Performance Evaluation of Power System Stabilizer for Transient Stability of a Power System

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Abstract: **With the growing demand of electrical power, the power system as a whole is becoming huge and therefore disturbance factors are also large in numbers. The main aim of the designer is to keep system in the best possible (healthy) conditions in and after the disturbance. Power System Stabilizers (PSS) is a control unit that counteract rotor angle variation and speed variation at the time of disturbance in the system and thus improving the transient stability of the system. This paper presents an operation of PSS at the time of single line to ground (L-G) fault. A test bench is created in Matlab/Simulink® to observe performance of PSS. The simulations presented here shows the working of PSS at the time of fault and it is found satisfactorily to mitigate rotor angle and speed variations at the time of disturbance with PSS which otherwise (without PSS) would have become unstable.**

Key Index: PSS, Transient Stability, Rotor Angle Difference, Speed of Machine, L-G Fault

1. INTRODUCTION

Transient stability of a machine can be enhanced by excitation systems with high gain and faster response. This can adversely result into small signal stability that is damping torque. Power System Stabilizer (PSS) is a control system that provides a positive contribution in damping rotor angle swings. These rotor angle swings are in the low frequencies ranging from 0.1 to 1.0 Hz known as intertie (interarea) modes or about 1.0-2.0 Hz known as local modes and about 2.0 – 3.0 Hz known as intra-plant modes [1-5].

The intertie (interarea) frequency modes (0.1 to 1 Hz) are caused by coherent groups of generators swinging against other groups in the interconnected system. If the ties are weak due to heavy system loading, damping to the disturbances may be insufficient. In this case, the Power System Stabilizer (PSS) will be able to provide much needed improvements in the interarea mode damping. PSS is installed on a generator unit. It monitors variables such as voltage, current and a shaft speed. It sends an appropriate signal to the voltage regulator to damp out the oscillations and thus the frequency can be kept in the tolerable limit. If the disturbances are prolonged due to insufficient damping, wide-scale outages are also possible. Hence, Power System Stabilizer are useful to avoid outages also [6-9].

Modern generators are built with turbine speed governing systems. So, when a small disturbance is observed, rotational speed of the generator will decrease or increase due to frequency variation. At this point, turbine control will inject slightly less or more fuel and thus system can mitigate these small oscillations. As the interconnected system has a variety of generators, each generator will have a different response and with this variation in response, system may no longer remain in the synchronism. So, to respond and damp out these oscillations quickly, PSS sends control signal to the generator voltage regulator. This will counteract the frequency oscillations [10-12].

2. SYSTEM UNDER STUDY

The system under consideration is modelled in Matlab/Simulink®. It has two hydro power plants. A Power System Stabilizer (PSS) is used to improve transient stability and to provide damping to the oscillations. The single line diagram of the system is presented in figure 1. G1 is a 1000 MW hydro generator, and it is connected to the load centre via 500 kV,700 km long transmission line. The total load on the system is 5000 MW. Both the generators have an operational voltage of 13.8 kV. Two transformers are connected at the two ends having rating 13.8/500 kV. Second generator G2 has a power rating 5000 MW. Load is taken to be a resistive and it is near to G2. The Matlab/Simulink® of the system is presented in figure 2.

3. TESTING THE PSS WITH L-G FAULT

As stated earlier, the role of a Power System Stabilizer (PSS) is to provide damping at the time of oscillations and to restore the system to the normal condition as quickly as possible. A test bench as shown in figure 2 was created in Matlab/Simulink®. This test bench was tested for the single line to ground fault (L-G fault) for observing the dynamic operation of the Power System Stabilizer. The fault created was in phase A. Initially the breaker was closed at t= 0 and a single line to ground fault (L-G fault) was created at t = 0.1 seconds and it was cleared at t = 0.2 seconds. Pre-fault, Fault and post fault conditioned were analysed with the graphical behaviour of the system.

4. RESULTS AND DISCUSSION

Figure 3 (a) to 3(d) presents results for the test bench. Total simulation time was taken as 4 seconds. Fault in the first phase (phase A) was created at 0.1 seconds. The fault was ON for 6 cycles that is for 0.1 seconds. So, it got cleared at 0.2 seconds (fault timings 0.1 to 0.2 seconds). In this situation, the results with PSS and without PSS are compared in figures 3 (a) to 3 (d). Figure 3 (a) shows the rotor angle difference. In the pre-fault conditions, it was around 50^0 - 52^0. Without PSS it goes on increasing and ultimately the machine will loose synchronism. With PSS (figure 3 (a)), the rotor angle difference for the initial part of the fault (for a few cycles) is increasing as a consequence of fault but in the post-fault conditions, with PSS it gets stable and again reaches to a value of 50^0 - 52^0. Similarly, as shown in figure 3(b), the machine speed without PSS is also getting unstable but with PSS, initially it reaches to around 1.005 pu but within a few cycles it is again getting normalised at 1.0 pu. Figure 3 (c) and 3 (d) represents voltage of the three phases and line power respectively. It is clear from these figures that the PSS control unit is capable to handle voltage and power variations also.

5. CONCLUSION

A single line to ground fault for a 700 km long, 500 kV transmission line with two generators of 1000 MW and 5000 MW was carried out on a test bench created in Matlab/Simulink®. It was found that without the Power System Stabilizer, the system reaches to unstable mode at the time of disturbance. In the case of single line to ground fault, with the help of PSS, the system regains its original state within a few cycles after the disturbance. Rotor angle variation and speed of the machine with PSS is observed to gain its original position with PSS within a few cycles after the disturbance which otherwise would have become unstable, and machine would have lost synchronism. The results found with PSS are satisfactory.

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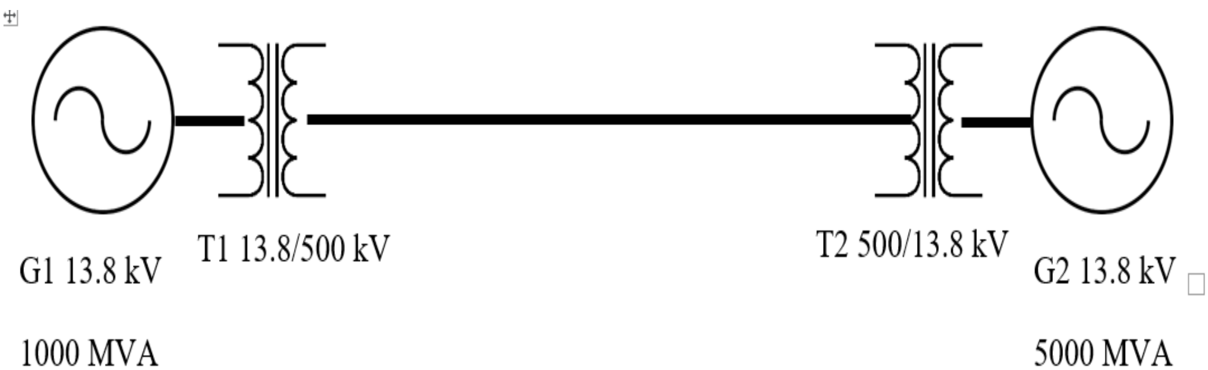

Figure 1: Single line diagram of the system under study

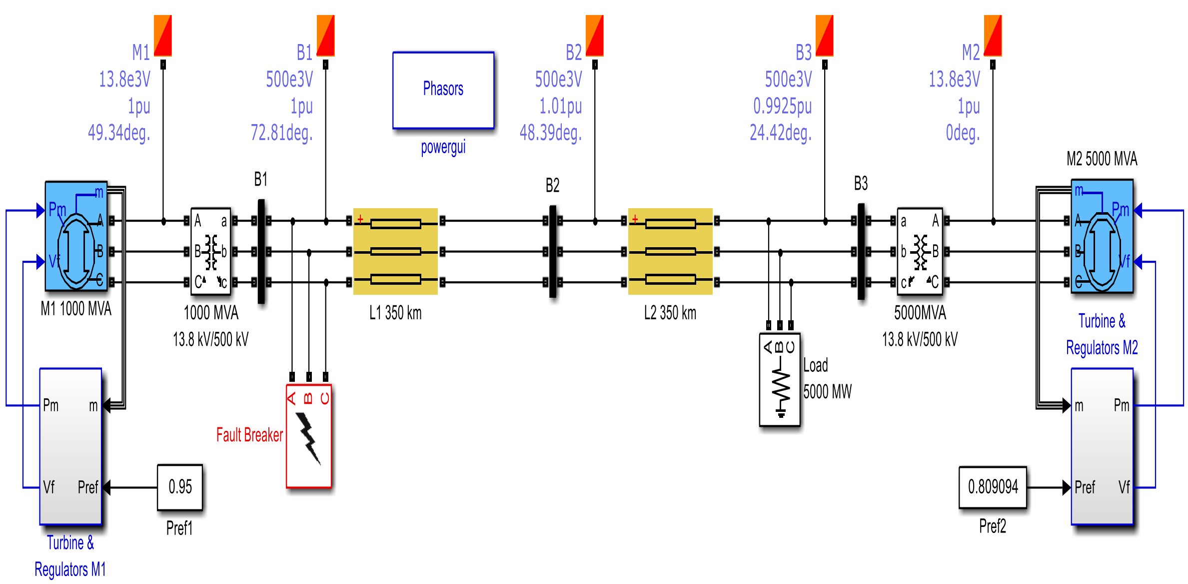

Figure 2: Matlab/Simulink® Model of the System Under Study

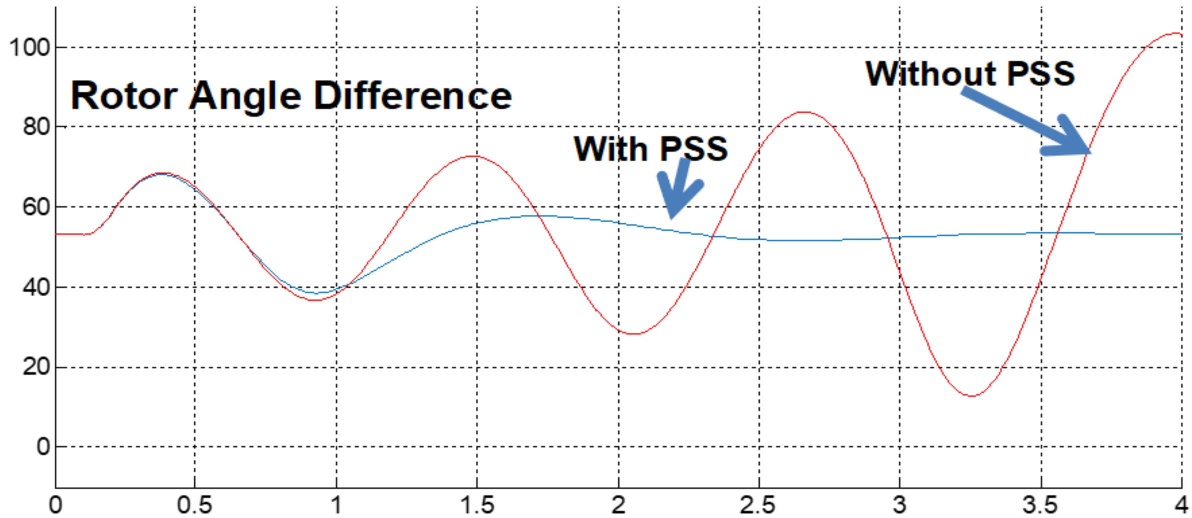

Figure 3 (a) Rotor Angle Difference with and without PSS

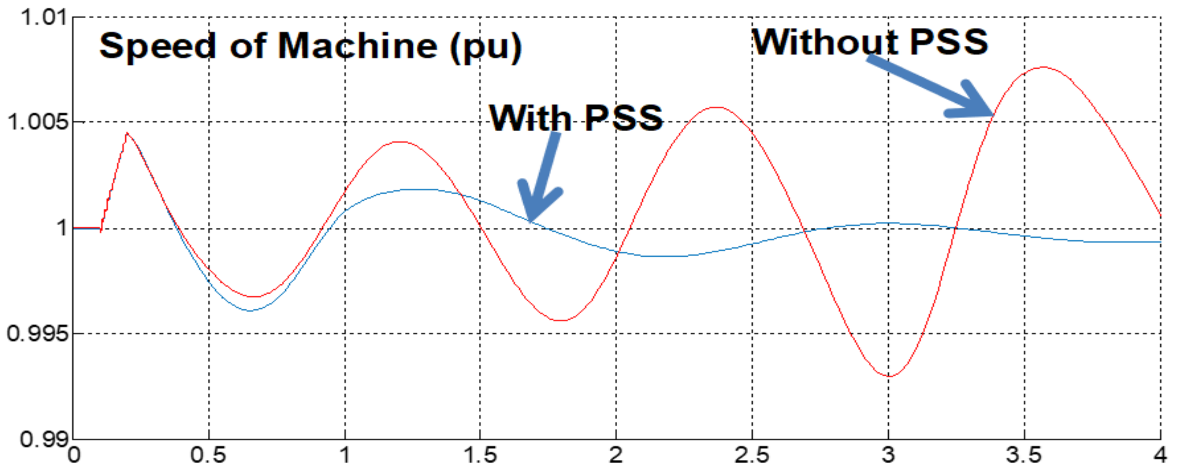

Figure 3 (b) Speed of Machine with and without PSS

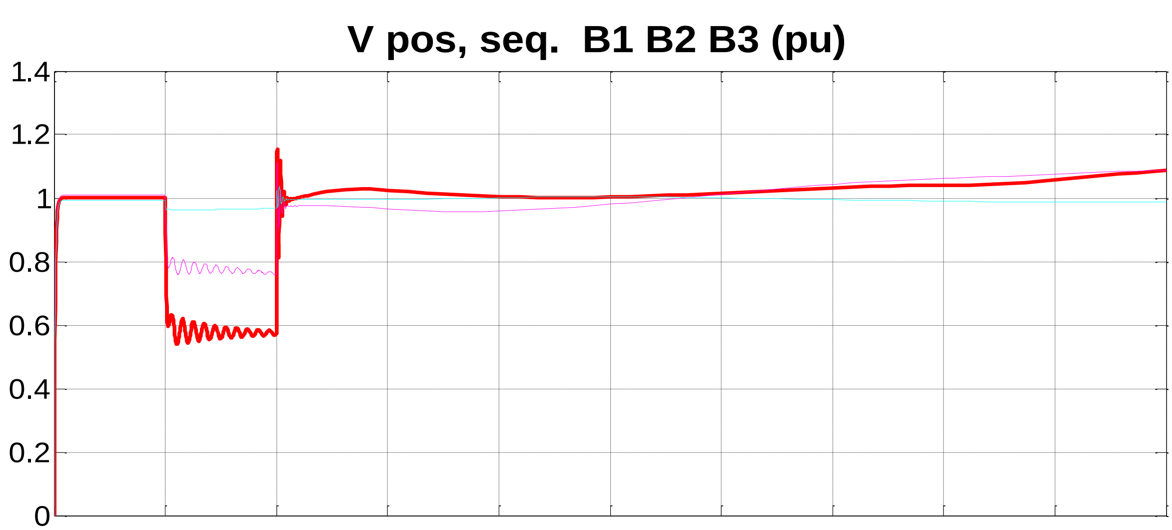

Figure 3 (c) Positive sequence voltages for the phases

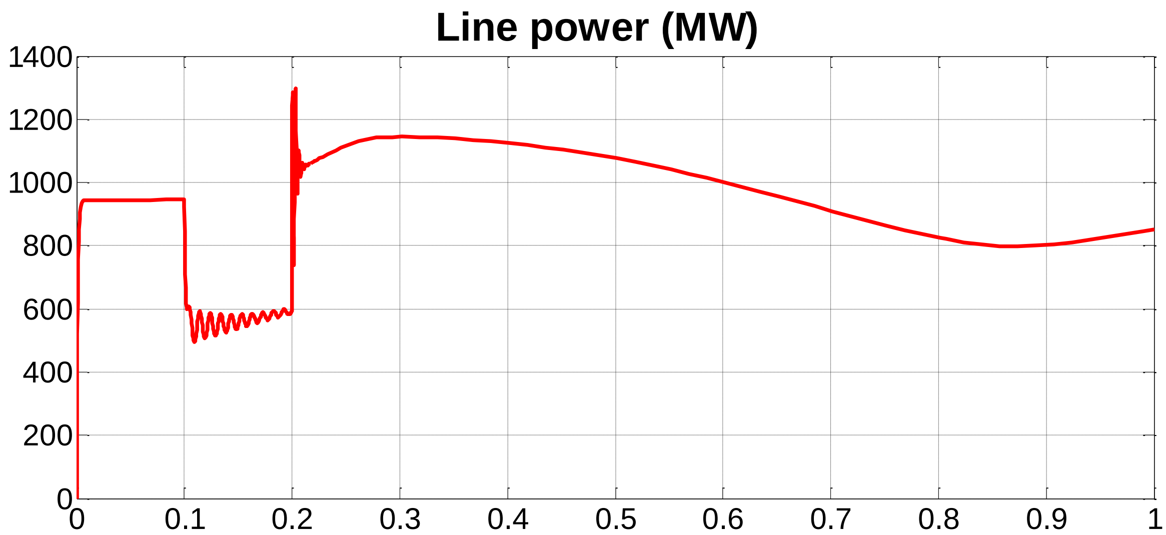

Figure 3 (d) Line power in pre-fault, at fault and post fault