EFFECT OF PA & MB-PSS ON TRANSIENT STABILITY OF POWER SYSTEM ALONG WITH SVC OPERATING IN VAR CONTROL MODE FOR A WEAKLY DAMPED POWER SYSTEM OPERATING NEAR STABILITY LIMIT

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Abstract- This paper presents the effect of Pa & MB-PSS on transient stability of power system along with SVC operating in Var control mode.The proper selection among Pa & MB-PSS can be beneficial for the improvement of transient stabilityof the power system. The transientperformance characteristics of power system with SVC and PSS are analysed and comparedby using the phasor simulation method in MATLAB/SIMULINK. During the transientperformance analysis, Impact of PSS on system stability for three-phasefaultsare evaluated.

Keywords: **FACTS, Static Var Compensator (SVC),Power System Stabilizer(PSS),Pa PSS, MB PSS,phasor simulation method,Transient stability,Reactive power Compensation**.

I. INTRODUCTION

The AC power transmission system hasvarious limits, classified as thermal, dielectric and stability limits [2].Out of which the study of stability limits of power system is of great importance. The transient stability analysis of power system is very important for understanding the dynamic behaviour of power systems. A static VARcompensator (SVC) is an electrical device used for providingfast-acting reactive powercompensation (as it combines the advantages ofboth BJTS & MOSFETS)on highvoltage large area transmission networks and it can contribute toimprove the voltage profiles in the transient state andtherefore, it can improve the qualities and performances ofthe electric services[3]. An SVC can be controlled externallyby using properly designed different types of controllerswhich can improve power system stability,voltage stability and reactive power compensationof a large scale powersystem[4], [5], [6].The Static Var Compensator (Phasor Type) block of the FACTS library is a simplified model, which can simulate different types of SVCs. Itcan be used with phasor simulation, available through the Powergui block, for studying dynamic performance and transient stability of power systems. Thetransient stability study of power systems usually requires simulation times of less than 50 seconds.

The Power System Stabilizer (PSS) enhances the damping of power systems. It extends the power transfer limits of transmission lines. The PSS cannot damp the oscillation in electrical systemswhich is weakly coupled. Whichcan causesuddenly growing oscillations. Enhanced damping isrequired when a weak transmission condition exists along with a heavy transfer of load.

This paper presents the Effect of Pa & MB-PSS on Transient Stability of Power System along with SVC Operating in Var Control Mode for a weakly damped Power System.The proper type of PSS can control the suddenly growing oscillationscalled power swings for the power system by using MATLAB/SIMULINK. ThePa PSS and the MB PSS are introduced and compared. Thestatic varcompensator (SVC) is discussed, the V-I characteristics as well as the dynamic properties arepresented. Thepower system is simulated using MATLAB and theeffects of Pa & MB-PSS on Transient Stability of Power System along with SVC Operating in Var Control Mode for a weakly damped Power System under threephase fault conditionis evaluated.

II. POWER SYSTEM UNDER STUDY

A. *Description of the power system*

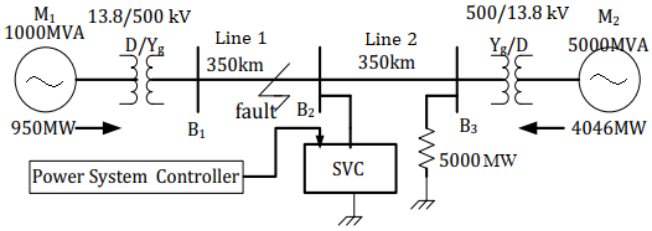

Fig. 1. power systemunder study

The power system under study is having two power stations with capacity of 1000 MVAand 5000 MVA.The generation voltage is 500kV. The load demand side is near to the 5000 MVA generator. The 700km transmission line is used to transfer the power from 1000 MVAto the load as shown in fig.1.the load is modelled by a 5000 MW resistive load through the transmission line. Initially a load flow has been performed on the power system under study and generation of both plants and line current are noted. The line current is found nearer to its its surge impedance loading (SIL). A 3 phase fault is created in the system near to bus B1. To maintain system stability after faults, the transmission line is shunt compensated at Bus B2 by a 200 Mvar static var compensator (SVC).

B. Modelling of the power generation plants

The two power generation plants having a hydraulic turbine and governor (HTG), excitation system, and power system stabilizer (PSS). Thehydraulic turbine and governor and the excitation system are also implemented inside subsystems. Two types of stabilizers can be connected on the excitation system: a generic (Pa type) model using the acceleration power (Pa=Pm-Pe) and a Multiband stabilizer (MB type) using the speed deviation (dw). These two stabilizers are standard models of the Fundamental Blocks/Machines library. Manual Switch blocks are used to select the type of stabilizer used for both machines.

C. Modelling of the Pa type PSS

The generic Pa type power system stabilizer (PSS) block can be used to add damping to therotor oscillations of the synchronous machine by controlling its excitation. The disturbancesoccurring in a power system induce electromechanical oscillations of the electrical generators.These oscillations, also called power swings, must be effectively damped to maintain thesystem stability.The output signal of the PSS is used as an additional input to the ExcitationSystem block. The PSS input signal can be either the machine speed deviation, dw, or the acceleration power(difference between the mechanical power and the electricalpower) type.

The output signal of the PSS is used as an additional input (Vstab) to the ExcitationSystem block. The PSS input signal can be either the machine speed deviation, dw, or itsacceleration power, Pa=Pm-Peo (difference between the mechanical power and the electrical power) [1].

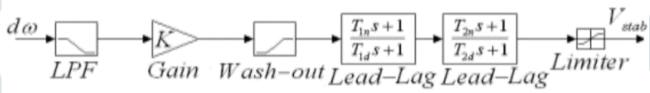

Fig. 2. Block Diagram of the Generic Power System Stabilizer

Fig. 1 shows the block diagram of the generic power system stabilizer (PSS), whichcan be modeled by using the following transfer function [1]:

$$G(s) = K \cdot \frac{T_{1n}s+1}{T_{1d}s+1} \cdot \frac{T_{2n}s+1}{T_{2d}s+1}$$

D. Modelling of the MB PSS

The disturbances occurring in a power system induce electromechanical oscillations ofthe electrical generators. These oscillations, also called power swings, must be effectivelydamped to maintain the system's stability. Electromechanical oscillations can be classified infour main categories [1, 3, 4]:

(1) Local oscillations: between a unit and the rest of the generating station and between thelatter and the rest of the power system. Their frequencies typically range from 0.8 to 4.0Hz.

(2) Interplant oscillations: between two electrically close generation plants. Frequencies canvary from 1 to 2Hz.

(3) Inter-area oscillations: between two major groups of generation plants. Frequencies aretypically in a range of 0.2 to 0.8Hz.

(4) Global oscillation: characterized by a common in-phase oscillation of all generators as foundon an isolated system. The frequency of such a global mode is typically under 0.2Hz.

The need for effective damping of such a wide range, almost two decades, of electromechanical oscillations motivated the concept of the multiband power system stabilizer (MBPSS), as shown in Fig.3. Just as its name reveals, the MB-PSS structure is based onmultiple working bands. Three separate bands are dedicated to the low-, intermediate-, andhigh-frequency modes of oscillations: the low band is typically associated with the power systemglobal mode, the intermediate with the inter-area modes, and the high with the local modes.

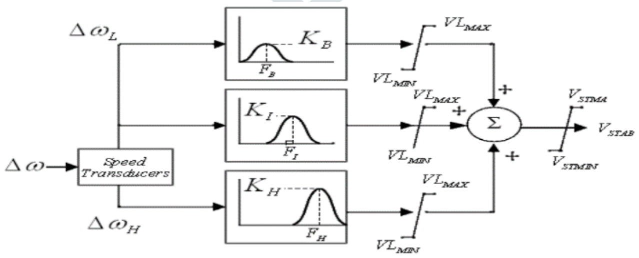

Fig. 3. Block Diagram of Multi-band Power System Stabilizer (MB-PSS)

E. Transmission System and SVCModelling

The SVC and power system stabilizers (PSS) areused to improve the transient stability and power oscillationdamping of the system. The SVC regulates voltage at itsterminals by controlling the amount of reactive power injectedinto or absorbed from the power system. The variation of reactive power is performed byswitching three-phase capacitor banks and inductor banksconnected on the secondary side of a coupling transformer. The SVC is the phasor model from the FACTS library. It does not have a power oscillation damping (POD) unit. TheSVC rating is +/- 200 Mvar. TheSVC can be operated in Voltage regulation or Var control (Fixed susceptance Bref) mode by selecting in the Control parameters. Initially the SVC is set in Var control mode with a susceptance Bref=0, which is equivalent to having the SVC out of service.

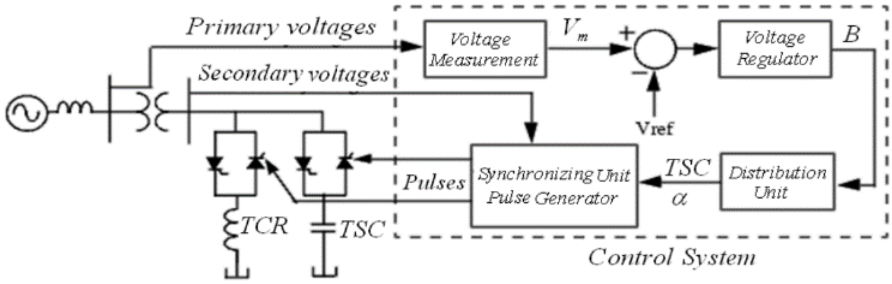

Fig. 4. Single-Line Diagram of a SVCwith its Control System

Fig.4 shows the single-line diagram of a static var compensator and its controlsystem. Each capacitorbank is switched on and off by three thyristor switches (Thyristor Switched Capacitor or TSC).Reactors are either switched on-off (Thyristor Switched Reactor or TSR) or phase-controlled(Thyristor Controlled Reactor or TCR) [1, 2].

The control system consists of the following issues:

1) A measurement system measuring the positive-sequence voltage is to be controlled.
2) A Fourier-based measurement system using a one-cycle running average is used.
3) A voltage regulator that uses the voltage error (difference between the measured voltage Vm and the reference voltage Vref) to determine the SVC susceptance B needed to keep the system voltage constant.
4) A distribution unit that determines the TSCs (and eventually TSRs) must be switched in and out, and computes the firing angle of TCRs.
5) A synchronizing system using a phase-locked loop (PLL) synchronized on the secondary voltages and a pulse generator that send appropriate pulses to the thyristors.

F. Simulink Model of the Power SystemUnder Study

The Complete Simulink Model of the Power Systemunder study is shown in Fig.5.A Static Var Compensator (SVC) and Power System Stabilizers (PSS), are used to improve transient stability and power oscillation damping of the system. The Pa and MB PSS along with SVC operating in Var control mode are used. In order to show the performances and observe the impact of Pa and MB PSS on the power system stability a three-phase fault have been applied on the first section of the line (L1).A Fault Breaker block is connected at bus B1. Theimpact of the both PSS along with SVC operating in Var control mode on system stability can be observed.

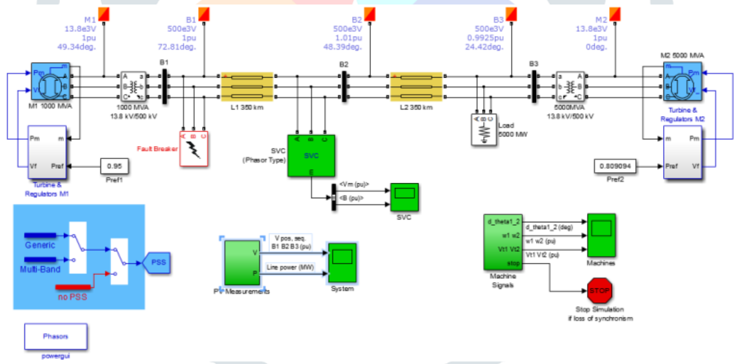

Fig. 5. Simulink model of power system under study

System description:

III. SIMULATIONOF SYSTEM UNDER STUDY

A. Load Flow Analysis

Initiallythe machines and the regulators are initialized by Powergui block.Then theLoad flow has been performed with machine M1 defined as a PV generation bus and machine M2 defined as a swing bus. After the load flow has been solved, the reference mechanical powers and reference voltages for the two machines have been automatically updated in system.

B. Effectof Pa & MB-PSS on transient stability of power system along with SVC operating in Var control mode

A3-phase fault is applied and the impact of the SVC is observed for stabilizing the network during a severe contingency. This part contains two tests.In first one both Generic Pa typePSSare put in service. TheFault Breaker block is programed to apply a 3-phase-to-ground fault.TheSVC is set tooperate in fixed susceptance mode with (Bref=0.42) this isequivalent to putting the SVC nearer to stability margin of the power system. Athree-phase to ground faulthave been applied at t=0.1 s and removed at t=0.2 s.

When the Pa typePSS are put in serviceand SVC is set tooperate in fixed susceptance mode(with Bref=0.42) which means the SVC is nearer to stability margin of the power system. By observing the d_theta1_2 signal (fig.6), it isseen that the two machines quickly lose the synchronism even after fault clearing(fig.8). The speeds of both machines changes very rapidly and shows that both the machines fall out of step with Pa typePSS. Also the terminal voltages both the machines has becomes unstable (fig.10).

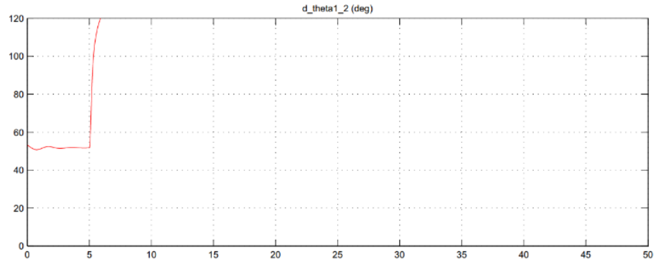

Fig. 6. Swinging of machines withPa PSS for 3-phase fault

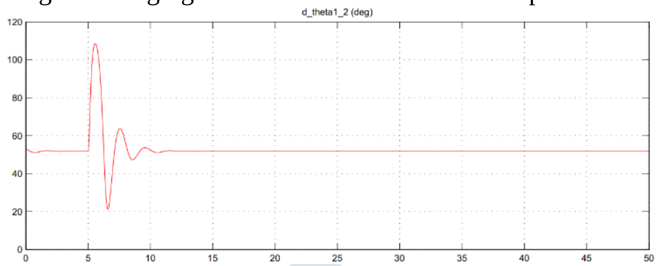

Fig. 7. Swinging of machines withMB PSS for 3-phase fault

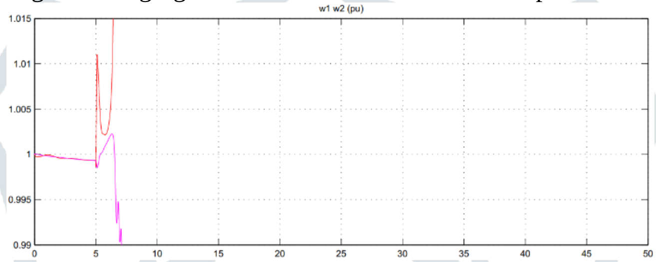

Fig. 8. Speeds of both machines withPa PSS for 3-phase fault

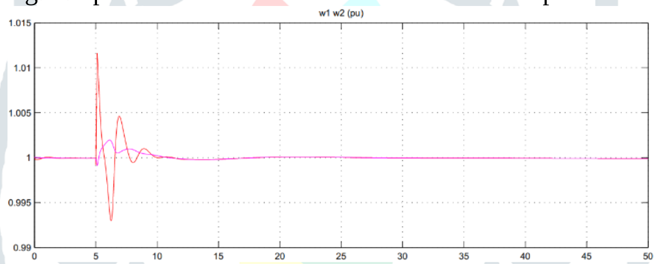

Fig. 9. Speeds of both machines withMB PSS for 3-phase fault

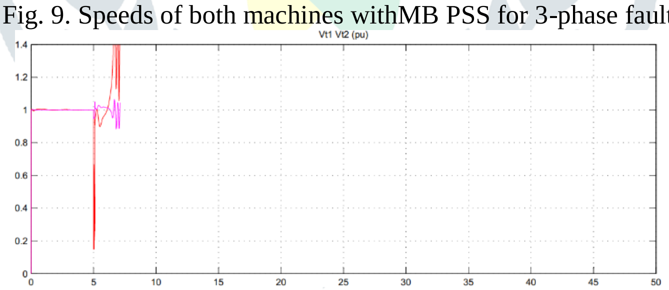

Fig. 10. Terminal voltages both machines withPa PSS for 3-phase fault

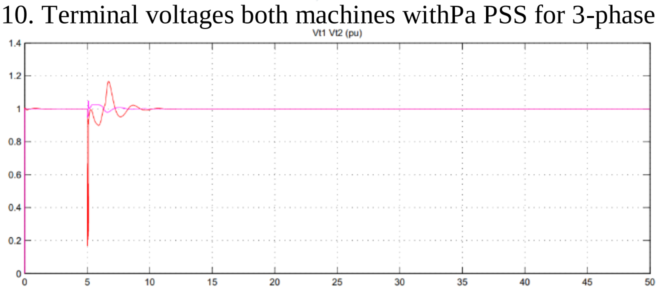

Fig. 11. Terminal voltages both machines withMB PSS for 3-phase fault

Now the MB typePSS are put in serviceand SVC is set tooperate in fixed susceptance mode(with Bref=0.42) which means the SVC is nearer to stability margin of the power system. Now the MB typePSS tries to support the damping to therotor oscillations of the synchronous machine by controlling its excitation. Three separate bands are dedicated to the low-, intermediate-, and high-frequency modes of oscillations: the low band is typically associated with the power system global mode, the intermediate with the inter-area modes, and the high with the local modes.

By observing the d_theta1_2 signal (fig.7), it isseen that the system is now stable with MB typePSS along with SVC operating in Var control mode under a 3-phase fault. The system is becoming stable in a very less time.The results of these studies shows that the MB typePSS has more capability in damping power system oscillations andenhances greatly the transient stability of the power system than the Pa typePSS.

IV. Conclusion

The work described in this paper illustrates how the MB typepower systemstabilizers (PSS) are superior toimprove transient stability and power oscillation damping ofthe systemthan the Pa type power system stabilizers (PSS). The results depict that a system has beendeveloped successfully for the stability of transients in transmission system with PSS. The basic structure of (SVC) is operating underfixed susceptance mode. The analysis of the PSS shows that how the MB type power system stabilizers (PSS) helps to improve the stability when Pa type power system stabilizers (PSS)is fail to maintain the stability.

From simulation results of the proposed model it is conclude that:

- The system under study is oscillatory and instable withoutPa type power system stabilizers (PSS)and SVC.
- The selective of power system stabilizers (MB type PSS) are capable of proving sufficient damping to the steady state oscillation and transient stability voltages performance over a wide range of operating conditions and various types of disturbances of the system used in system under study.
- If there is three phase transient fault, then With SVC and Pa typePSS are not able to maintain the stability.
- TheMB type PSS quickly damp out oscillations thanthe Pa typePSS and system is becoming stable in a very less time.

V. References

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