Power System Stabilizer for Stability Improvement of Power System

Bhumika, Jitendra Kasera

***Abstract*— This paper presents a systematic procedure for modeling, simulation & optimum parameter tuning of power system stabilizer (PSS) using genetic algorithm in power system. Interconnection of power system generate transient in network that produce low frequency oscillations & voltage instability. Power system stabilizer (PSS) is used to damp out this low frequency oscillation generated by interconnection of power system & improve stability of power system. The power system model is represented SMIB model. The effect of power system stabilizer (PSS) is demonstrated on power system (SMIB) using MATLAB/SIMULINK software package. Simulation result verify that power system stabilizer (PSS) improve stability of proposed model of power system.**

***Index Terms*— LFO, GA, Power System, PSS, SMIB.**

I. INTRODUCTION

Interconnection of large power system via relatively weak tie line will produce low frequency oscillations. These oscillations may sustain & increase to cause system out of synchronization if no adequate damping is provided. Power system utilities widely used conventional power system stabilizer (CPSS) for voltage stability, load angle stability, power oscillation & frequency stability. Security of power system is indicated by voltage profile. Stability of power system generator is depends on the load angle stability. Power system face speed deviation when connected load does not matched with generated power.

I. POWER SYSTEM

The SMIB system model is used to represent power system for stability analysis. The generated power fed to infinity bus handled by single transmission line. The terminal voltage of synchronous machine is shown by E_t while infinity bus voltage is shown by E_b. Line current I flow from generator to infinity bus.

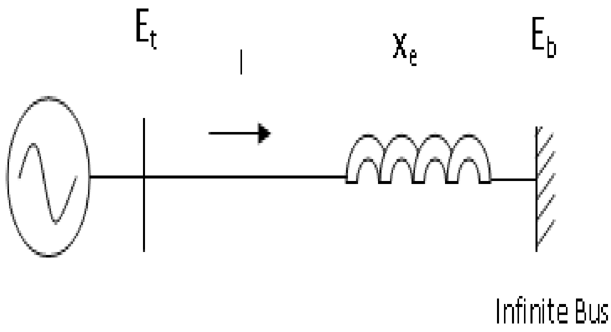

Fig. 1: SMIB system model to represent power system.

The synchronous generator is represented by a model 1.1, i.e. with field circuit and one equivalent damper winding on q axis. The machine equations are:

$$\frac{d\delta}{dt} = w_B (S_m - S_{mo}) \quad (1)$$

$$\frac{dS_m}{dt} = \frac{1}{2H} [-D (S_m - S_{mo}) + T_m - T_e] \quad (2)$$

$$\frac{dE'_q}{dt} = \frac{1}{T'_{do}} [-E'_q + (x_d - x'_d) i_d + E_{fd}] \quad (3)$$

$$\frac{dE'_d}{dt} = \frac{1}{T'_{qo}} [-E'_d + (x_q - x'_q) i_q] \quad (4)$$

The electrical torque T_e is expressed in terms of variables E'_d, E'_q, i_d and i_q as:

$$Te = E'_d i_d + E'_q i_q + (x'd + x'q) i_d i_q \quad (5)$$

For a lossless network, the stator algebraic equations and the network equations are expressed as:

$$E'_q + x'_d i_d = V_q \quad (6)$$

$$E'_d - x'_q i_q = V_d \quad (7)$$

$$V_q = -x_e i_d + E_b \cos\delta \quad (8)$$

$$V_d = x_e i_q - E_b \sin\delta \quad (9)$$

Solving the above equations, the variables i_d and i_q can be obtained as:

$$i_d = \frac{E_b \cos\delta - E'_q}{X_e + X'_d} \quad (10)$$

$$i_q = \frac{E_b \sin\delta - E'_d}{X_e + X'_q} \quad (11)$$

The above equations and notations for the variables and parameters described are standard and defined in the nomenclature.

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II. Power System Stabilizer (PSS)

The main function of a PSS is to add damping to the generator rotor low frequency oscillations by controlling its excitation using additional stabilizing signal. To provide accurate damping, the stabilizer will produce a electrical torque component in phase with the rotor speed deviation. A cost effective and satisfactory solution for oscillatory instability will provide damping to generator rotor oscillations. This is conveniently done by supplementary controllers in the excitation systems which provided by Power System Stabilizers (PSS).

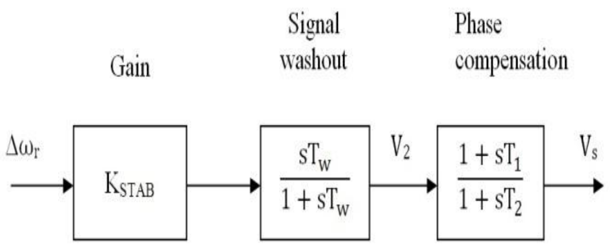

Fig. 2: Conventional power system stabilizer.

From above figure we preturbed value, we write:

$$\Delta V_2 = \frac{pT_w}{1+pT_w}(K_{STAB}\Delta\omega_r) \qquad (12)$$

Hence

$$p\Delta V_2 = K_{STAB}\, p\Delta\omega_r - \frac{1}{T_w}\Delta V_2 \qquad (13)$$

Taking state variables for $p\Delta\omega_r$ in equation (13) we can rewrite above equation in state variables.

$$p\Delta V_2 = K_{STAB}[a_{11}\Delta\omega_r + a_{12}\Delta\delta + a_{13}\Delta\psi_{fd} + \frac{1}{2H}\Delta T_m] - \frac{1}{T_w}\Delta V_2 \qquad (14)$$

$$p\Delta V_2 = a_{51}\Delta\omega_r + a_{52}\Delta\delta + a_{53}\Delta\psi_{fd} + \frac{K_{STAB}}{2H}\Delta T_m \qquad (15)$$

Where

$$a_{51} = K_{STAB}\, a_{11}$$

$$a_{52} = K_{STAB}\, a_{12}$$

$$a_{53} = K_{STAB}\, a_{13}$$

$$a_{55} = \frac{1}{T_w}$$

$$a_{54} = a_{56} = 0$$

$$\Delta V_s = \Delta V_2 \frac{1+pT_1}{1+pT_2} \qquad (16)$$

So

$$p\Delta V_s = \frac{T_1}{T_2}p\Delta V_2 + \frac{1}{T_2}\Delta V_2 - \frac{1}{T_2}\Delta V_s \qquad (17)$$

Substituting value $p\Delta V_2$ from equation (3.19) we get

$$p\Delta V_s = a_{61}\Delta\omega_r + a_{62}\Delta\delta + a_{63}\Delta\psi_{fd} + a_{64}\Delta V_c + a_{65}\Delta V_2 + a_{66}\Delta V_s + \frac{T_1}{T_2}\frac{K_{STAB}}{2H}\Delta T_m \qquad (18)$$

Where

$$a_{61} = \frac{T_1}{T_2}a_{51}$$

$$a_{62} = \frac{T_1}{T_2}a_{52}$$

$$a_{63} = \frac{T_1}{T_2}a_{53}$$

$$a_{65} = \frac{T_1}{T_2}a_{55} + \frac{1}{T_2}$$

$$a_{66} = -\frac{1}{T_2}$$

III. Genetic Algorithm & Objective Function

Genetic Algorithm is an extensive application widely used to solving globally optimized searching problems. The closed form optimization technique cannot be applied to some optimization problems then a genetic algorithm is a better option. Genetic Algorithm find out too many points in the given space for single parameter hence it is more closely to converge towards global minimum solution.

- Genetic Algorithm is used to find out optimal parameters of PID controller used in power system stabilizer (PSS). Genetic Algorithm is powerful searching method based on the mechanics belongs to natural selection and natural genetics.
- Genetic algorithm based on a population of strings, searching many parallel peaks, opposition to a single point.
- Genetic Algorithm used strings of characters which defining set of parameter.
- Genetic Algorithm follows probabilistic transition rules rather than deterministic rules.
- Genetic Algorithm directly utilized objective function information & not required derivatives or other auxiliary knowledge.

GA method is applied to find out the optimal settings of controller. Genetic algorithm optimization technique is used to minimize performance index which is integral square error (ISE) type. Speed deviation has been chosen as an error function. Objective function given is

$$\text{Minimize } J_e = \int_0^{\infty} e^2(t)\, dt$$

IV. SIMULATION & RESULTS

The proposed model of power system with power system stabilizer is simulated by using MATLAB. The oscillations are created using deviation in rotor speed. The power system stabilizer (PSS) is connected in system & performance of system is observed.

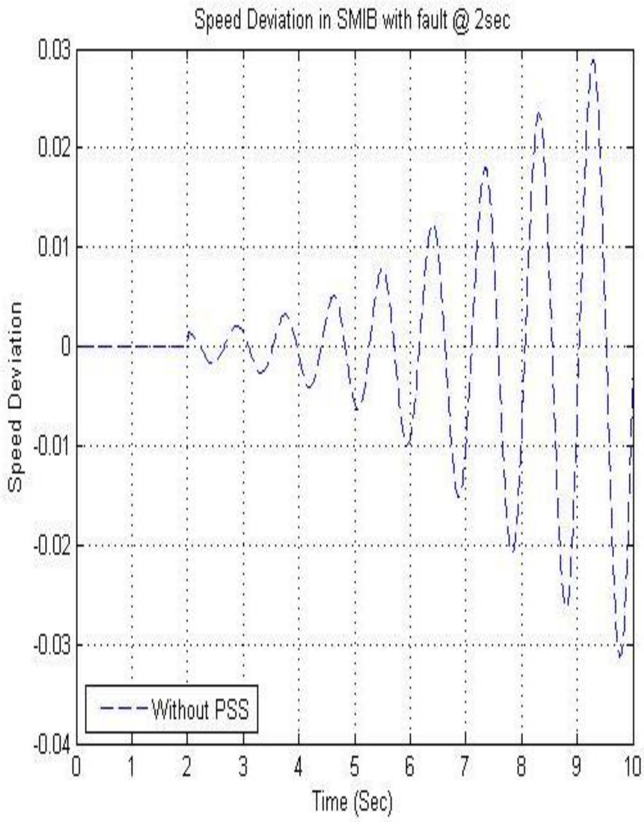

Fig. 3: Speed deviation in SMIB without PSS.

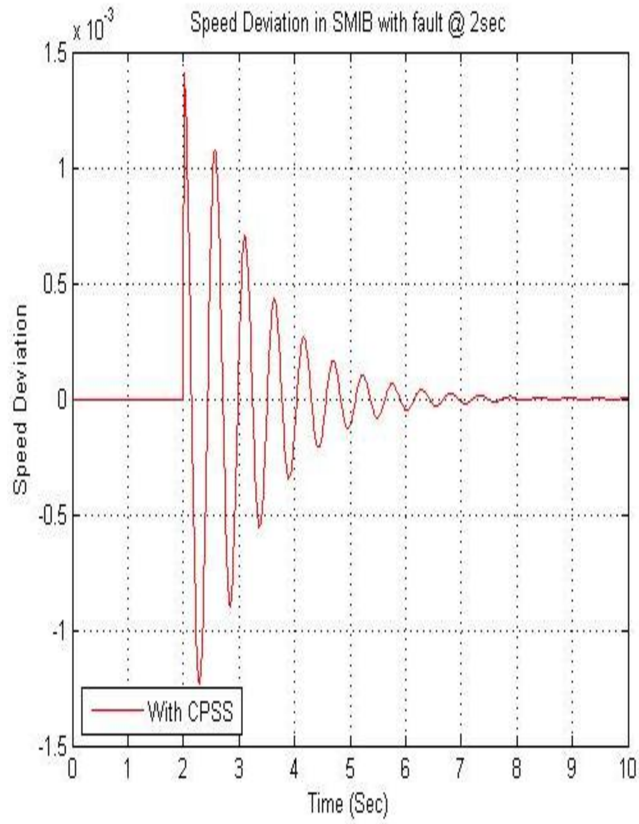

Fig. 4: Speed deviation in SMIB with CPSS.

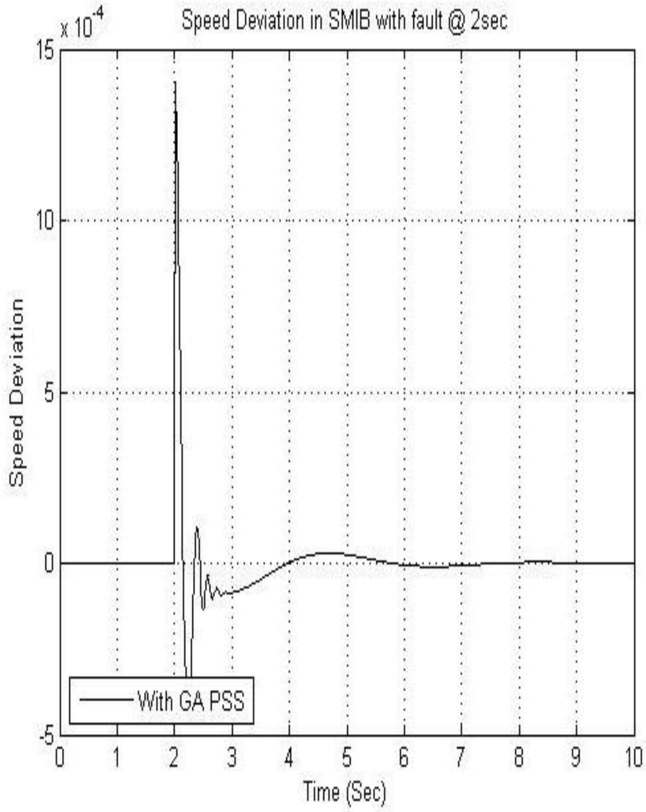

Fig. 5: Speed deviation in SMIB with GA-PSS.

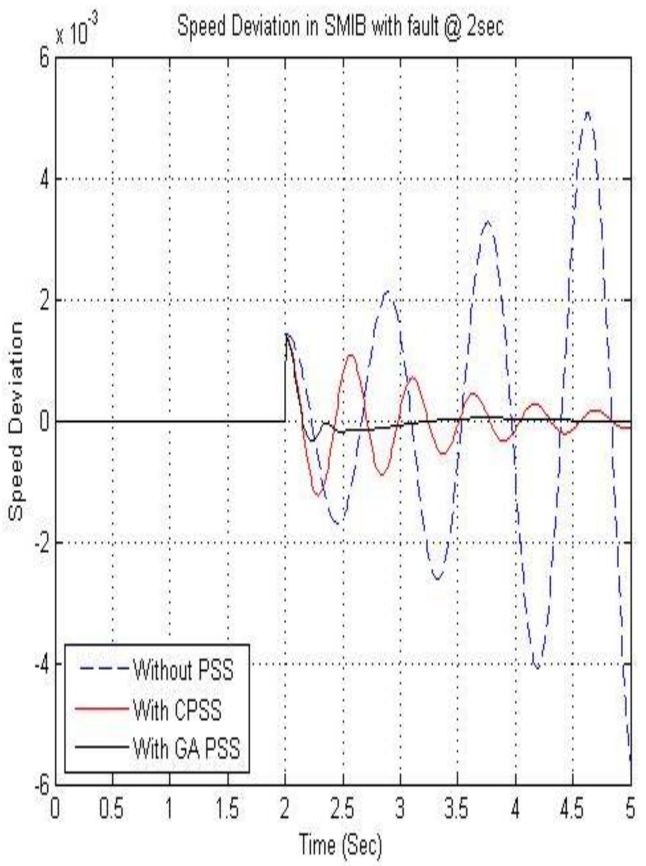

Fig. 6: Comparison of speed deviation in SMIB without & with PSS.

V. CONCLUSION

The behaviors of power system without & with power system stabilizer are observed. Conventional power system stabilizer (CPSS) is used to deviates low frequency oscillations. The genetically tuned power system stabilizer improves stability performance of power system with effectively damp out of low frequency oscillation. Results show that proposed model is suitable for stability analysis of power system with power system stabilizer

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