ENHANCEMENT OF DAMPING POWER SYSTEM OSCILLATION VIA STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC) WITH POD

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Abstract- The main objective of this paper is to investigate an enhancement of damping power system oscillation via static synchronous series compensator (SSSC). In this paper we proposed simple Lead-Lag structure type damping controller for power system stability enhancement. Proposed SSSC based damping controller is tested on single machine infinite bus system (SMIB) under several phase fault conditions in MATLAB Simulink software. The linearized model of the SSSC integrated into power systems is established and methods to design the SSSC damping controller are proposed.

Keywords- Power oscillation damping (POD), Static synchronous series compensator (SSSC), stability enhancement

I. INTRODUCTION

Maintaining stability of such an interconnected multi area power system has become a cumbersome task. As a counter measure against these problems, Flexible AC Transmission System (FACTS) devices were proposed [1].The flexible AC transmission systems (FACTS) can then be defined as the transmission systems of alternating current that incorporate in them electronics based on power and other controllers that are static to improve the capability of power transfer and controllability. One member of the flexible AC transmission systems (FACTS) device is Static Synchronous Series Compensator (SSSC) that consists of a voltage-sourced converter and a transformer connected in series with a transmission line [2]. FACTS Controllers are power electronic based controllers which can influence transmission system voltages, currents, impedances and/or phase angles rapidly [3]. The static synchronous series compensator (SSSC) is a VSC based series FACTS controller which is used for power transmission control. It injects a voltage in series with the line. This injected voltage is in phase quadrature with the line current. An injected voltage which is in quadrature with the line current emulates an inductive or capacitive reactance in series with the transmission line. The resistive compensation is very beneficial when it comes to the power oscillation damping [4]. These reactive and resistive compensations influence the power flow in the transmission line.

II. POWER SYSTEM OSCILLATIONS

Many electric utilities world-wide are experiencing increased loadings on portions of their transmission systems, which can, and sometimes do, lead to poorly damped, low-frequency oscillations (0.5 – 2 Hz). Power system oscillations can be damped, when extra energy is injected into the system which is instantaneously decelerated, and/or when extra energy is consumed in the system which is instantaneously accelerated. Nowadays, series FACTS controllers demonstrate superior and competitive features to improve Power Oscillation Damping (POD) [5]. Power oscillation damping, stability enhancement, and frequency stabilization are studied in this proposed work. [6]

III. SSSC Configuration

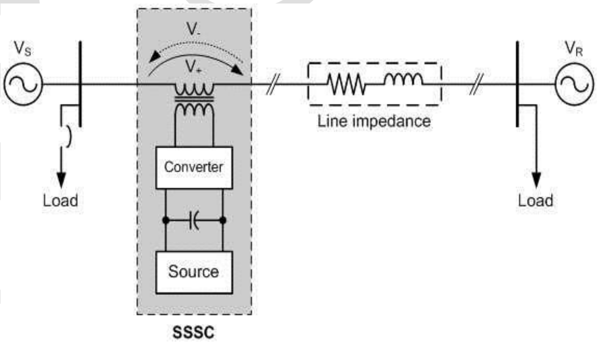


Fig: 1 SSSC configuration

The SSSC is typically applied to correct the voltage during a fault in the power system. However, it also has several advantages during normal conditions for Power factor correction through continuous voltage injection and in combination with a properly structured controller. The power transmission without and with SSSC is expressed in the following equations below;

$$P=\frac{v^2}{x_L}\sin\delta \qquad \text{eq1}$$

$$P=\frac{v^2}{x_L}\sin\delta+\frac{V}{x_L}v_{sssc}(\xi)\cos\frac{\delta}{2} \qquad \text{eq2}$$

Where;
P=transmission line active power
v=line voltage
x_L=line reactance
$v_{sssc}(\xi)$=sssc injected voltage

IV. POD CONTROLLER

The SSSC injected voltage reference is normally set by a POD (Power Oscillation Damping) controller whose output is connected to the V_{qref} input of the SSSC. The POD controller consists of a general gain, a low-pass filter, a washout high pass filter, a lead compensator, and an output limiter as its basic structure as shown in figure 2 below.

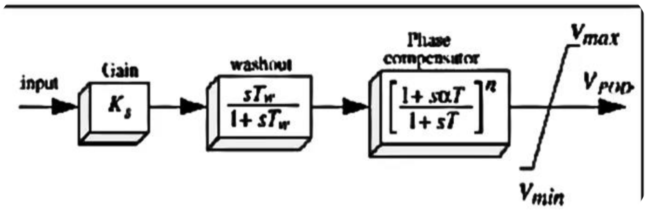


Fig 2: Power Oscillation Damping controller

The purpose of the wash-out filters is to eliminate the average and extract the oscillating part of the input signal. The lead-lag compensators provide the desired phase shift at the oscillation frequency.

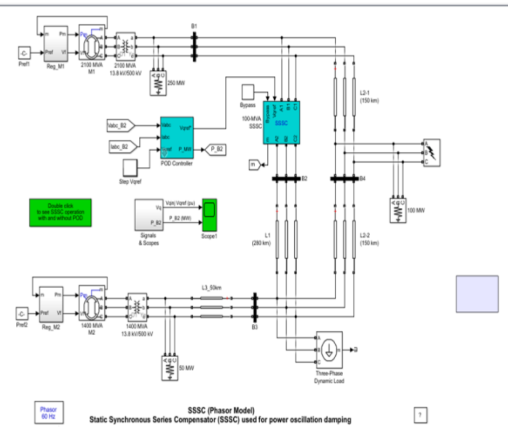
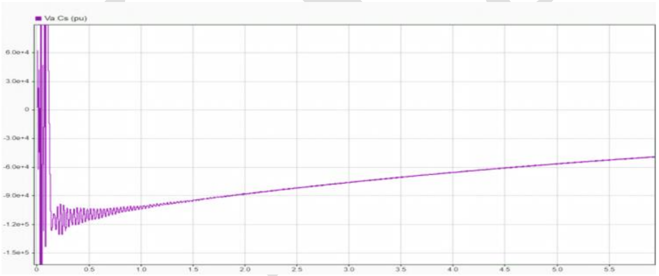
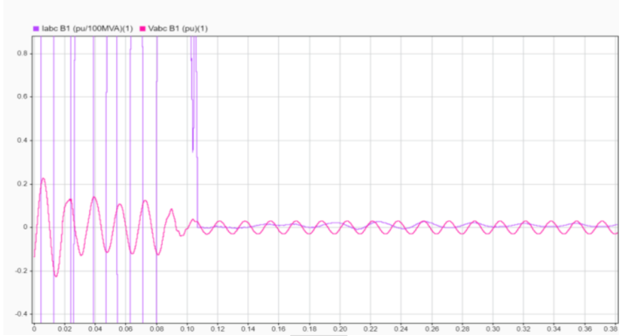


Fig: 3 Power simulating model of SSSC with pod

V. SIMULATING RESULTS



Time (s)
Fig:4 (a) Transmission line real power flows



Time (s)
Fig: 4(b) Transmission line real power flows for bus1

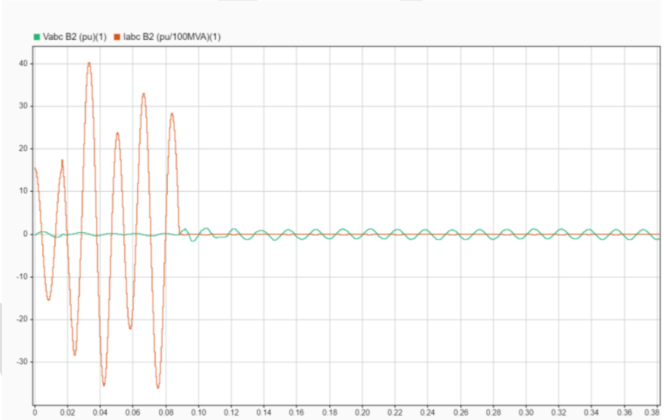
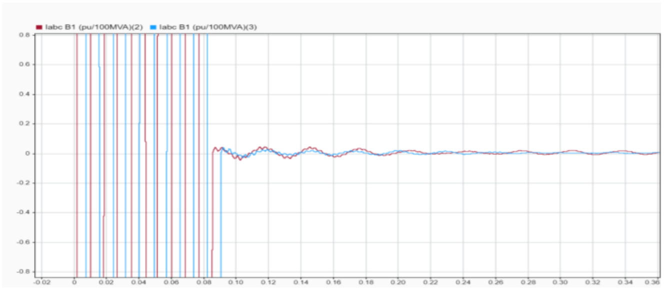


Fig: 5(a) per unit voltage and current oscillation for bus 2

Time (s)
Fig: 5(b) Transmission line real power flows



Time (s)
Fig:5 (c) 3 phase current flow for fault at line 1 and 2

VI. CONCLUSION

A single machine infinite bus system (SMIB) with SSSC is simulated in MATLAB/Simulink software. Simulation results show the effectiveness of this controller for power system stability enhancement under different transmission lines interconnection. The main objective of this work is to investigate the possibility of damping power system oscillations resulting from large disturbances (mainly transmission line faults) in multi-machine power systems using SSSC with pod controller. In this paper, a study has been carried out for the improvement in the power system stability by damping of power system oscillations using pod controller. The SSSC-based controller (lead–lag structure) is used for damping out of power system oscillations. In this paper, the simulation of a two-machine power system model with Static synchronous series compensator (SSSC) based damping controllers in the presence of a three-phase short circuit fault is performed and studied. The results show that the power system oscillations are damped out very quickly with the help of SSSC based damping controllers in few seconds.

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