generators, transmission and distribution facilities and electrical loads element are connected to each other regularly. Such due to large system is different types of disturbances produced which may lead to unwanted or unnecessary effects on the network, such as blackouts or loss of synchronism in generators. Evaluation of transient stability search out 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 [3]. The static synchronous series compensator (SSSC) is a series device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids [1, 3]. The SSSC regulates voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system.

Here in this paper a new simple concept is introduced with simultaneous operation of two machine system with SSSC converter. The SSSC is connected at bus-3 of the transmission line. The two-machine power system is simulated using MATLAB and the effect of with and without SSSCon system and in fault condition are simulated.

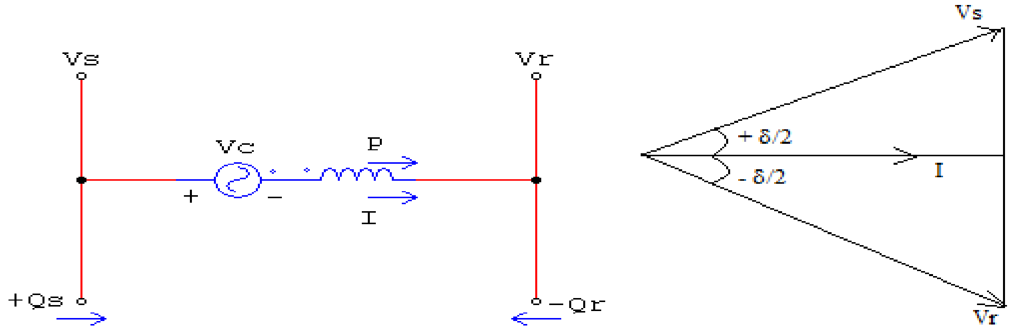
II. STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)



(a) Symbol of SSSC (b) equivalent circuit of SSSC

Fig. 1 Schematic of SSSC

The static sysnchronous series compensator (SSSC) is a series device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids. In place of using capacitor and reactor banks, a SSSC use self-commutated voltage-source switching converters to synthesize a three-phase voltage in quadrature with the line current. The main interest is to use the SSSC for controlling flow of power (active and/or reactive) in transmission lines, whereas the SSSC is mainly recommended for damping electromechanical oscillations. Thus, the SSSC control system may be made by a compensation control loop, to accomplish its steady-state function, and by a fast response control, to act during electromechanical transients.[9][11]



(a) Single line diagram (b) Phasor diagram

Fig. 2 Representation of SSSC in Transmission line

The power flow (P) in the transmission line of system is given by

$$P = VI\ \text{Cos}\ \frac{\delta}{2} = \frac{V.Vc}{X}\text{Cos}\ \delta + \frac{V^2\ \text{Sin}\ \delta}{X}$$

The reactive power supplied at the two ends of the line are equal (Q). The expression for Q is given by

$$Q = VI\ \text{Sin}\ \frac{\delta}{2} = \frac{V.Vc}{X}\text{Sin}\ \frac{\delta}{2} + \frac{V^2}{X}\ (1 - \text{Cos}\ \delta)$$

III. TWO MACHINE SYSTEM MODELING

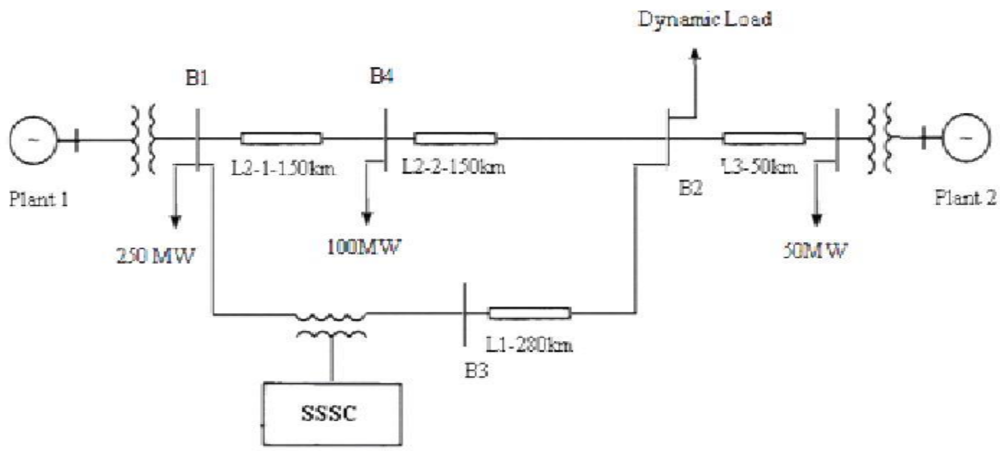


Fig. 3 Test System

As shown in fig. 3 in this paper two machine system used and at bus-3 SSSC is connected using insertion transformer. Bus B1 to B4 connected to each other through three phase transmission line L1,L2-1,L2-2,L3 which are 280km,150km,150km and 50km long respectively.in system phase to phase voltage is equal to 13.8kv ,base parameter in pu Sb=100MVA.control of power is done using PI controller, first sampling from current and voltage done and transformed to dq0 values. Measured value and reference value of active and reactive power are compared and error signal is given by PI controller. output of the controllers are transformed to abc value. Bus-3 is selected at where SSSC is installed.

SIMULATION RESULT with MATLAB

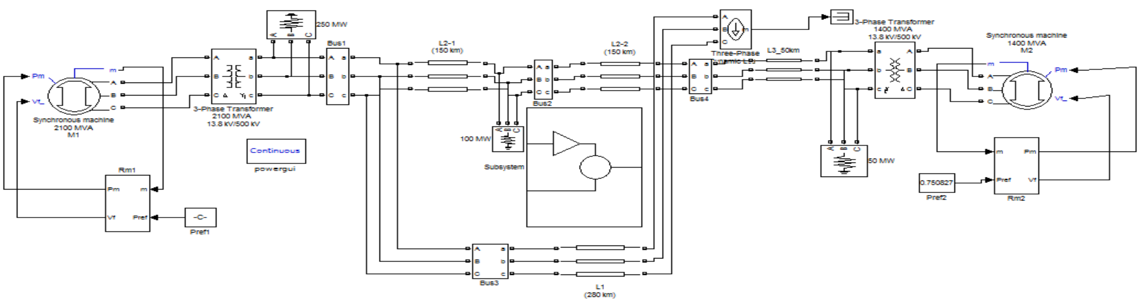


Fig. 4 Two machine system without SSSC

Table.1 The Specification and Parameters of the two-Machine System

Specification	System Parameters
Machine1(G1)	2100MVA,13.8KV
Machine2(G2)	1400MVA,13.8KV
Transformer 1 (TR1)	2100MVA,13.8/500KV
Transformer 2 (TR2)	1400MVA,13.8/500KV
Load	2000MW
Base power	100MVA

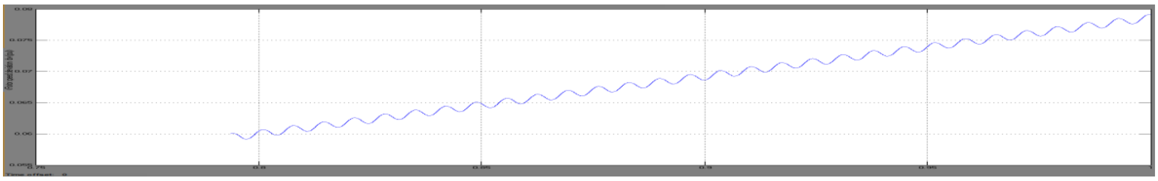


Fig. 5Rotor speed deviation without SSSC

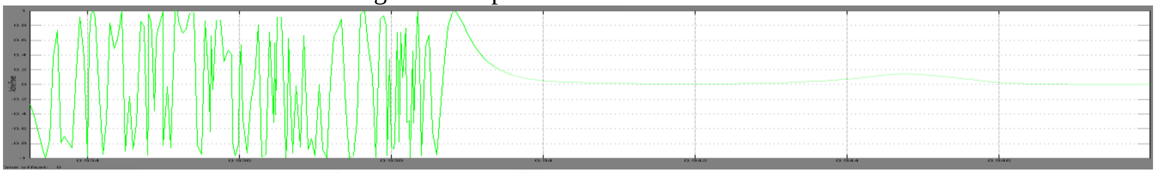


Fig. 6 active power without SSSC

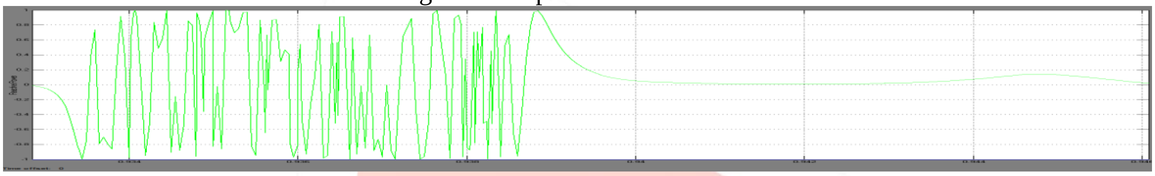


Fig. 7 reactive power without SSSC

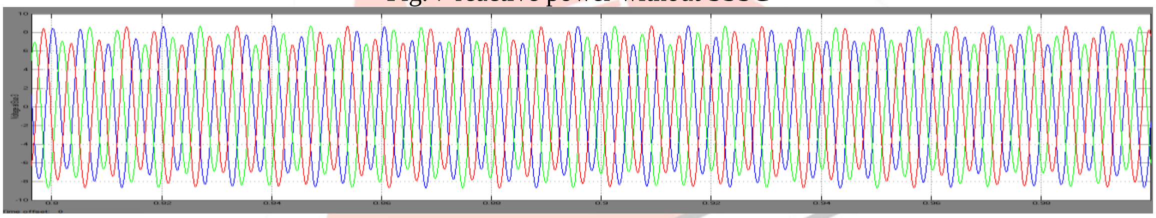


Fig. 8 Voltage at Bus-3 without SSSC

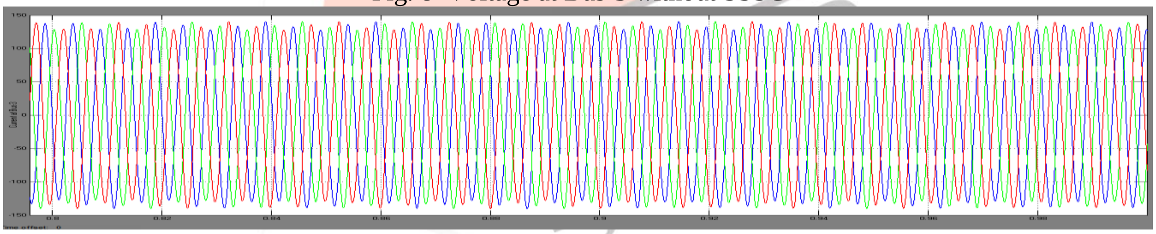


Fig. 9 Current at Bus-3 without SSSC

BUS-3 Parameter without SSSC

In rotor speed deviatiob ,active power,reactive power, voltage and current changes of bus-3 are obtained in real time. As shown in fig.5 at the starting roptor speed deviation contains some oscillation due to initial load on system. Fig.6 shows the active power got oscillations in starting more due to initial load but plant stabilizing devices try to control this oscillations.same as fig.7 shows reactive power got oscillation first more and then due to stabilizing device in plant oscillation are control after some time. Due to ohmic part of the system oscillation amplitude are affected. According to fig. 8 and fig.9 due to transient mode more disturbance created and they are not in sinusoidal form.

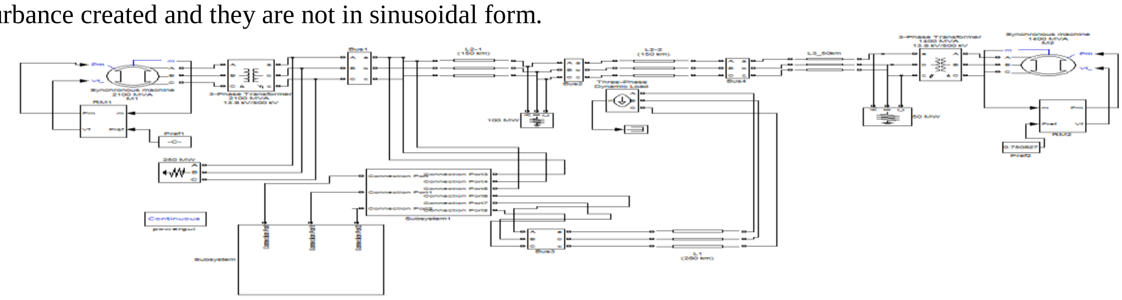


Fig. 10 Two-machine system with SSSC

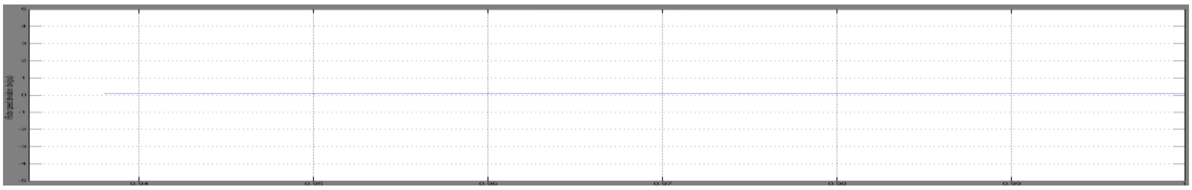


Fig. 11 Rotor speed deviation with SSSC

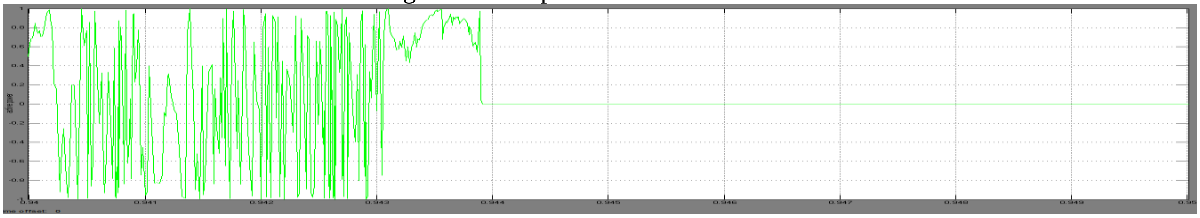


Fig. 12 Active Power with SSSC

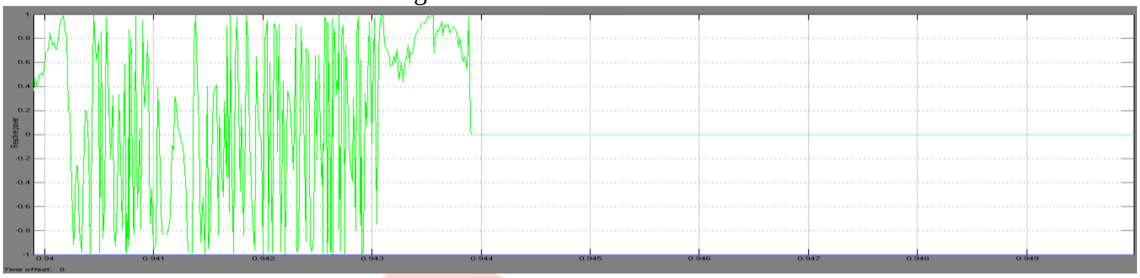


Fig. 13 Reactive Power with SSSC

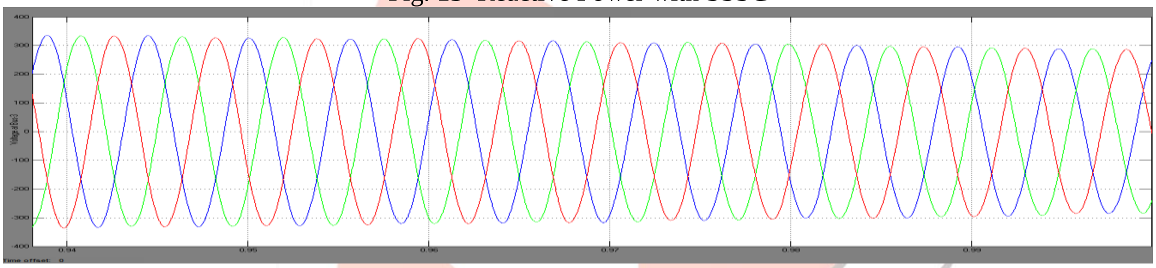


Fig. 14 Voltage at Bus-3 with SSSC

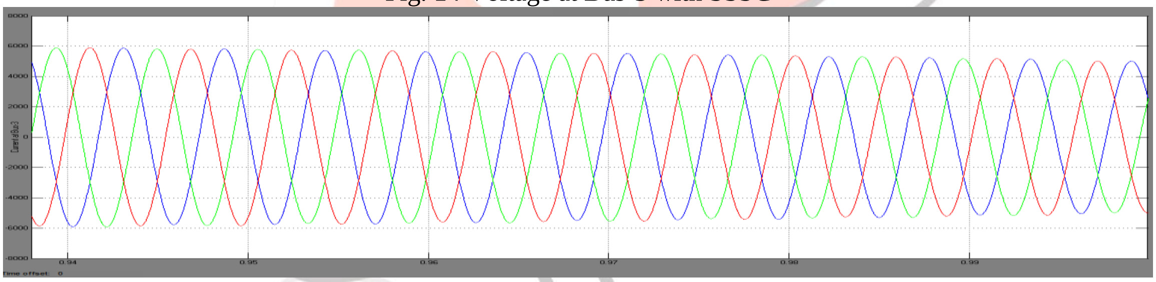


Fig. 15 Current at Bus-3 with SSSC

Bus-3 Parameters with SSSC

As shown in fig. 11 the rotor speed deviation oscillation are damped out when SSSC is connected in system. When SSSC is placed at bus-3 the main role of SSSC is to control the active and reactive power.as shown in fig.12 active power oscillation are damped out and voltage value is in 1pu constant, active power damping time is less IN system with SSSC compared to system without SSSC.also in fig.13 the reactive power damping time is decreased compared to system without SSSC. Fig. 14 and fig. 15 shows the voltage and current waveform are sinusoidal and hence disturbance removed.

SYSTEM BEHAVIOUR UNDER FAULT CONDITION

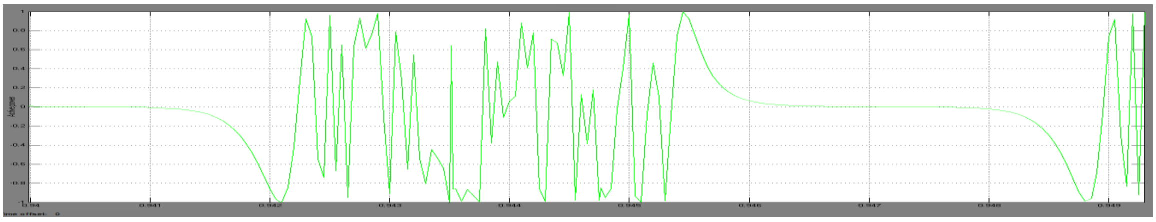


Fig. 16 Active Power without SSSC at LG fault

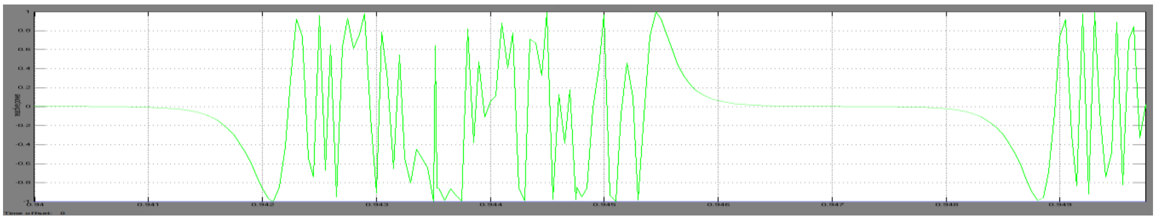


Fig. 17 Rective Power without SSSC at LG fault

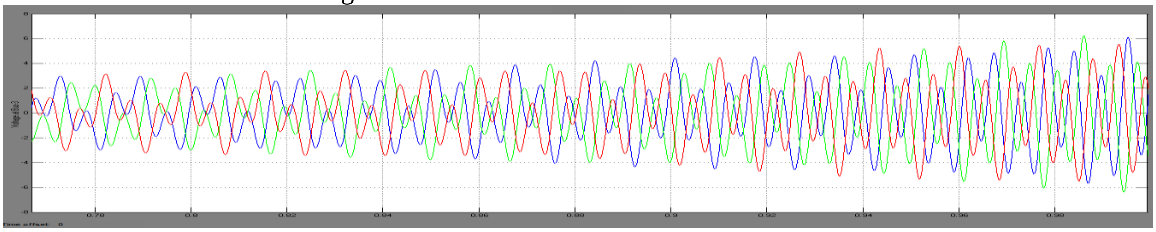


Fig. 18 Voltage at Bus-3 without SSSC at LG fault

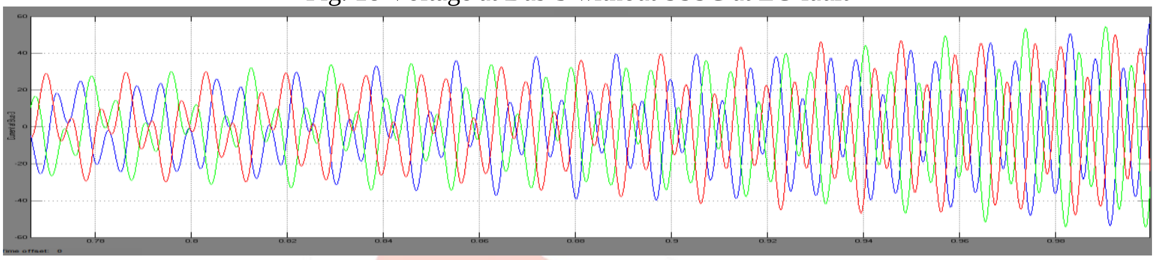


Fig. 19 Current at Bus-3 without SSSC at LG fault

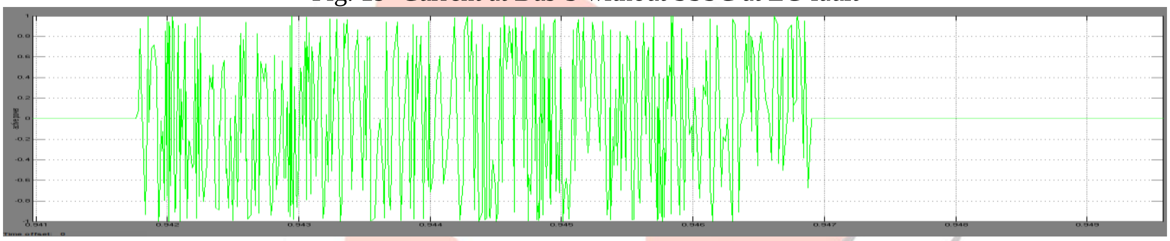


Fig .20 Active Power with SSSC at LG fault

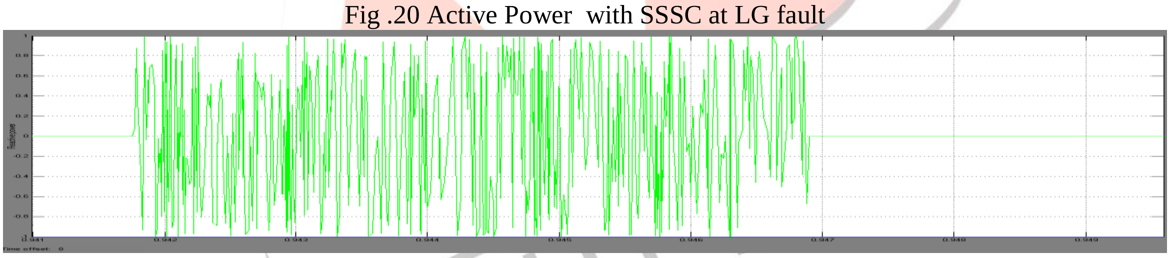


Fig .21 Reactive Power with SSSC at LG fault

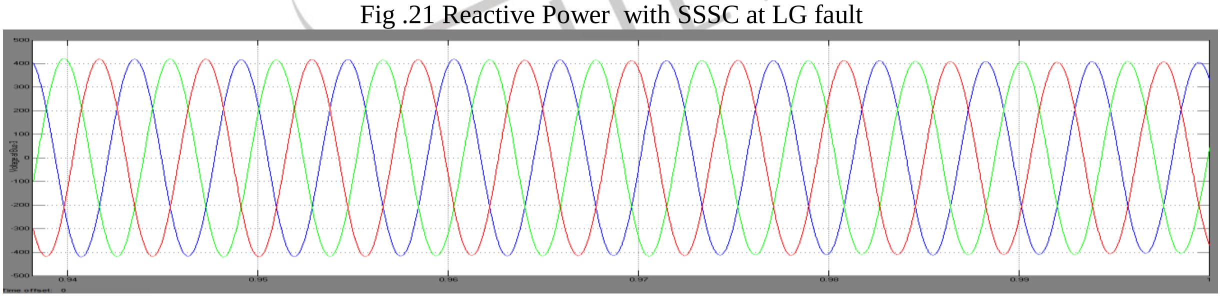


Fig. 22 Voltage at Bus-3 with SSSC at LG fault

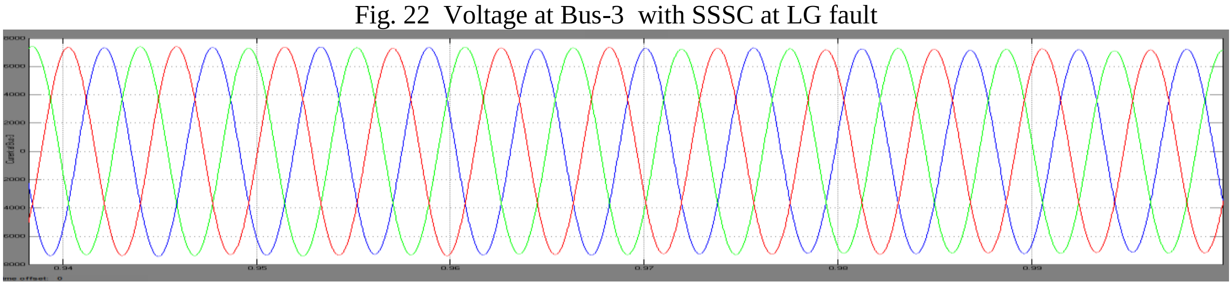


Fig. 23 Voltage at Bus-3 with SSSC at LG fault

As shown in above system behaviour in fault condition the active and reactive power without SSSC contains more oscillation and system become unstable. Same as voltage and current of bus are non-sinusoidal and having more oscillation with non-sinusoidal waveform. But when SSSC is connected in system in fault condition active –reactive power oscillation are damped out voltage and current waveform are sinusoidal and disturbance is removed.

IV. CONCLUSIONS

From simulation results we see that active power damping time is more for system without SSSC compared to system with SSSC. System in fault condition also shows that in fault condition active power oscillation are damped out faster with SSSC in system compared to without SSSC. Reactive power oscillation time is also more for system without SSSC compared to system with SSSC. Same as in fault condition for reactive power oscillation are damping time is less for system with SSSC compared to system without SSSC. Simulation results for system without SSSC voltage and current at desired point possess more oscillation-disturbance in waveform and totally non sinusoidal waveform we get. But by connecting system with SSSC voltage and current wave form oscillation are damped out and wave form are nearly sinusoidal. So from simulation results we conclude that transient disturbance in system using SSSC hence by damping power system oscillation in system system's transient stability is improved. In future it should be extended to complex transmission system. Location of SSSC should be optimized for network through further studies of system.

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