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Voltage Stability analysis by using SVC With Fuzzy Logic Controller in Multi -Machine Power System

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Abstract: **Power system can be simulated and analyzed based on a mathematical model however; uncertainty still exists due to change of loads and an occurrence of fault. Recently, fuzzy theory highly flexible easily operated and revised, theory is a better choice, especially for a complicated system with many variables. Hence, this work aims to develop a controller based on fuzzy logic to simulate an automatic voltage regulator in transient stability power system analysis. By adding power system stabilizer for tuning of fuzzy logic stabilizing controller there is no need for exact knowledge of power system mathematical model. The fuzzy controller parameters settings are independent due to nonlinear changes in generator and transmission lines operating conditions. Because of that proposed fuzzy controlled power system stabilizer should perform better than the conventional controller. To overcome the drawbacks of conventional power system stabilizer (CPSS), numerous techniques have been proposed in the article. The conventional PSS's effect on the system damping is then compared with a fuzzy logic based PSS while applied to a single machine infinite bus power system.**

Keywords**: FACTS, fuzzy logic, reactive power, SVC, voltage stability.**

1. INTRODUCTION

As power systems become more interconnected and complicated, analysis of dynamic performance of such systems become more important. Synchronous generators play a very important role in the stability of power systems. The requirement for electric power stability is increasing along with the popularity of electric products. Thus, an AVR is needed to enhance a stable voltage while using delicately designed electric equipment or in areas where power supply is not constantly stable.

The use of power system stabilizers has become very common in operation of large electric power systems. The conventional PSS which uses lead-lag compensation, where gain settings designed for specific operating conditions, is giving poor performance under different loading conditions. Therefore, it is very difficult to design a stabilizer that could present good performance in all operating points of electric power systems. In an attempt to cover a wide range of operating conditions, Fuzzy logic control has been suggested as a possible solution to overcome this problem, thereby using linguist information and avoiding a complex system mathematical model, while giving good performance under different operating conditions]. In this paper, a systematic approach to fuzzy logic control design is proposed.

The study of fuzzy logic power system stabilizer for stability enhancement of a single machine infinite bus system is presented. In order to accomplish the stability enhancement, speed deviation and acceleration of the rotor synchronous generator are taken as the inputs to the fuzzy logic controller. These variables take significant effects on damping the generator shaft mechanical oscillations. The stabilizing signals were computed using the fuzzy membership function depending on these variables. The performance of the system with fuzzy logic based power system stabilizer is compared with the system having conventional power system stabilizer and system without power system stabilizer.

Power systems are subjected to low frequency disturbances that might cause loss of synchronism and an eventual breakdown of entire system. The oscillations, which are typically in the frequency range of 0.2 to 3.0 Hz, might be excited by the disturbances in the system or, in some cases, might even build up spontaneously. These oscillations limit the power transmission capability of a network and, sometimes, even cause a loss of synchronism and an eventual breakdown of the entire system. For this purpose, Power system stabilizers (PSS) are used to generate supplementary control signals for the excitation system in order to damp these low frequency power system oscillations.

2. POWER SYSTEM STABILIZER

Power system stabilizer PSS are generator control used in fed back to enhance the damping of rotor oscillation due to signal disturbance. The disturbance may be caused by the even small change in the reference voltage regulator exciter which results in ever increasing rotor oscillations.

Power system stabilizer (PSS) controller design, methods of combining the PSS with the excitation controller (AVR), investigation of many different input signals and the vast field of tuning methodologies are all part of the PSS topic. Control Action and Controller Design.

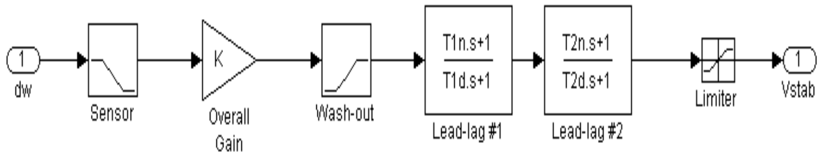

Figure.1: block diagram of the PSS

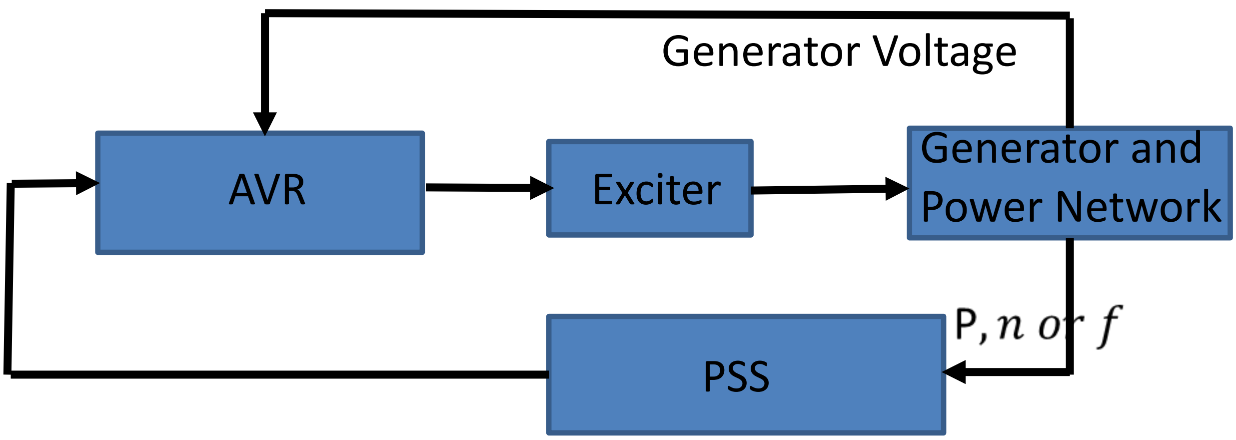

Figure.2: Structure of power system stabilizer (PSS)

The action of a PSS is to extend the angular stability limits of a power system by providing supplemental damping to the oscillation of synchronous machine rotors through the generator excitation. This damping is provided by an electric torque applied to the rotor that is in phase with the speed variation. Once the oscillations are damped, the thermal limit of the tie-lines in the system may then be approached. This supplementary control is very beneficial during line outages and large power transfers. However, power system instabilities can arise in certain circumstances due to negative damping effects of the PSS on the rotor. The reason for this is that PSSs are tuned around a steady-state operating point; their damping effect is only valid for small excursions around this operating point. During severe disturbances, a PSS may actually cause the generator under its control to lose synchronism in an attempt to control its excitation field.

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Power system stabilizer is a generator control used in feedback to enhance the damping of rotor oscillation due to signal disturbance. The disturbance may be caused even by small changes in the reference voltage regulator exciter, resulting in ever increasing rotor oscillations. The generic PSS can be used to add damping to the rotor oscillation of the synchronous machine by controlling its excitation. To maintain stability, the power system's electromechanical oscillation (also called power swing) must be damped. The input signal of PSS is machine speed division (dw), and the output signal is additional input (Vstab) to the excitation system. The generic power system stabilizer is modeled by the nonlinear system shown in Fig.1.1. By controlling the excitation of the generator rotor oscillation using auxiliary stabilizing signal, PSS has become the most prevalent damping controller used in all synchronous generators, because of its low cost. PSS is used to this important function damp these oscillation by adding a signal to the reference voltage signal, based on the automatic voltage regulator AVR; using power deviation, speed deviation, or frequency deviation with additional torque coaxial, PSS can increase the damping of low frequencies and developed the dynamic stability.

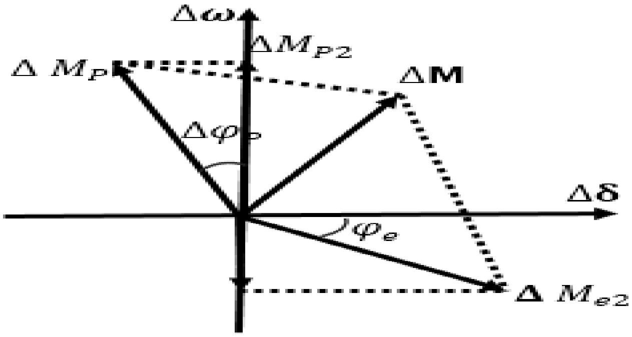

Figure.3: Torque analysis between PSS and AVR

The high gain of AVR will give a good voltage control and will increase the opportunities of retaining the synchronizing of the generator at the large disturbance, therefore this strife is almost solved by limiting the output of PSS to 0.5% set point of the AVR.

3. STATIC VAR COMPENSATOR

A Static Var compensator consists of capacitors and reactors connected in shunt, which can be quickly controlled by thyristor switching. In effect SVC is a variable shunt susceptance. The susceptance is varied in response to system voltage conditions by a thyristor controlled reactor in parallel with a combination of fixed and switched capacitors and reactors. Direct and rapid bus voltage control forms the principal basis of SVC for transient stability enhancement. SVC increases power transfer during low voltage conditions while fault on the system by decreasing generator acceleration and vice versa when the fault is cleared. If SVC is on the system, it reduces the adverse impact of the fault on the generator's ability to maintain synchronism. The SVCs in use nowadays are of variable susceptance type.

The SVC regulates voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system. There are two types of the SVC. They are fixed capacitor thyristor controlled reactor (FC-TCR) and thyristor switched capacitorthyristor controlled reactor (TSC-TCR). The later type is used commonly because it is more flexible than FC-TCR and it uses lower reactor rating. The basic diagram of FCTCR based SVC is shown in the Fig.

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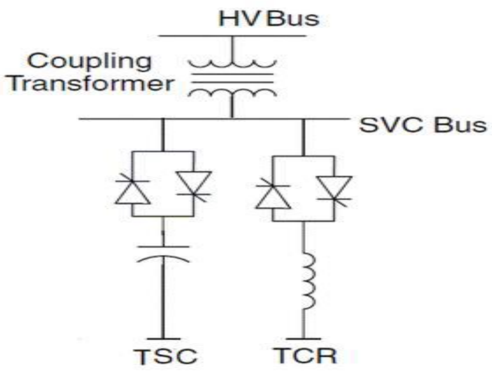

Figure.4: Basic configuration of SVC

4. FUZZY RELATION MATRIX (FOR 7 VARIABLES)

A fuzzy relation matrix must be set up and stored in computer memory. A set of decision rules relating inputs to the output are first compiled. These decision rules are expressed using linguistic variables such as large positive (LP), medium positive (MP), small positive (SP), very small (VS), small negative (SN), medium negative (MN), and large negative (LN).For example, a typical rule reads as follows:Rule1: If error1 is LP and error3 is LN, then errorres should be VS.Fig. (1.4)

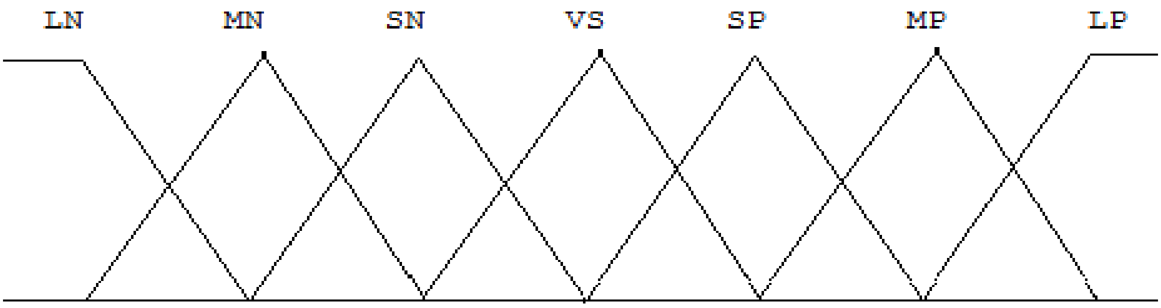

Figure.1.4: Output control signals

4.1 MEMBERSHIP VARIABLES:

To express the error inputs in linguistic variables LP, MP, SP, VS, SN, MN, and LN, the measured stabilizer inputs error3 and error1 are first normalized based on the previous experience. Here, from the conventional PID method it is found that the error3 is varying from -30 to 30 and error1 is varying from -1 to 1.

Error 1	Error 3						
	LN	MN	SN	VS	SP	MP	LP
LP	VS	SP	MP	LP	LP	LP	LP
MP	SN	VS	SP	MP	MP	LP	LP
SP	MN	SN	VS	SP	SP	MP	LP
VS	MN	MN	SN	VS	SP	MP	MP
SN	LN	MN	SN	SN	VS	SP	MP
MN	LN	LN	MN	MN	SN	VS	SP
LN	LN	LN	LN	LN	MN	SN	VS

So for normalizing the values, error3 is divided by 25 and error1 is divided by 4, i.e.,

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$$Error_1 = \frac{Error_1}{1}$$

$$Error_3 = \frac{Error_3}{30}$$

5. MAT-LAB SIMULATION

A test system consists of 2 machines with 3 buses is considered. Plant 1 (M1) is a 1000 MW Generation Plant is connected to a load center through a long 500 kV, 700 km transmission line. The load center is represented as a 5000 MW resistive load and supplied by the remote plant 2 (M2). Consists of a 5000 MVA plant and a local generation of 5000 MVA shown in Fig.. The two machines are equipped with a hydraulic turbine and governor (HTG), excitation system and Power System Stabilizer. Figure 15 to 17 shows Result of Positive Sequence Voltages at buses B1, B2, and B3 and Power as well as Rotor angel, Speed and Terminal Voltage without any controller which shows the local oscillation. Without PSS controller in Power System Oscillation damping after fault in two machine system is examined.

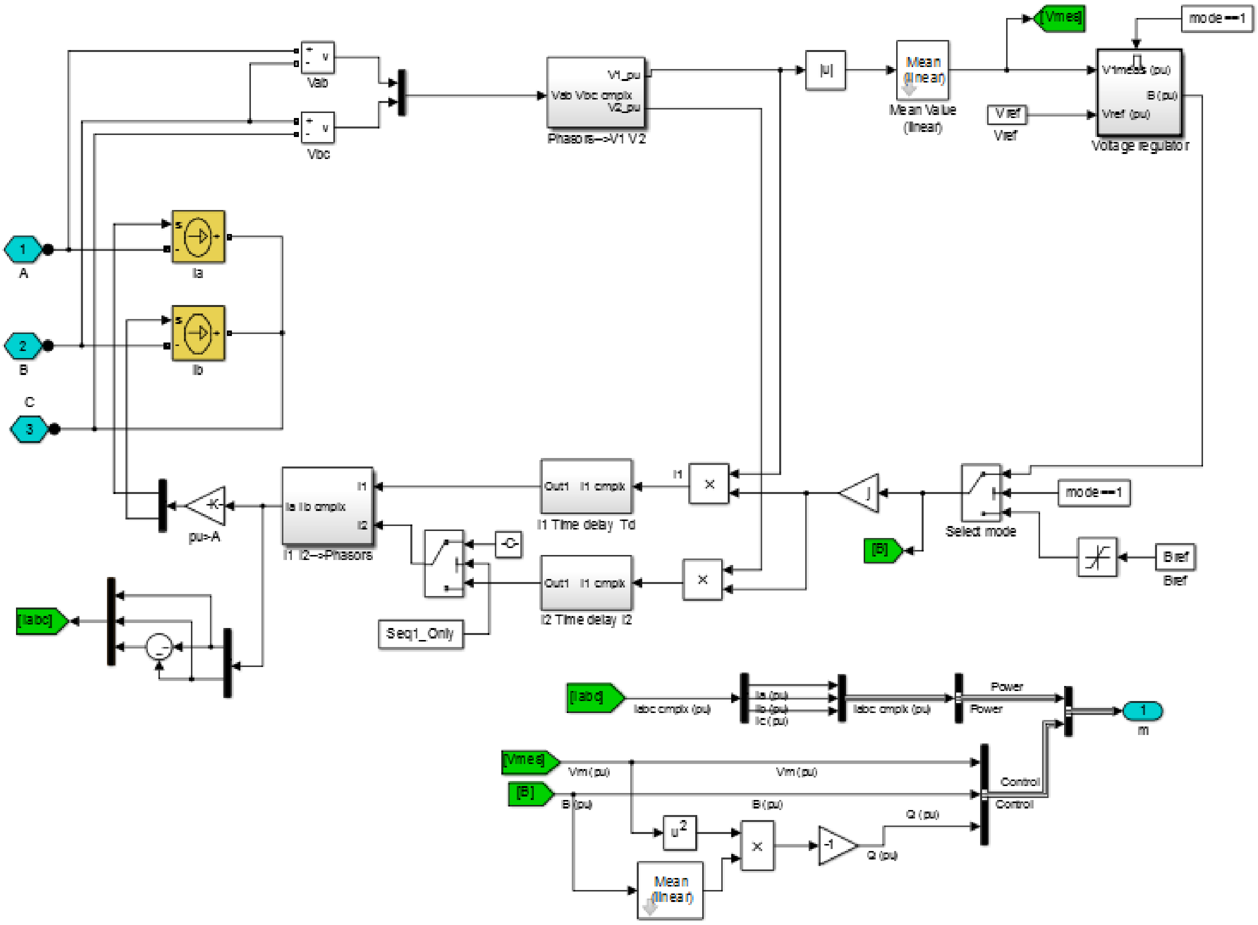

Figure.5: Fuzzy controller simulation model

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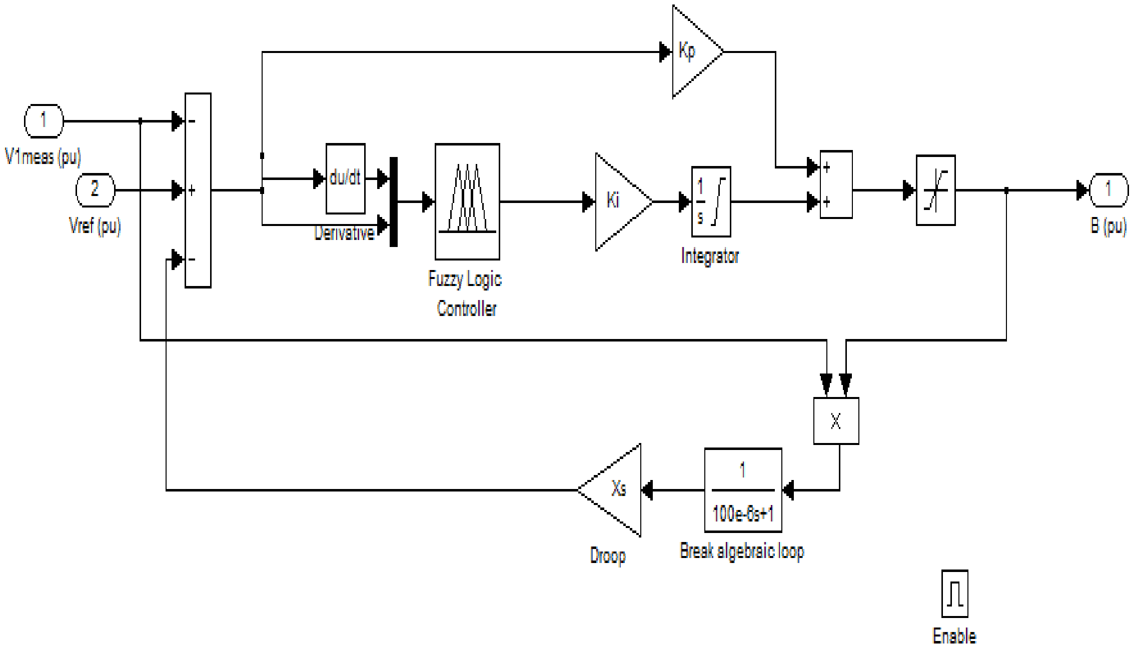

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6. RESULTS

It is observed that as fault occurred between Bus 1 and Bus 2, terminal voltage Vt1 is also affected. Observation from Fig. 7, Vt1 is less oscillated and stabilized faster with the FUZZY-SVC controller used in the system

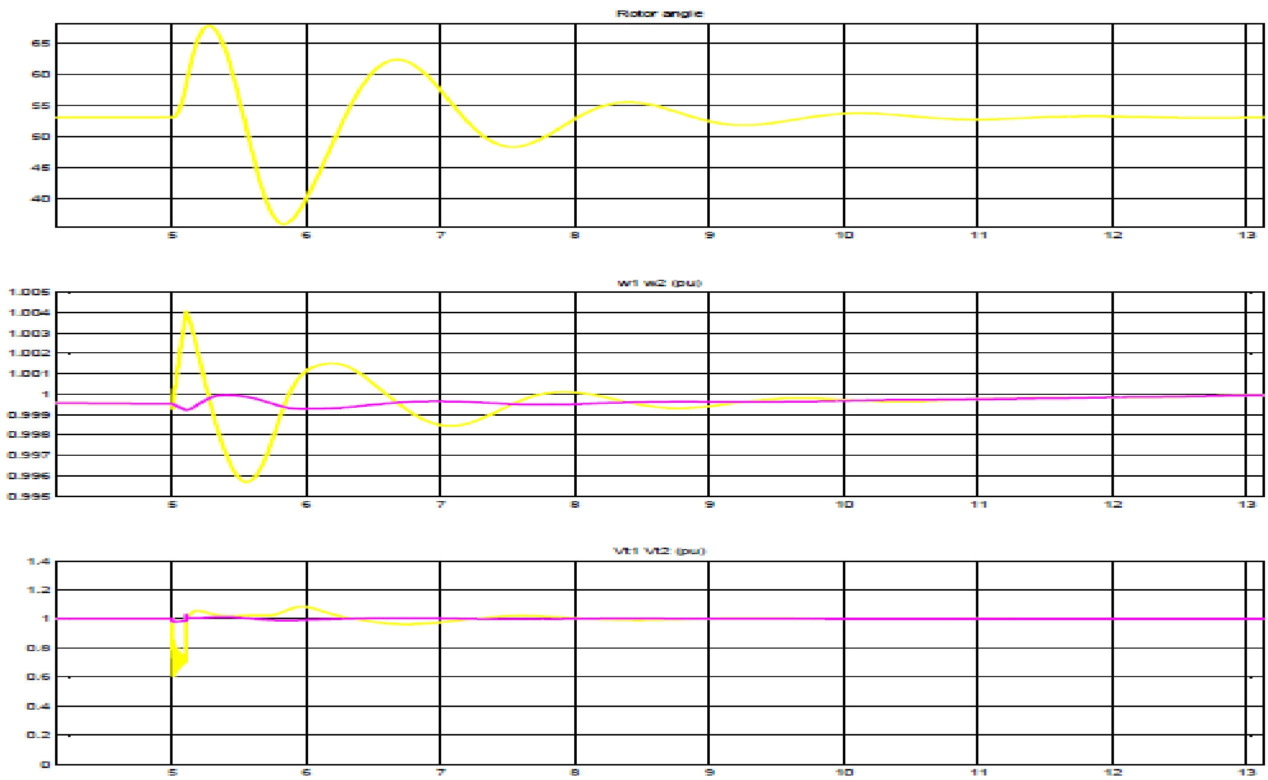

Fig.6: Terminal voltage of system with svc during LG fault

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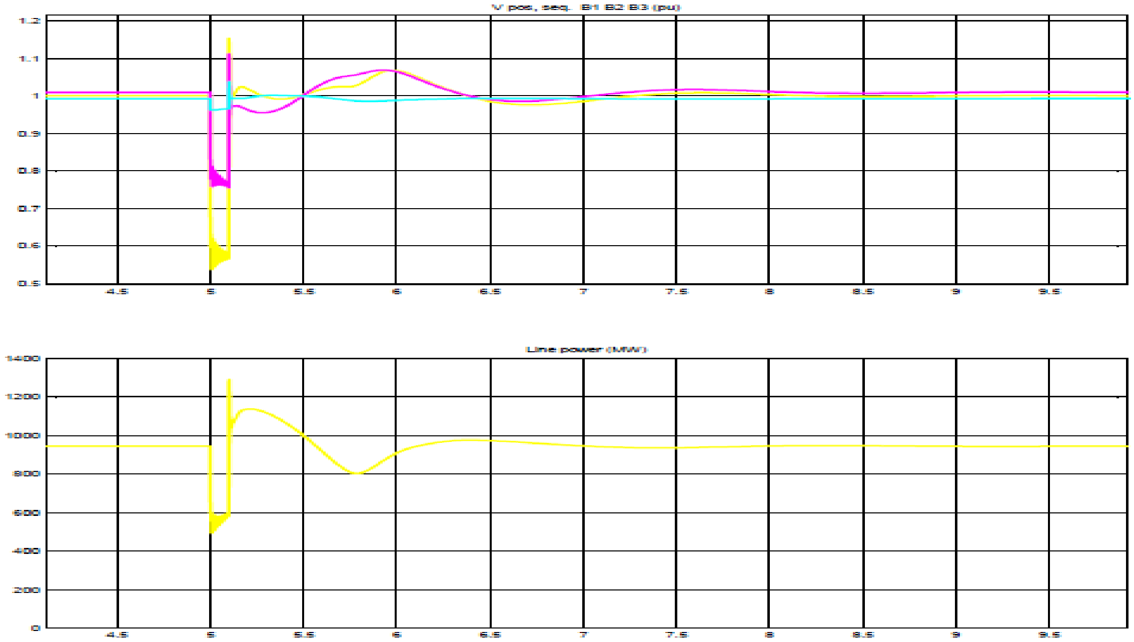

Fig.7: Positive sequence voltage and active power

Fig: 9 show the difference of rotor angle of Generator (G1) of the test system. After the occurrence of the three phase fault at t1=5s, the two generators quickly fall out of synchronization. Observation from Fig.9 show that system implemented with FUZZY-SVC controller. The difference of rotor angle is stabilized faster with the controller at t=10s which is 4.9 second after fault clearance.

7. CONCLUSIONS

The SVC with fuzzy logic controller has been tested in a 2-machines 3-bus power system where several parameters including the difference of rotor angle between the machines, speed of the machines, terminal voltage and the transmission line active power have been observed. The performance of the system implemented with the FUZZY-SVC controller .The system implemented with the Fuzzy-SVC controller show better performance in damping oscillations, maintain terminal voltage and control the power after the system is subjected to disturbance.

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