

Comparative Study of Power System Stability Enhancement of Various IEEE Bus System using SSSC

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Abstract—In this paper we investigate the controlling and enhancing power flow in a transmission line using a Static Synchronous Series Compensator (SSSC). The Static Synchronous Series Compensator is used to investigate the device in controlling active and reactive power as well as damping power system oscillations in transient mode. The SSSC device is equipped with a SOURCE ENERGY to absorb or supply the active and reactive power to or from the line. Various IEEE bus system have been stabilized using this FACTS device. The results are obtained by simulating the various power system in MATLAB/SIMULINK.

Keywords—*Static Synchronous Series Compensator(SSSC), FACTS, Active And Reactive Power, IEEE Bus System, Voltage Source Converter(VSC).*

I. INTRODUCTION

Generally, nowadays a greater demand has been placed on the transmission network. The increase in demands will rise because of increasing number of non utility generators and heightened competition utilities. These utilities needs to use their power transmission system more effectively to improve utilization degree. To reduce the effective reactance of lines by series compensation is a direct approach to improve transmission capability. For long transmission line the power transfer capability is limited because of stability consideration.

In this article for stability improvement we investigate the Static Synchronous Series Compensator (SSSC), FACTS device controller for its performance[1],[2]. FACTS devices contain a solid state voltage source converter (VSC) it will generate the control to alter the current at fundamental frequency. When the injected voltage is kept in quadrature with the line current, to emulate the inductive or capacitive reactance so as to influence the power flow through transmission lines[1]. The primary purpose of a SSSC is to control the power flow in steady state, and it can also improve the stability of the power.

II. LITERATURE REVIEW

Successful operation of a power system depends largely on the ability to provide reliable and uninterrupted service to the load. The continuous demand in electric power system network has caused the system to be heavily loaded leading to voltage instability. The project describe the active approach to series line compensation, in which static voltage sourced converter, is used to provide controllable series

compensation, in which static voltage sourced converter, is used to provide controllable series compensation. This compensator is called as Static Synchronous Series Compensator (SSSC). Some of the research work and literature are as given below.

S Arun Kumar, C Easwarlal, M Senthil Kumar (2012) proposes the enhancement of voltage stability using Static Synchronous Series Compensator (SSSC). The continuous demand in electric power system network has caused the system to be heavily loaded 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. The result would be the occurrence of voltage collapse which leads to total blackout of the whole 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 investigate 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 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 for IEEE 4 bus system[1].

M. Faridi, H. Maeiat, M. Karimi, P. Farhadi and H. Moseleh (2011) proposed a Static Synchronous Series Compensator (SSSC) is used to investigate the effect of the device in controlling active and reactive powers as well as damping power system oscillations in transient mode. The SSSC equipped with a source of energy in the DC link can supply or absorb the reactive and active power to or from the line[2].

Abido M. A. (2009), proposed power demand has increased substantially while the expansion of power generation and transmission has been severely limited due to limited resources and environmental restrictions. As a consequence, some transmission lines are heavily loaded and the system stability becomes power transfer limiting factor. Flexible AC transmission systems (FACTS) controllers have been used for solving various power system steady state control problems. However, latest studies shows that FACTS controllers could be employed to enhance power system stability in addition to their main function of power flow control[3].

L. Gyugyi (1994), proposed a novel approach in which solid state synchronous voltage sources are employed for the dynamic compensation and real time control of power flow in the transmission system[4].

L. Gyugyi, C. D. Schauder and K. K. Sen (1997), proposed an active approach to series line compensation in which a synchronous voltage source implemented by a gate turn off thyristor based voltage source inverter is used to provide controllable series compensation. This compensator called Static Synchronous Series Compensator (SSSC) can provide controllable compensating voltage over an identical capacitive and inductive range independently of the magnitude of the line current. It is immune to classical network resonances. In addition to reactive compensation with an external DC power supply it can also compensate the voltage drop across the resistive component of line impedance [5].

Kalyan K. Sen (1998), describes the theory and the modeling of the flexible alternating current transmission systems (FACTS) device, namely, Static Synchronous Series Compensator (SSSC) using an Electromagnetic Transient Program (EMTP) simulation package. The SSSC a solid state voltage source inverter coupled with a transformer, is connected in series with a transmission line. An SSSC injects an almost sinusoidal voltage of variable magnitude in series with a transmission line. This injected voltage is in quadrature with line current, thereby emulating an inductive or a capacitive reactance in series with transmission line. The emulated variable reactance influences the electric power flow in the transmission line [6].

Sandeep Gupta, R. K. Tripathi (2010), proposed a review on the research and developments in voltage stability improvement by using FACTS controller [7].

H. Taheri, S. Shahabi, Sh. Taheri and A. Gholam (2009), proposed the problem of controlling and modulating power flow in transmission line using a SSSC [8].

Laszlo Gyugyi and Narain G. Hingorani, provides the detail study of the flexible AC transmission system (FACTS) devices and also comparison of each device [9]. Muhammad Harunur Rashid, provides detail study of electronic devices for our study we will refer to PI controller and various PWM techniques [10].

III. STRUCTURE OF SSSC

Basically the SSSC consisting of the converter with a semiconductor devices having turn off capability to couple with transformer and capacitor. The converters are connected to a power system through a coupling transformer. In that the DC capacitor deliver or provides a DC voltage support for the converter to function and operate as energy storage element. SSSC injects a voltage in series with transmission lines through the series transformer. It is connected in series with the transmission line.

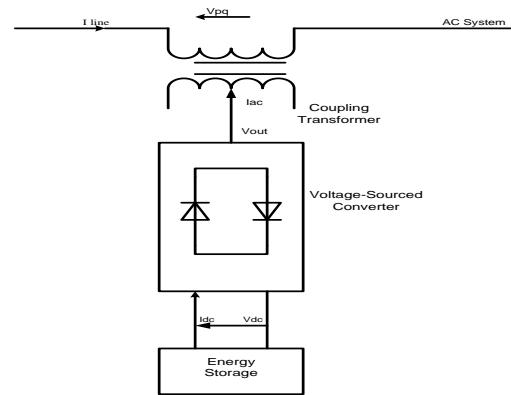


Fig.1. Functional Model of SSSC.

The Fig.1 shows the functional model of SSSC[7] 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 output voltage phase displacement of the inserted voltage V_{pq} , with respect to the transmission line current I_{line} , to determines the exchange of the real and reactive power with AC system[7].

IV. CONTROL SYSTEM OF SSSC

Fig.2 shows single line diagram of a simple transmission system with an inductive reactance, XL , connecting sending end voltage, VS , and a receiving end voltage, VR respectively.

SSSC is similar to the variable reactance because the injected voltage and current to the model circuit by this devices are changing depending upon system condition. To respond to the dynamic and transient modifications created in design, SSSC utilizes the series converter[1],[2].

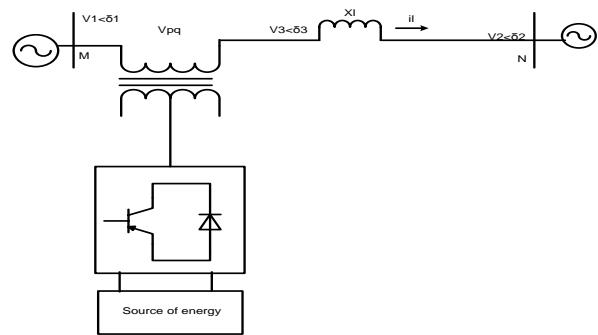


Fig.2 . Simple Transmission Line with SSSC

One of the port is connected to the AC system and the other port is connected to a capacitor and battery within the system. We make a assumption that DC source is acting like battery.

If any dynamic changes occur in the system[3], SSSC circuit work according to the control model circuit, the energy of the battery will be converted to AC by converter and then the voltage is injected to the circuit to damp the changes appropriately.

The active and reactive power of the bus is 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. We adjust the parameters of PI controller, trying to achieve zero signal error, so that power can follow through the reference powers precisely. Then the output of the controllers are transformed to abc reference voltage and given to the PWM.

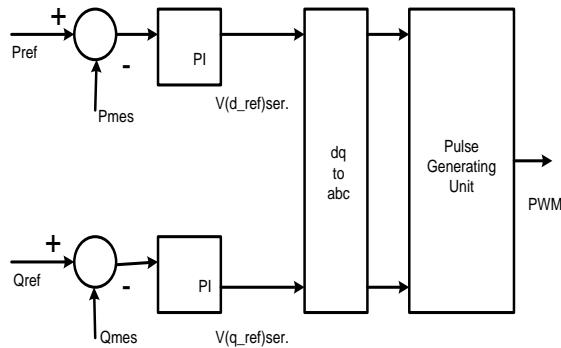


Fig.3 .Control Scheme of SSSC

V. ADVANTAGES

The various advantages of Flexible AC Transmission Systems (FACTS) devices are:

- I. Better utilization of existing transmission systems assets.
- II. Increased transmission system reliability and availability.
- III. Increased dynamics and transient grid stability and reduced of loop flows.
- IV. Increased quality of supply for sensitive industries.

VI.APPLICATION

The application of Static Synchronous Series Compensator (SSSC) is as follows:

- i. Power flow control.
- ii. Series compensation.
- iii. Voltage Regulation for long transmission line.
- iv. Economic operation.
- v. Voltage stability.

VII. SIMULATION AND RESULT

The simulation and result of the 4 bus system and 6 bus system are as follows

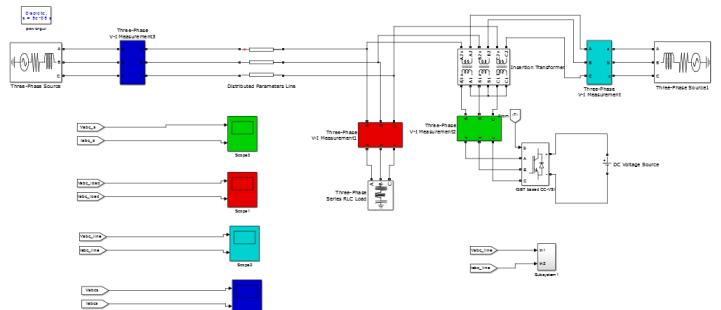


Fig.4 Simulation module of 4 bus system

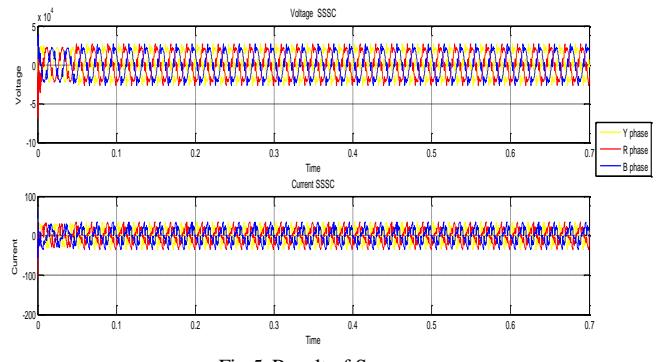


Fig.5 Result of Source scope

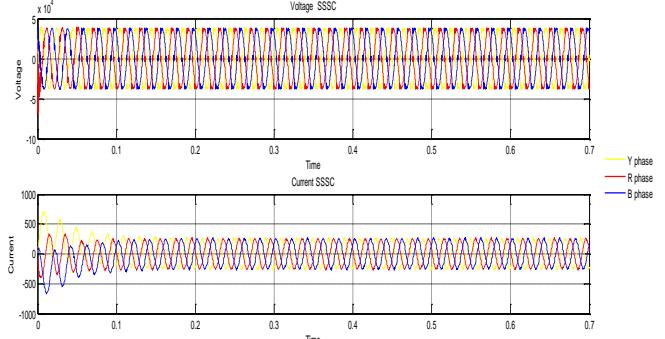


Fig.6 Result of Load scope

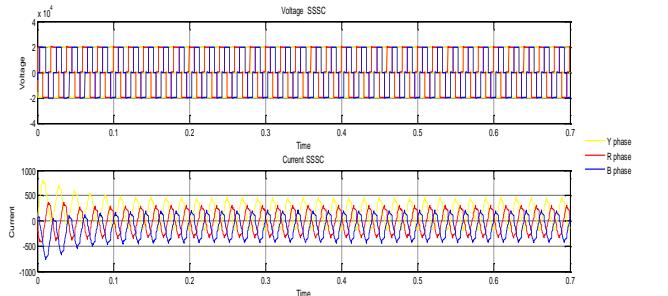


Fig.7 Result of scope connected to the SSSC

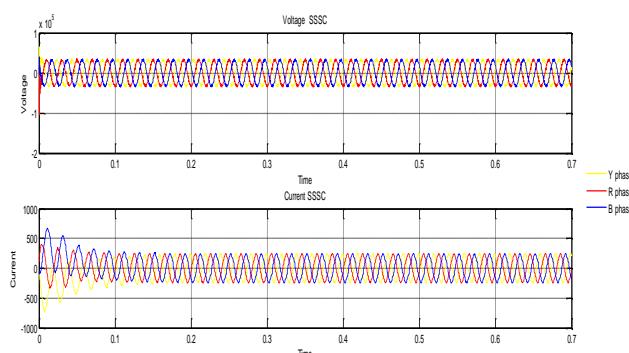


Fig.8 Result of Line scope

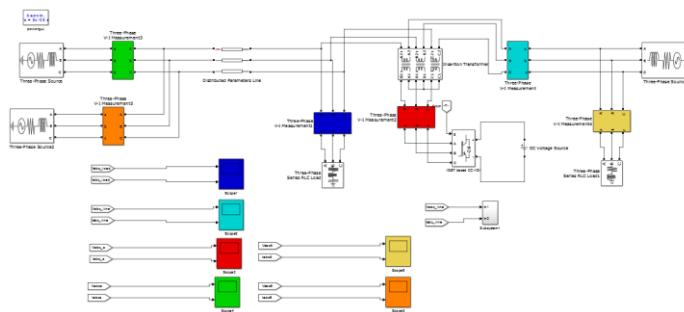


Fig.9 Simulation of 6 bus system

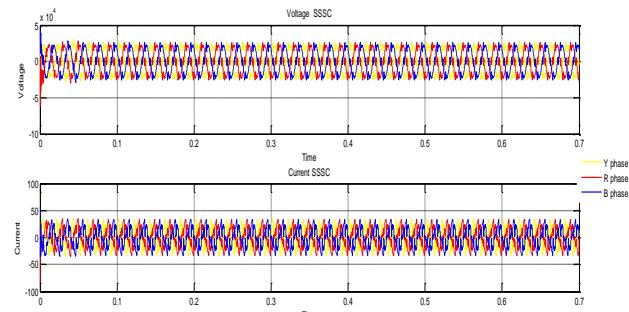


Fig.10 Result of load scope

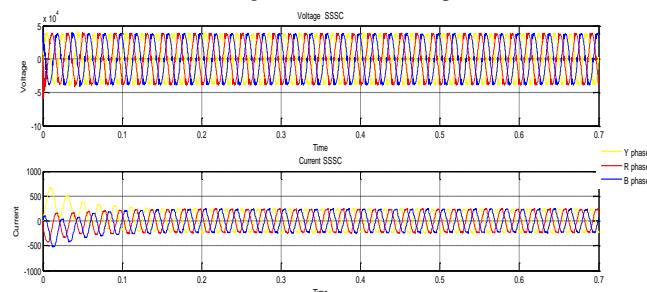


Fig.11 Result of line scope

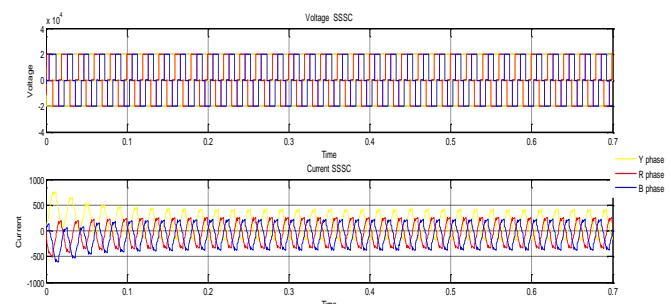


Fig.12 Result of SSSC connected line scope

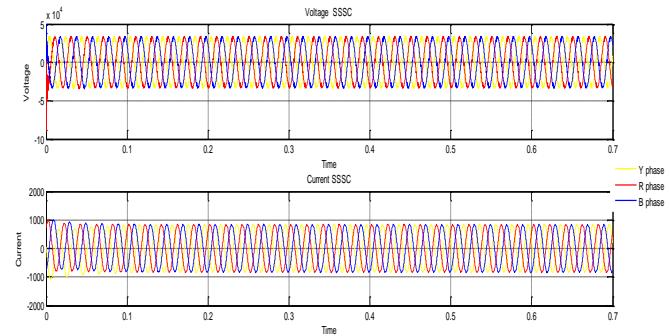


Fig.13 Result of source scope

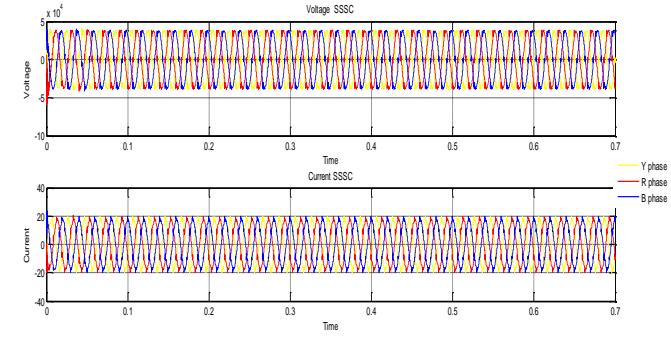


Fig.14 Result of secondary load scope

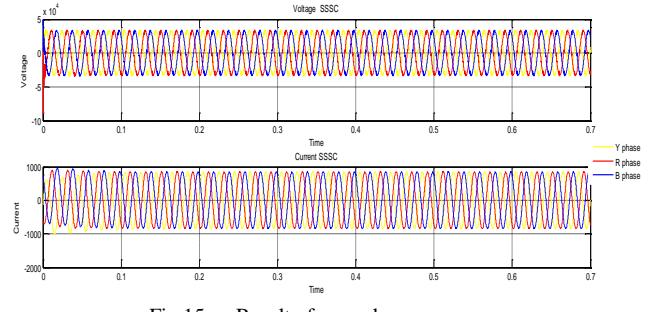


Fig.15 Result of secondary source scope

The total harmonic distortion of the system is maintained 5%-10% in both the bus system.

VIII. CONCLUSION

In our proposed method the SSSC is capable of controlling the flow of power at a particular point in the transmission line. Also it is observed that the SSSC to inject a fast changing active voltage in series with the line irrespective of the phase and magnitude of the line current. In this research SSSC is used to damp power oscillation on a grid power system. Comparison of various IEEE bus system with and without SSSC is been processed in this paper using MATLAB/SIMULINK environment.

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