Vol 11, Issue 4 , April/2020
ISSN NO:0377-9254

DYNAMIC STABILITY IMPROVEMENT OF POWER SUPPLY SYSTEM BY POWER SUPPLY STABILIZER

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***Abstract*— In large interconnected power system instability of oscillations is a common problem. Power system is subjected to small and large disturbances due to change in load, change in transmission and distribution configuration or due to fault on the system. Weak tie line, small disturbances such as small changes in load or generation is cause of oscillations and due to this loss of synchronism and sometimes eventual break down of the power system.**

In this project, main objective is to enhancement the dynamic stability of power system using PSS. The power system stabilizer adds the additional signal to the excitation system for the oscillation. We expressed the enhancement of dynamic stability by simulation of single machine to infinite bus model and Multi machine model with the use of PSS.

***Keywords*— Power System, Stabilizer, MATLAB Software, Generator**

1. INTRODUCTION

Modern Power system is highly interconnected comprising of large number of different dynamic devices such as synchronous machines and loads. The power system is a highly nonlinear system that operates in a constantly changing environment; loads, generator outputs, and key operating parameters change continually. Power system is subjected to small and large disturbances due to change in load, change in transmission and distribution configuration, or due to fault on the system and low frequency disturbance that cause loss of synchronism & eventual breakdown of entire system. The oscillations which are typically in the frequency range of 0.2 to 3 Hz might be excited by disturbance in the system. These oscillations limit the power transmission capability of the network.

In a power system, all components will be operating in parallel. Due to some fault or other operational condition change, if one component derails from synchronism then it will affect the other components and thereby affecting the whole network. If we consider five generators operating in parallel and due to a fault if any one generator losses synchronism, certainly it will affect the other generators. Due to this, the whole system will undergo a drastic change. So, the faulty generator must be switched out immediately. If the faulty generator is not switched out immediately, then it will affect the voltage profile of the system. There will be large fluctuations in voltage and the consumer cannot operate his equipments more satisfactorily. Electrical power system is incomplete without the study of power system stability.

2. POWER SYSTEM STABILIZER

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Damping of oscillations is necessary for stable and secure operation of power system otherwise it will result in loss of synchronism, reduction in power transfer capability of lines and eventual breakdown of the power system. Power system stabilizer provides supplementary excitation control signal for resolving oscillatory instability problem. PSS is generator control equipment which is used in feed back to enhance the damping of rotor oscillation caused due to small signal disturbance. The basic operation of PSS is to apply a signal to the excitation system that creates damping torque which is in phase with the rotor oscillations.

Generator and system damping can be improved by introducing a PSS into the excitation control scheme of the generator. Under oscillatory system conditions its purpose is to induce a component of electrical power that is in phase with rotor speed variations, thereby improving damping. A PSS may be based on a signal derived from generator speed, electrical power or network frequency. The signal is processed via appropriate filters to provide the required phase relationship

Vol 11, Issue 4 , April/2020
ISSN NO:0377-9254

between the induced electrical power variations and generator rotor speed.

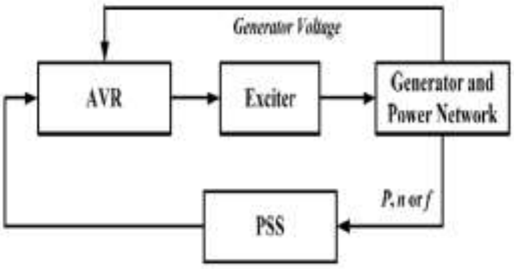

Fig. 1 A sample line graph General arrangement of control system

A power system stabilizer (PSS) installed in the excitation system of the synchronous generator improves the small-signal power system stability by damping out low frequency oscillations in the power system. It does that by providing supplementary perturbation signals in a feedback path to the alternator excitation system.

2.1. GENERAL STRUCTURE OF PSS

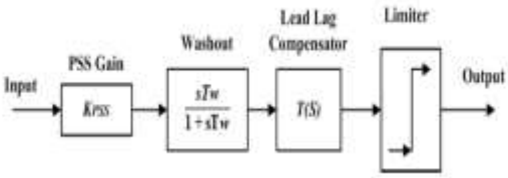

Fig. 2 Functional block diagram of PSS

A. Gain

Stabilizing gain KPSS determines the amount of damping introduced by PSS. Ideally, PSS gain is set to get the maximum damping of the oscillatory modes. However, due to practical considerations, high gain may not be always the best option and may cause excessive amplification of stabilizer input signal. In general, the gain value is set such that it results in satisfactory damping of critical system modes without compromising the stability limits.

B. Washout Circuit

It is a high pass filter. It passes those signals which are responsible for oscillation in rotor frequency. It is long enough to pass stabilizing signals over frequency of interest unchanged. It blocks the steady state changes in frequency otherwise it will modify the system voltage during overload or islanding condition. The wash out time T_w constant may be in the range of 1 to 20 seconds. For local modes of oscillations it can be 1 to 2 seconds and for inter area mode 10 to 20 seconds.

C. Phase Compensation

To damp rotor oscillations, the PSS must produce a component of electrical torque in phase with rotor speed deviation. This requires phase-lead circuits to be used to compensate for the lag between the exciter input (i.e., PSS output) and the resulting electrical torque. In practice two or more first order may be used to achieve the desired phase lead compensation.

D. PSS Output Limits

Stabilizer output voltage is limited between typical maximum and minimum values to restrict the level of generator terminal voltage fluctuation during transient conditions. Large output limits ensure maximum contribution of stabilizers but generator terminal voltage may face large fluctuation. The main objective in selecting the output limits of PSS is to allow maximum forcing capability of stabilizer, while maintaining the terminal voltage within desired limits.

2.2. CLASSIFICATION OF PSS

A. Speed As Input

Power system stabilizer utilizes change in speed as input to enhance damping of generator rotor oscillations. The problem with this stabilizer is presence of torsional mode. The effect of torsional mode can be reduced by measuring speed deviation along the shaft and using average speed deviation as input.

B. Power As Input

The advantage of using accelerating power is it requires minimum lead compensation and insensitive to torsional modes. It can eliminate requirement of torsional filter or simplifies it design.

C. Frequency As Input

Frequency signal is less sensitive to intra plant modes and torsional frequency components, but it is prone to noise cause by nearby loads.

3. POWER SYSTEM MODELLING

3.1. SINGLE MACHINE CONNECTED TO INFINITE BUS (SMIB)

For the sake of understanding the classical model better the case of a generator connected to an infinite bus through a transformer and transmission lines is considered. This type of system is called as Single Machine Infinite Bus (SMIB) system.

The single line diagram of SMIB system is shown in below Figure. Since resistance of synchronous generator stator, transformer and the transmission line are relatively negligible as compared to the corresponding reactances; only reactances of synchronous generator, transformer and transmission line are considered. Here, infinite bus represents rest of the system or grid, where the voltage magnitude and frequency are held constant. The infinite bus can act like infinite source or sink. It can also be considered as a generator with infinite inertia and fixed voltage.

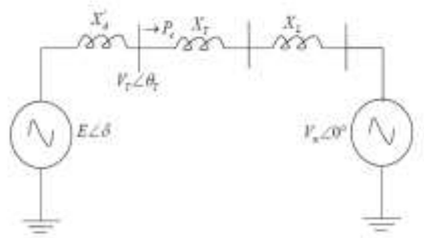

Fig. 3 Single Line Diagram of SMIB

In Above figure , E□□□represents the complex internal voltage of the synchronous generator behind the transient reactance X'd. VT □□$_T$ is the terminal voltage of the synchronous generator. X_T , X_L represent the transformer and line reactance. The complex infinite bus voltage is represented as $V_{\square}$ □0.

The infinite bus voltage is a taken as the reference because of which the angle is taken as zero. The generator internal voltage angle □□is defined with respect to the infinite bus voltage angle. The input mechanical power is represented as P_m and the output electrical power is defined by P_e. H is the inertia constant of the generator. $H_{\square}$ is the inertia constant of the grid equivalent generator connected at the infinite bus and its value can be taken as □□

A. MATLAB Simulation

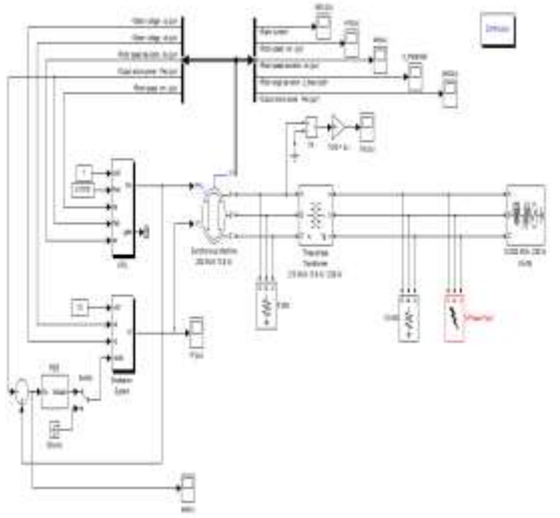

Fig. 4 MATLAB Model of SMIB

B. Results of MATLAB Simulation

[a] Without PSS waveform of Accelerating Power (Pa) V/S Time L-G Fault

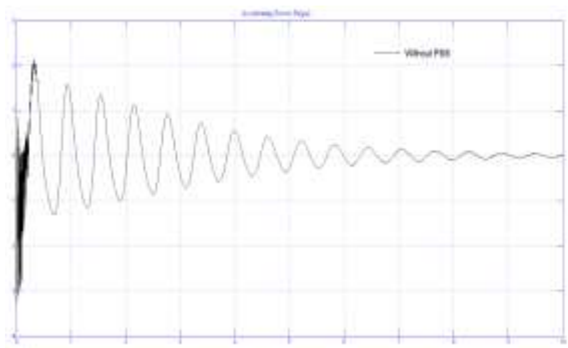

Fig. 5 Without PSS waveform of Accelerating Power v/s Time (L-G fault)

[b] With PSS waveform of Accelerating Power (Pa) v/s Time L-G fault

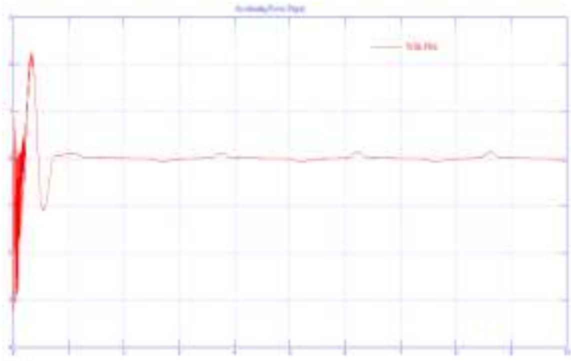

Fig. 6 with PSS waveform of Accelerating Power v/s Time (L-G fault)

[c] Without PSS waveform of Rotor speed deviation (dw) v/s Time L-G fault

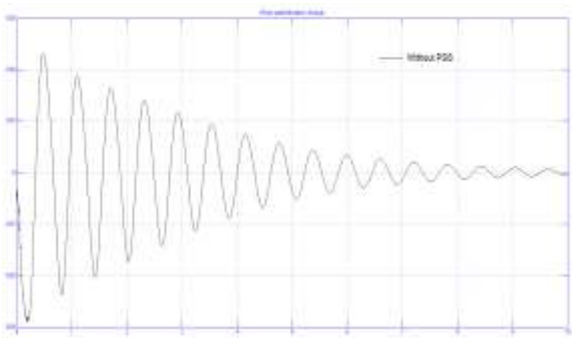

Fig. 7 Without PSS waveform of Rotor speed deviation (dw) v/s Time (L-G fault)

[d] With PSS waveform of Rotor speed deviation (dw) v/s Time L-G fault

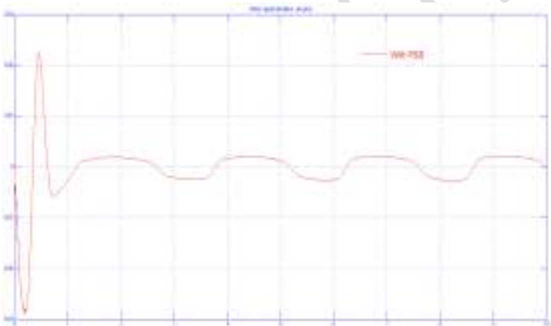

Fig. 8 With PSS waveform of Rotor speed deviation (dw) v/s Time (L-G fault)

[e] Without PSS waveform of Rotor angle v/s Time L-G fault

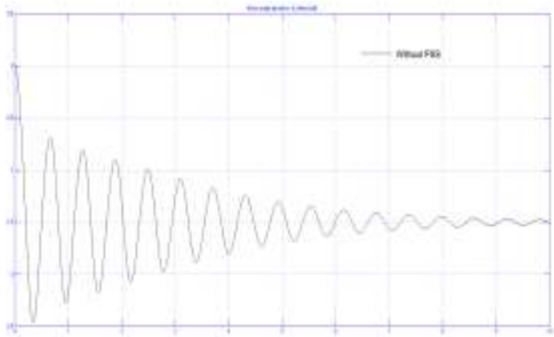

Fig. 9 Without PSS waveform of Rotor angle v/s Time (L-G fault)

[f] With PSS waveform of Rotor angle v/s Time L-G fault

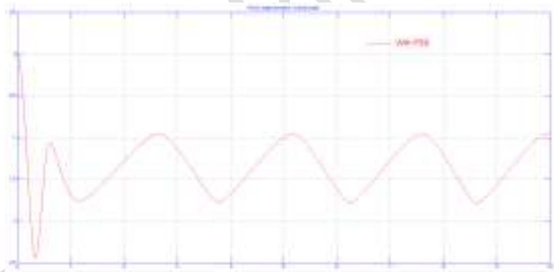

Fig. 10 With PSS waveform of Rotor angle v/s Time (L-G fault)

3.2. MUTLI MACHINE SYSTEM (3 MACHINE 9 BUS SYSTEM)

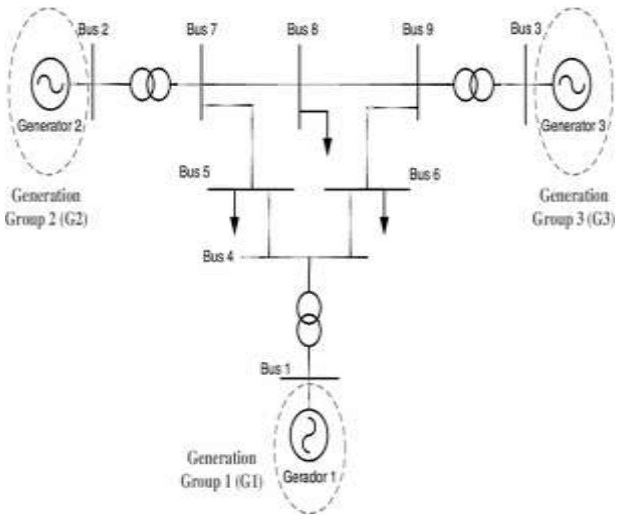

Fig. 11 Single line diagram of 3 machine 9 bus system

A. MATLAB Simulation

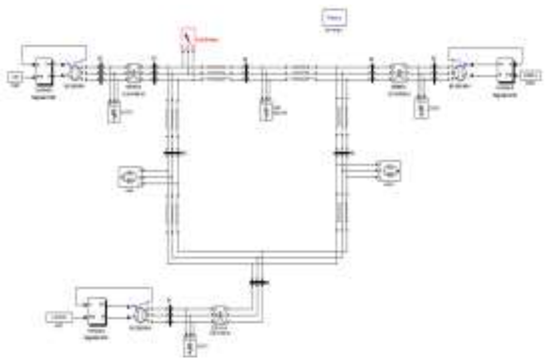

Fig. 12 MATLAB Model of 3 machine 9 bus system

B. Results of MATLAB Simulation

[a] Without PSS waveform of Accelerating Power (Pa) [Generator-2]

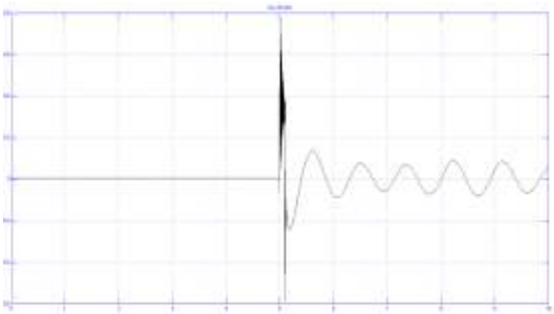

Fig. 13 Without PSS waveform of Pa v/s Time (Generator-2)

[b] With PSS waveform of Accelerating power (Pa) [Generator-2]

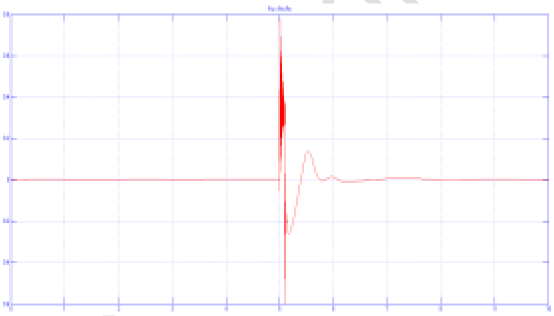

Fig. 14 With PSS waveform of Pa v/s Time (Generator-2)

[c] Without PSS waveform of Accelerating Power (Pa) [generator-1]

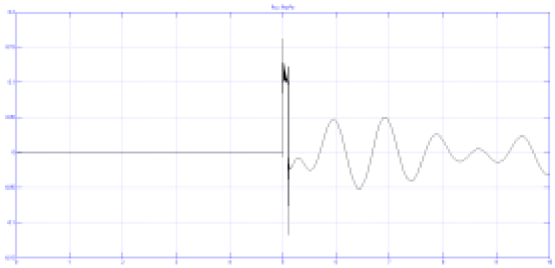

Fig. 15 Without PSS waveform of Pa v/s Time (Geneartor-1)

[d] With PSS waveform of Accelerating Power (Pa) [Generator-1]

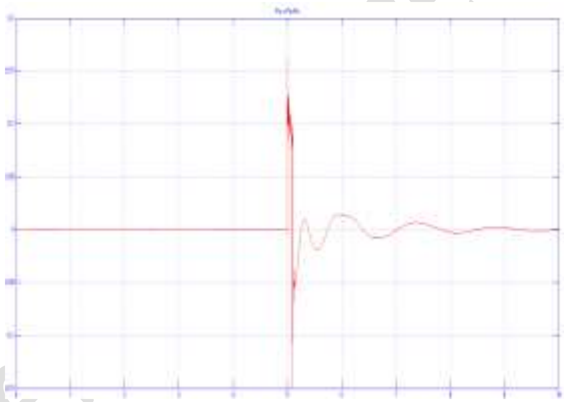

Fig. 16 With PSS waveform of Pa v/s Time (Generator-1)

[e] Without PSS waveform of Accelerating Power (Pa) [Generator-3]

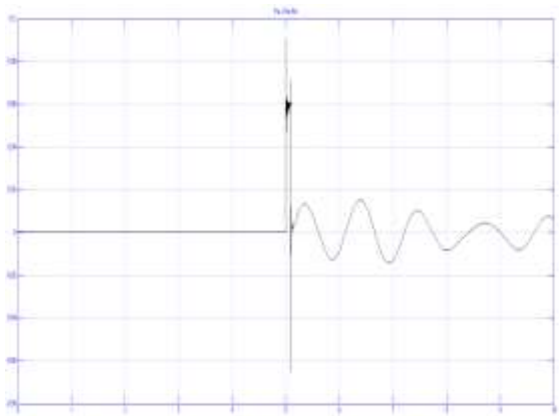

Fig. 17 Without PSS waveform of Pa v/s Time (Generator-3)

[f] With PSS waveform of Accelerating Power (Pa) [Generator-3]

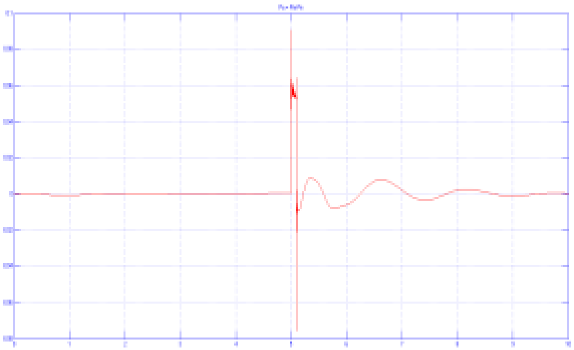

Fig. 18 With PSS waveform of Pa v/s Time (Generator-3)

[g] Without PSS waveform of Rotor speed deviations (dw) [Generator-2]

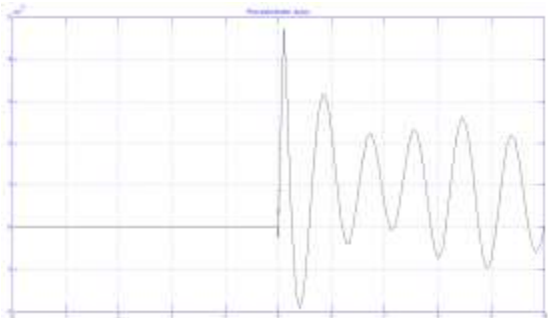

Fig. 19 Without PSS waveform of dw v/s Time (Generator-2)

[h] With PSS waveform of Rotor speed deviations (dw) [Generator-2]

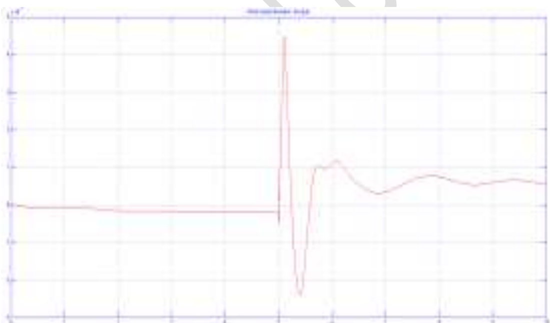

Fig. 20 With PSS waveform of dw v/s Time (Generator-2)

[i] Without PSS waveform of Rotor speed deviations (dw) [Generator-1]

Fig. 21 Without PSS waveform of dw v/s Time (Generator-1)

[j] With PSS waveform of Rotor speed deviations (dw) [Generator-1]

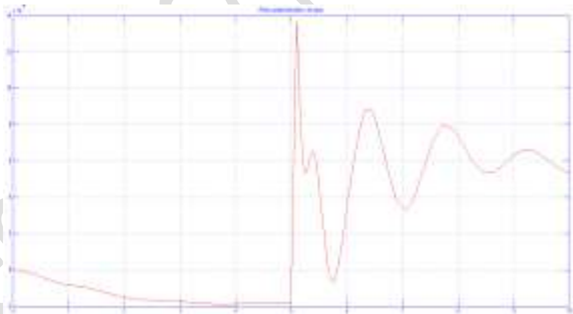

Fig. 22 With PSS waveform of dw v/s Time (Generator-1)

[k] Without PSS waveform of Rotor speed deviations (dw) [Generator-3]

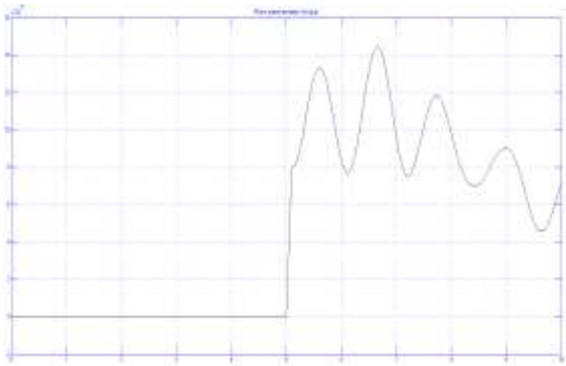

Fig. 23 Without PSS waveform of dw v/s Time (Generator-3)

[l] With PSS waveform of Rotor speed deviations (dw) [Generator-3]

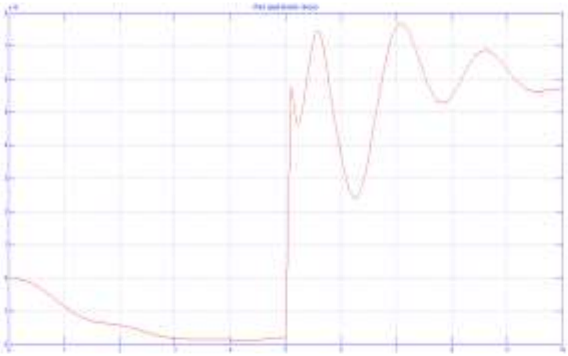

Fig. 24 With PSS waveform of dw v/s Time (Generator-3)

[m] Without PSS waveform of Rotor angle deviation (dΘ) [Generator-2]

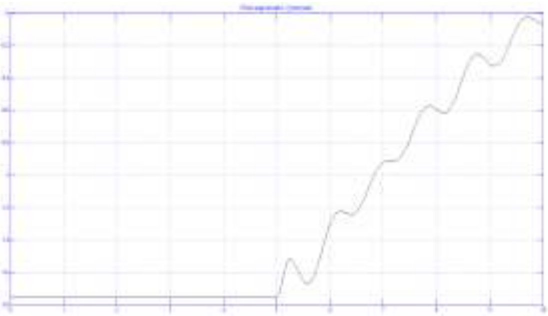

Fig. 25 Without PSS waveform of dΘ v/s Time (Generator-2)

[n] With PSS waveform of Rotor angle deviation (dΘ) [Generator-2]

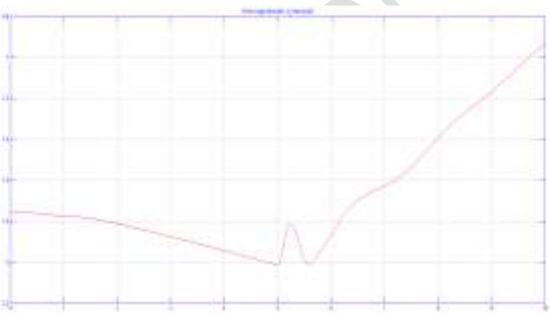

Fig. 26 With PSS waveform of dΘ v/s Time (Generator-2)

[o] Without PSS waveform of Rotor angle deviations (dΘ) [Generator-1]

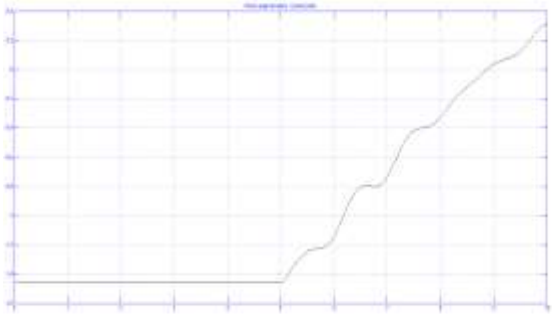

Fig. 27 Without PSS waveform of dΘ v/s Time (Generator-1)

[p] With PSS waveform of Rotor angle deviation (dΘ) [Generator-1]

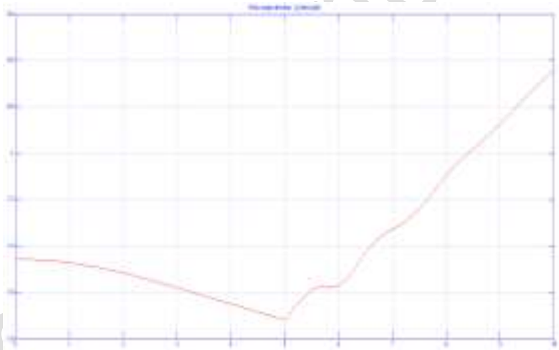

Fig. 28 With PSS waveform of dΘ v/s Time (Generator-1)

[q] Without PSS waveform of Rotor angle deviation (dΘ) [Generator-3]

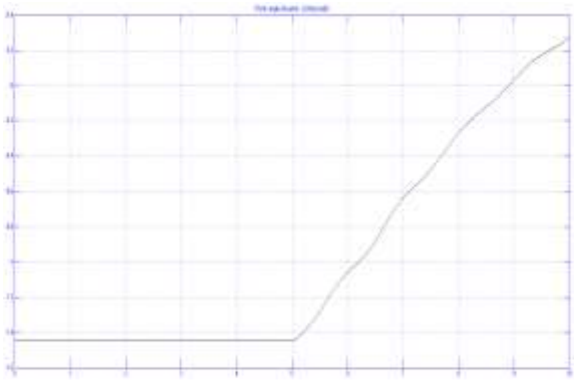

Fig. 29 Without PSS waveform of dΘ v/s Time (Generator-3)

[r] With PSS waveform of Rotor angle deviation (dϴ) [Generator-3]

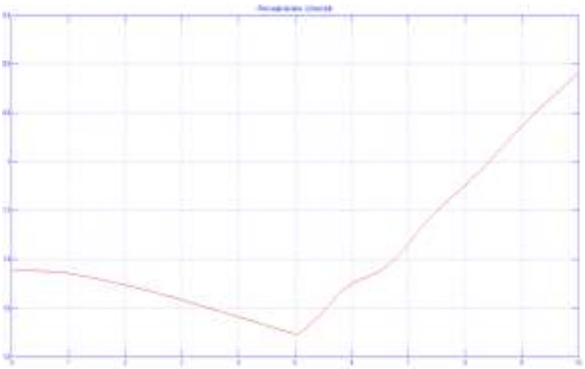

Fig. 30 With PSS waveform of dϴ v/s Time (Generator-3)

CONCLUSION

A power system stabilizer (PSS) installed in the excitation system of the synchronous generator improves the Dynamic stability by damping out low frequency oscillations in the power system. It does that by providing supplementary control signals in a feedback path to the alternator excitation system. And hence, improves the Dynamic stability of Single Machine to Infinite bus system and Multi machine system.

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