Improvement of Small Signal Stability of SMIB System with Optimized Power System Stabilizer

Y. Raghuvamsi, Imran Abdul, Ch. Rajesh

***Abstract:** As electrical power system is a complex system, there are more chances of stability issues may arise. One of the stability issues is Low Frequency Oscillations (LFOs) which makes the system unstable. As these oscillations are having low frequency i.e. large time constant with slowly increasing magnitude, they are referred to small signal stability. The main reason of these oscillations is due to lack of sufficient damping torque. Automatic Voltage Regulator (AVR) action in generator is providing sufficient synchronizing torque for system stability. This is possible with high gain and low time constant AVR which results in reduction of damping torque. Power System Stabilizer (PSS) is used together with AVR for providing necessary damping torque to minimize the LFOs. For effective damping, the PSS performance is improved by optimizing its parameters. In this paper, Single Machine Infinite Bus (SMIB) system is considered for studying the effect of LFOs. The SMIB system is simulated for a step disturbance in reference voltage and the results are carried out for different optimizing techniques Particle Swarm Optimization (PSO), Cat Swarm Optimization (CSO), Teaching and Learning based Optimization (TLBO).*

***Keywords:** Automatic Voltage Regulator, Cat Swarm Optimization, Particle Swarm Optimization, Power System Stabilizer, Teaching and Learning based Optimization.*

I. INTRODUCTION

As electrical power system is a very big interconnected network, there are so many chances of stability problems. Now a days, electricity is spreading to all areas including rural areas, hilly areas, etc. For this, the generating power needs to transmit for long distances using new transmission lines or existing ones. As new transmission lines involve more cost and more space, it is economical to transmit the power using existing transmission lines which makes the system interconnected. This makes the existing transmission lines getting overloaded and operating nearer to their stability limits. Due to this reason, even a small disturbance can make the system unstable. Low Frequency oscillations (LFOs) are nothing but the rotor of generator will oscillate at low frequencies. If there is no sufficient damping torque, these oscillations may sustain and their magnitude increases with time which makes the systems unstable.

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The LFOs in a power system are more prone to system instability. They limit the power transfer in the steady state and modify the economics and security aspects of the system [1], [2].

Small signal stability is fall under the category of rotor angle stability. In small signal stability, the change in rotor angle is small and maximum limit for rotor angle or torque angle is 90 degrees. As long as the electromagnetic torque and electromechanical torques of synchronous machine are in equilibrium state, the system is stable. The electromagnetic torque is a complex quantity, in which the real part represents Synchronizing torque (T_S) and the imaginary part represents Damping torque (T_D). Generally the torque T_S and the rotor angle deviation ($\Delta\delta$) are in phase with each other and the torque T_D and speed deviation (Δw) are in phase with each other [3]. Insufficient synchronizing torque leads to instability without any oscillations and insufficient damping torque leads to instability with LFOs.

The high speed Automatic Voltage Regulator (AVR) is a device which maintains the alternator terminal voltage at constant value. But, its function causes other effects: one is supplying T_S and sometimes it may decrease T_D. So, the AVR can provide the "coarse adjustment" to maintain rotor speed of alternators as constant. However, this AVR could not provide "smooth adjustment" to decrease the oscillation in the rotor. Hence, one more device is used for controlling these oscillations, known as Power System Stabilizer (PSS) was used in addition with AVR. The stabilizer can provide smooth adjustment to reduce the rotor oscillations i.e. LFOs by giving damping torque T_D [4]. In addition to fast exciter, frequency dependent loads, network characteristics and malfunction of controllers are some of the sources that bring the Low frequency oscillations into the system [3]. In general, these LFOs are defined for the oscillations that are in the range of 0.1 to 2Hz. Inter area mode oscillations having frequencies in range of 0.1 – 0.7Hz and Local plant mode oscillations having frequencies in range of 0.7 – 1.5Hz are the most dominant oscillations which affects the system stability adversely. So, parameters of PSS are selected in such a way that it provides damping for these dominant oscillations. Conventional Power Systems Stabilizers provide damping for the system under given operating conditions only. Also, designing PSS using conventional method involves lot of mathematical computations and process is time consuming. In addition, the obtained PSS parameters using conventional method may not be optimal values. So, the controller parameters are to be optimized for effective damping under different system conditions.

So many optimization techniques are available for optimizing the PSS parameters.

Particle Swarm Optimization (PSO) is a classical heuristic technique and is having advantages over Genetic Algorithm (GA). There are many similarities between GA and PSO but PSO is a very simple technique and easy to implement as there is no crossover and mutation. But the convergence of PSO is affected by the values of predefined parameters like inertia weight w and weighting factors c_1 and c_2.

In this paper, a Cat Swarm Optimization technique which is extension of PSO and one of the advanced techniques Teaching-Learning Based Optimization (TLBO) are adopted for optimizing PSS parameters. The CSO algorithm is extension to PSO, as it involves two sub-modes in the process which allow it to give best fitness value. The TLBO algorithm is an advanced technique with the advantages of fast convergence and less predefined parameters. The control input signal to the PSS can be speed, frequency and electrical power input signals. In this paper, the simulation is carried out for speed input stabilizer with optimized values for a nominal loading system.

II. SMIB SYSTEM

The linearized model of Single Machine Infinite Bus (SMIB) system is shown in Fig. 1. This system consists of different types of blocks which include Exciter, Field circuit, Power System Stabilizer related gain and compensator blocks and damping of synchronous machine, Voltage transducer and Heffron-Phillips constants (K_1 - K_6).

The transfer function of exciter and AVR is represented by exciter block which is shown as ST1 in figure. The main function of the excitation system is to maintain a constant terminal voltage and to reduce oscillations caused by transient rotor angle instability.

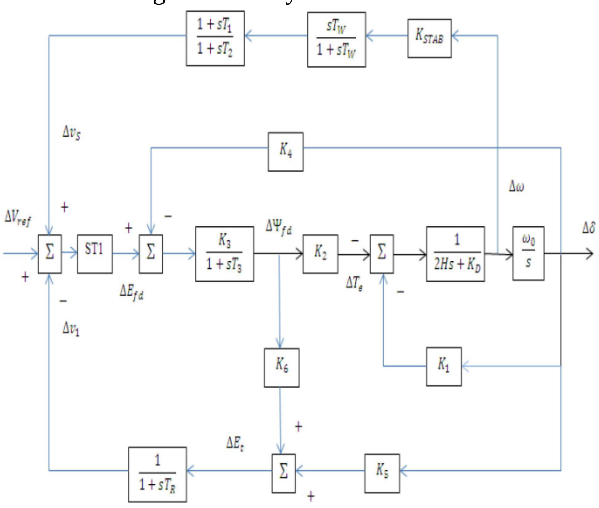

Fig. 1. Block diagram of SMIB

The input to the excitation system is given by taking a difference between a reference (step) voltage and the feedback signals from transducer and PSS. Thermal and hydraulic units, normally use the static exciters (thyristor family devices) for excitation. As the power electronic devices are having fast response and increased reliability with firing angle control, the static exciters are very useful for excitation control. Normally, it is difficult to maintain the terminal voltage as constant from time to time by manual control of excitation system. Hence, for maintaining the constant terminal voltage under any disturbance, a new device called Automatic Voltage Regulator (AVR) is used. In ST1 transfer function, the gain of exciter and AVR is represented by K_A and the time constant of the AVR is represented by T_A which is negligible [5].

The field circuit transfer function is represented by K3/(1+sK3Tdo') where Tdo' represents the d - axis transient open circuit time constant. The terminal voltage of synchronous machine is rectified and filtered before applying to excitation system. This filtering action takes the time in the range of 0.01 to 0.02 sec which is represented by a voltage transducer with transfer function of $1/(1+sT_R)$ where T_R is the time constant. The torque-angle loop of synchronous machine is represented with inertia constant H and damping coefficient K_D. The Heffron-Phillips constants (K_1 - K_6) represent the system dynamics. Generally, the Heffron-Phillips constants K_1, K_2, K_3 and K_6 are always positive under any condition. But the constants K_4 and K_5 values depends upon certain conditions of power system. Generally, the constant K_4 value is positive which represents the effect of variation in flux caused by armature reaction and it provides the positive T_D. But in some situations, the value of K_4 will be negative. Normally, salient pole type synchronous machines uses damper windings which are used for damping the oscillations in the rotor under any disturbance. Generally the salient pole type alternators are used in hydel power plant as the speed of hydel turbine is low. The value of K_4 is negative, when this salient pole type generator also called as hydraulic generator is operating at small load without damper windings and is connected by a transmission line with small X/R ratio to a large power system network. Also, there is one more situation for negative value of K_4 i.e. a large load connected locally is fed by both the alternator and the remote power system. For these situations, the generators produce negative damping as the armature reaction effect caused by induced currents produces the torques which have the components out of phase with Δw [4]. The value of constant K_5 depends on the loading condition and the transmission line impedance R_e+jX_e. Normally, the generator is having an electromagnetic torque T_e which is a complex quantity having a real part called synchronizing torque T_S and imaginary part called damping torque T_D. When the value of constant K_5 is positive, the AVR provides negative T_S and a positive T_D. The constant K_5 is positive, when the machine is operating with small values of external system reactance X_e and generating low power output. In such cases, even though the AVR action is reducing synchronizing torque, the overall synchronizing torque of the system is significantly greater than zero because the value of constant K_1 is so high [4]. With K_5 negative, the AVR action is opposite to the previous effect i.e. the AVR provides a positive T_S component and a negative T_D component. This effect is considerably increased with the increase in exciter response. This K_5 value is negative when the machine is operating with high values of external reactance and generating high power output.

In such cases, the fast action of AVR makes the damping torque T_D negative which brings the low frequency oscillations into the system.

Hence, the negative value of K_5 is chosen for stability analysis. The following SMIB system parameters are considered for the analysis: the AVR gain $K_A = 50$, AVR time constant $T_A = 0.05$ sec, $T_{do}' = 6$sec, $T_R = 0.01$ sec and inertia = 5sec. The data regarding generator reactance and external line reactance along with operating conditions are necessary for calculating Heffron-Phillips constants $K_1 - K_6$ and those values are represented as follows [1]:

D - axis reactance of generator X_d = 1.6pu
Q- axis reactance of generator X_q = 1.55pu
D-axis transient reactance of generator = 0.32pu
Transmission line reactance X_l = 0.4pu
Loading conditions: Real power P = 0.8pu,
Reactive power Q = 0.6pu,
Frequency f = 50Hz, Initial output voltage (V_{t0}) = 1pu.

III. POWER SYSTEM STABILIZER AND OPTIMIZATION

A. Power System Stabilizer (PSS):

As the fast acting AVR is introducing negative damping torque, it is necessary to place a new controller for supplying the required damping torque (T_D) to the system. Hence, a new controller called Power System Stabilizer (PSS) is used and it damps out the synchronous machine rotor oscillations by controlling the excitation using secondary signals [4].

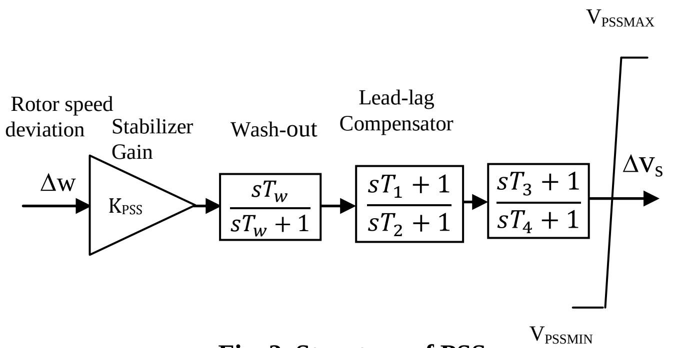

Fig. 2. Structure of PSS

From the Fig. 2, the washout filter is represented by a transfer function where T_w is the time constant and it is taken as 10sec. The stabilizer gain is represented by K_{PSS} and two stage lead lag compensators with time constants T_1, T_2 and T_3, T_4 are used. The washout filter is nothing but a high pass filter which is used in such a way that the PSS should respond only for the LFO range i.e. 0.1 to 2Hz. In other words, the washout filter is used to remove dc bias in the stabilizer output otherwise it will change the machine voltage. Hence, the washout filter time constant is selected based on LFOs and PSS should not respond to the dc offsets in the signal [5]. Stabilizer gain K_{PSS} is decided by the damping which is needed to minimize the oscillations. Lead-lag compensator is used for compensating any phase delay between the transfer functions of field exciter and generator. Finally, a limiter is used to limit the output of PSS in order to avoid the crossing of ceiling limits in the process of controlling excitation. The function of PSS is to provide a necessary T_D only and it should not affect the T_S at critical oscillation frequencies.

$$M\frac{d^2\Delta\delta}{dt^2} + \frac{T_D}{w_b}\frac{d\Delta\delta}{dt} + T_S\Delta\delta = 0 \quad (1)$$

From this equation, if both synchronizing torque (T_S) and damping torque (T_D) are positive under all conditions, then the oscillations caused by any disturbance will be damped out and finally system remains stable. If any one of the torque component is negative, then the system will become unstable indicated by one real root in right half of s-plane. One of the reasons for the instability is due to the fast acting exciter as it gives negative damping torque under certain operating conditions that lead to $K_5 < 0$.

B. Particle Swarm Optimization (PSO):

PSO method belongs to swarm techniques which search for the best evaluation value by using population for every particle. It is a fundamental and traditional algorithm in which the particle position is updated by flying around in a multidimensional search space. Generally this PSO technique is derived from two models of: i) social only model which tells that the individuals neglect their personal experience and modify their behavior based on successful beliefs of individuals in the surroundings and ii) cognition model considers the individuals as separated beings [6].

Algorithm [7]:

Step i: Firstly, define the number of particles, population size and maximum number of iterations along with the predefined parameters w, c_1, c_2

Step ii: Now generate the random initial positions (x) with random velocities (V) for each particle. Take the iteration count (z) starts with zero. Calculate the present fitness value for every particle in the population. At starting, the personal best (pbest) of every particle is its own fitness value, and the corresponding position is the personal best position.

Step iii: Now the minimum of personal best fitness gives the global best fitness value and its position.

Step iv: Increment the iteration count z and adjust the weight w

$$z = z+1 \quad (2)$$

$$w = ((\max(z)-z)/\max(z)) \quad (3)$$

Step v: Now modify the particle position by adding the updated particle velocity for next iteration by

$$V_i^{z+1} = wV_i^z + c_1*rand_1*(pbest_i - s_i^z) + c_2*rand_2*(gbest-s_i^z) \quad (4)$$

$$x_i^{z+1} = x_i^z + V_i^{z+1} \quad (5)$$

Step vi: Now, calculate the present fitness value of every particle. If present fitness is less than personal best, then update the personal best as present fitness value and also update with present position.

Step vii: Then the present global best fitness for the z^{th} iteration is calculated by taking present global best fitness as minimum of personal best fitness. If present global best fitness is less than gbest, then update gbest as present global best fitness and update with associated position.

Step viii: Finally, make a loop to the steps 4, 5 and 6 until z reaches the maximum iterations.

Step ix: Stop the process, when the above violations are appeared.

C. Cat Swarm Optimization (CSO):

This optimization was developed by considering the behavior of cats while catching their food.

Generally, the cats spend more time in alert mode instead of chasing the food by wasting its energy resources. This behavior is reflected into two sub-modes for developing new optimization called CSO. These sub-modes are referred as seeking mode and tracing mode, which follows two different ways in the algorithm. The behavior of the cat while chasing for a target is considered to be modeled as tracing mode and the alert mode of cat i.e. observing the surroundings carefully is considered to be modeled as seeking mode. In this algorithm, firstly the number of cats are decided and then some of the cats will be allocated for seeking mode and remaining for tracing mode. The individual cat is defined with a random position composed of M dimensions, and randomly generated velocities for each dimension. Then a fitness value is calculated and a flag is used for identifying the cat mode. The best position will be the cat which is having best fitness value. The CSO stores the optimal solution until the maximum iteration count is reached [8].

The two sub-modes will be combined by defining a parameter called mixture ratio (MR) which distinguishes the number of cats in both modes. As the cats usually spend maximum time in alert mode, a small value of MR is considered.

Algorithm [8]:

Step 1: Firstly, define the number of cats for the process.

Step 2: Now, randomly allocate the positions and velocities to all the cats in the M-dimensional solution space. Then by defining MR, arbitrarily pick number of cats and set some cats into tracing mode and remaining into seeking mode. Finally assign flag to the cats in order to distinguish seeking mode cats from tracing mode cats.

Step3: Now evaluate the objective function and calculate the fitness value of each cat. The position of the cat which is nearer to the optimal value is treated as best cat and keep it in memory. For further process, we need the position of best cat (x_{best}) because it represents the best solution so far.

Step 4: Throw the cats into seeking mode and tracing mode based on flags assigning to them.

Step5: Now, collect all cats from both modes and once again set them into two modes based on MR.

Step 6: For every iteration, check the maximum iteration or any termination condition and if it is violated, then stop the process otherwise go to step 3 and repeat.

D. Teaching and Learning Based Optimization (TLBO):

This is one of the advanced optimizing techniques which is having the advantage of less predefined parameters and hence it is selected for optimizing the PSS parameters. TLBO algorithm is derived from the concept of the role of a teacher and the coordination of the students in the class. As this algorithm involves the students as population, it is also considered as one of the population-based methods and nature inspired techniques. TLBO has two phases: Teacher Phase reflects the student learning process form teacher in class and the Learner Phase reflects the student interaction learning among them. In this, the optimized parameters are considered as number of subjects to be learned. Firstly, the set of subjects are randomly initialized among the number of students in searching space. Next, for each set, the fitness values are calculated and the one with best fitness value is treated as teacher and the sets excluding teacher are treated as learners. Then the iteration process started to shift the population towards the best solution in two following phases.

Teacher phase: Generally, a good teacher improves his or her students by sharing the knowledge and thereby the average of a class increases from M_A to M_B. But in practice, all learners cannot catch the teacher knowledge effectively and thereby a teacher can try to improve the mean of the class to some extent depending on student capability. Let the mean of the class is defined by M_i and teacher at i^{th} iteration is represented as T_i. Teacher will try to bring the mean closer to its knowledge level, so now the modified mean will be represented as M_{new}. After this, the process continues by taking the difference between the present mean and the new mean given by

$$\text{Delta\_mean}_i = r_i\,(M_{new} - T_F M_i) \quad (6)$$

where T_F represents teaching factor which describes the mean to be changed, and r_i generates a random number between 0 and 1. Now, the new solution becomes

$$Y_{new,i} = Y_{oldi} + \text{Difference\_Mean}_i\ . \quad (7)$$

Learner phase: Generally, the students increase their subject knowledge in two ways: one is from teacher input and the other from interaction with their friends in the class. In this way, a learner can improve his/her knowledge if the interaction is with other learner who is best in knowledge level than him or her.

For i = 1 : P_n
Randomly select two learners Y_i & Y_j , ($i \neq j$)
If $f(Y_i) < f(Y_j)$
$Y_{new,i} = Y_{old,i} + r_i^*(Y_i - Y_j)$
else
$Y_{new,i} = Y_{old,i} + r_i^*(Y_j - Y_i)$
End If
End For

Replace Y_{new} with old one, if it is improved i.e. giving a best fitness value than earlier [9].

Next repeat these two phases, until the maximum iteration count or termination condition is reached.

E. System model and PSS structure [7]:

The nonlinear differential equations of a power system can be expressed as

$$\dot{X} = f(X, U) \quad (8)$$

where X represents the state vector and U represents the input vector. This equation can be linearized by taking small signal represented by Δ

$$\Delta\dot{X} = f(\Delta X, U) \quad (9)$$

Now, the final system state equation can be written as

$$\Delta\dot{X} = A\Delta X + BU \quad (10)$$

The SMIB system shown in Fig.1 is having seven state variables and two input signals. In this work, the change in excitation is taking as input only for the analysis. Hence, state matrix A is 7x7 size and input matrix B is 7x1 size.

For a single stage lead-lag stabilizer, the PSS output signal is

$$\Delta v_s = K_{PSS}\frac{sT_w}{1+sT_w}\frac{(1+sT_1)}{(1+sT_2)}\Delta w_r \quad (11)$$

From this equation, the optimized parameters are time constants T_1, T_2 and gain K_{PSS}. T_w is taken as 10sec.

F. Objective Function:

There are different types of error functions are available and here, Integral time absolute error (ITAE) is chosen as fitness function J [10].

$$J = \int_{t=0}^{t=t_{sim}} t(|\Delta w|)dt \qquad (12)$$

Minimize J

Subject to the minimum and maximum constraints

$$K_{pss}^{min} \leq K_{pss} \leq K_{pss}^{max}$$
$$T_{1pss}^{min} \leq T_{1pss} \leq T_{1pss}^{max}$$
$$T_{2pss}^{min} \leq T_{2pss} \leq T_{2pss}^{max}$$

The parameter ranges are typically [0.1-100] for K_{PSS}, [0.1-1] for T_1 and [0.01-1] for T_2.

IV. SIMULATION OF SYSTEM AND RESULTS

Fig. 3 shows the SMIB system which is considered for analysis.

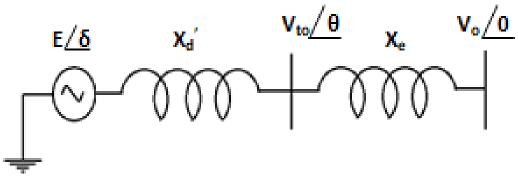

Fig. 3. SMIB system

The Heffron-Phillips model of SMIB system is simulated using MATLAB/SIMULINK without stabilizer and with optimized stabilizer as shown in Fig. 4 and Fig. 5 respectively.

A. Simulation:

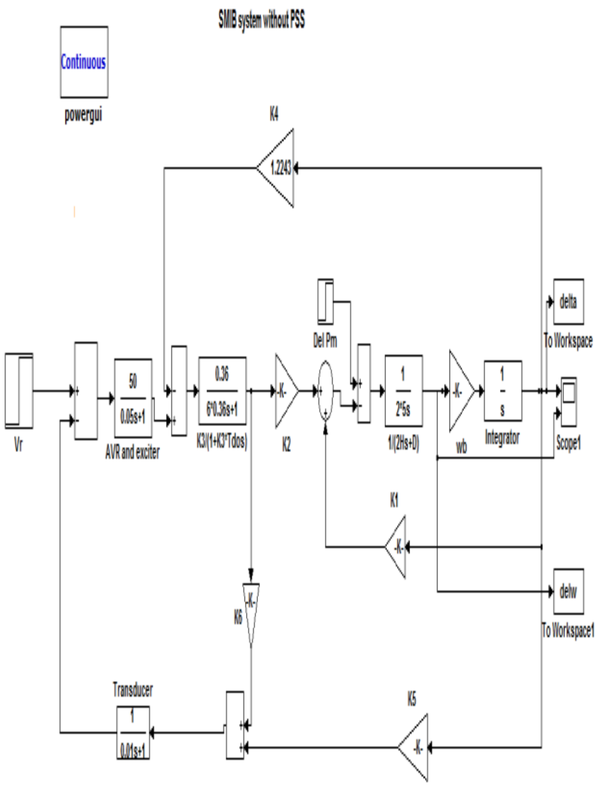

Fig. 4. SMIB simulation without stabilizer

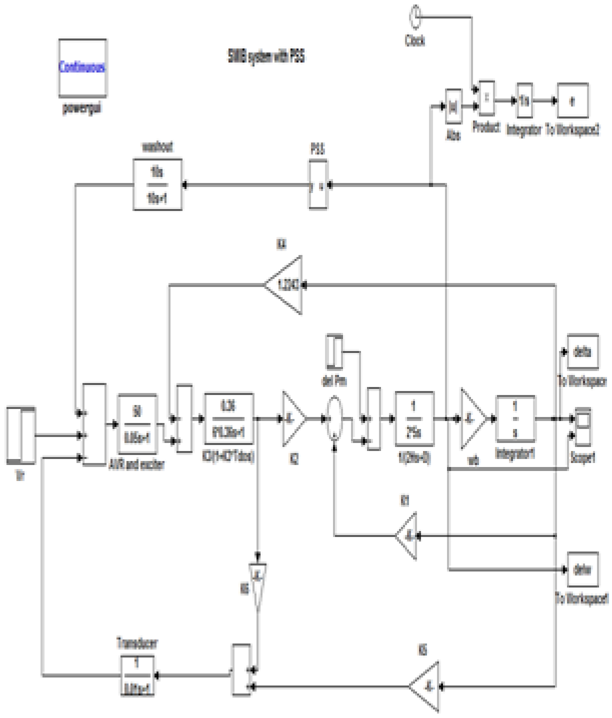

Fig. 5. SMIB system with stabilizer

B. Simulation Results:

For a step disturbance of reference voltage, the deviations in torque angle and speed without stabilizer are shown in Fig. 6 and Fig. 7 respectively. From the waveforms, the oscillations are increasing with respect to time as there is no controller for supplying required damping torque T_D. Hence, for any disturbance, the system is becoming unstable with ever increasing oscillations.

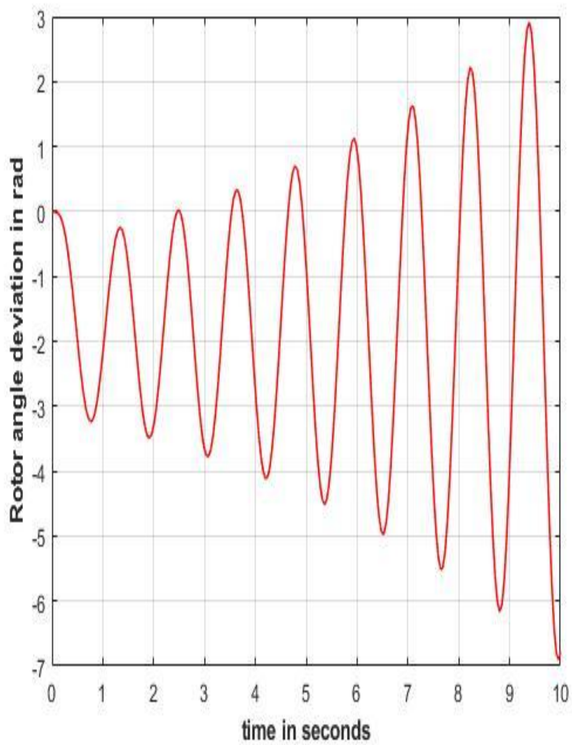

Fig. 6. Rotor angle deviation without stabilizer

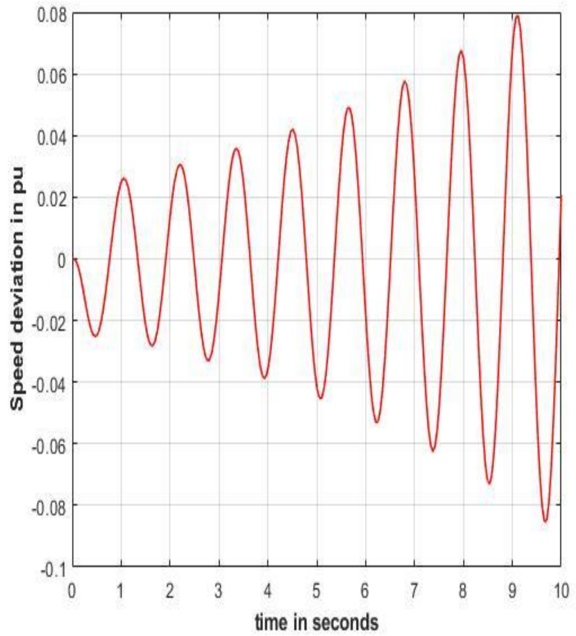

Fig. 7. Speed deviation without stabilizer

The above oscillations can be damped out by placing the stabilizer as feedback to the system and here the speed input stabilizer is used. The output of the stabilizer is used for changing the excitation in such a way that the oscillations are nullified.

Next, the same waveforms after optimizing the stabilizer parameters using PSO, CSO and TLBO are shown in Fig. 8 and Fig. 9 respectively. From the waveforms, the oscillations are eliminated within no time as the stabilizer parameters are optimized. It can be seen that the response is almost same with all optimizing techniques PSO, CSO and TLBO.

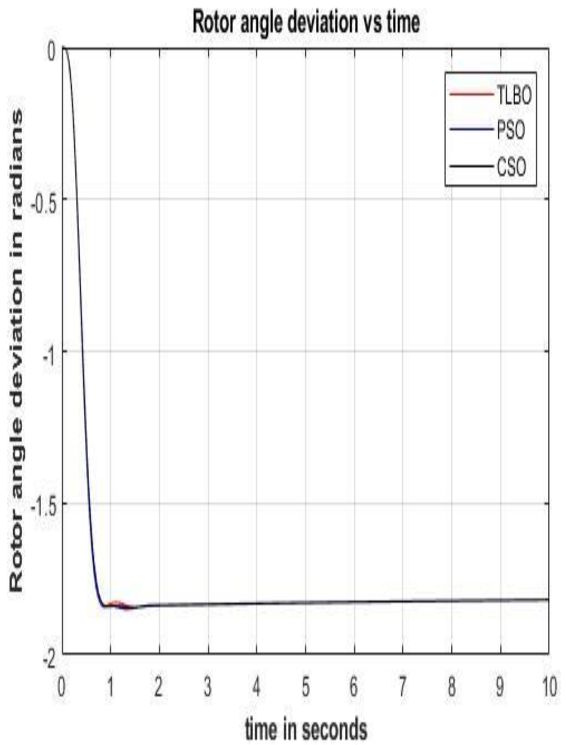

Fig. 8. Rotor angle deviation with optimized stabilizer

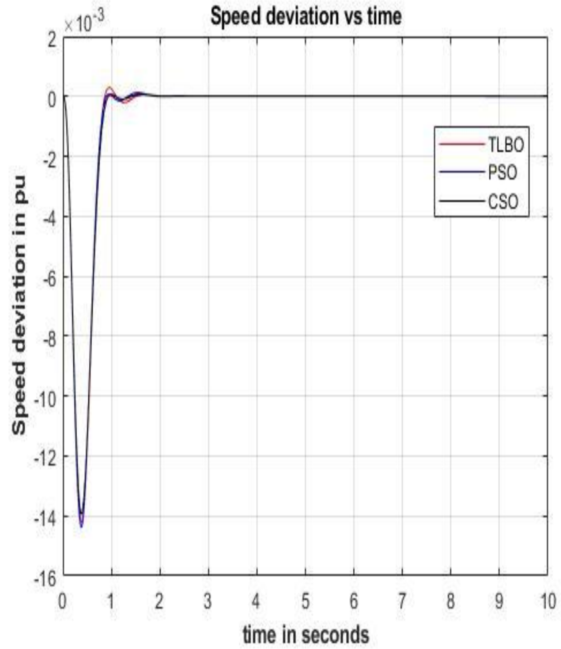

Fig. 9 Speed deviation with stabilizer

Table I shows the time domain specifications with different types of optimization techniques.

Table I Time domain specifications

Cases	Undershoot value	Settling time(sec)
With Optimized PSS parameters using PSO	- 0.0144	0.847
With Optimized PSS parameters using CSO	- 0.014	0.878
With Optimized PSS parameters using TLBO	- 0.0142	0.836

It shows that the undershoot value and settling time parameters are almost same value with PSO, CSO and TLBO. On comparing PSO and CSO, the settling time is less with PSO and the undershoot value is less with CSO. In general, both parameters are important and they have to be reduced for better response. But normally the decrease in undershoot value increases the settling time and vice versa. Therefore both the PSO and CSO are efficient in setting the stabilizer parameters. When comparing with TLBO technique, the settling time is less than both PSO and CSO techniques and the undershoot value is mean of that of PSO and CSO. Hence, the TLBO is somewhat effective compared to both PSO and CSO algorithms. The table II shows the eigen values of the system without PSS and with different optimizing techniques applied for PSS parameters. From the first row, it can be observed that some of the eigen values lying on right half of s-plane. As there are four roots located on right half of the s-plane, the system is going to become unstable. Two complex roots with positive real part of 0.14 is clearly indicating that the system is getting unstable with ever increasing oscillations.

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After installing the PSS, all the eigen values will be shifted towards left half of s-plane.

Table II Eigen values

Cases	Eigen values
Without PSS	-100.96, 0.14 ± 5.48i, 12.42, 7.36
With Optimized PSS parameters using PSO	-100.97, -49.06, -3.91±8.63i, -4.58±2.72i, -0.102
With Optimized PSS parameters using CSO	-101.99, -100.00, -4.27±8.19i, -4.96±2.57i, -0.102
With Optimized PSS parameters using TLBO	-101.93, -100.00, -3.92±7.95i, -5.34±2.31i, -0.102

By optimizing the stabilizer parameters with PSO, CSO and TLBO techniques, the eigen values move further away from the imaginary axis. Some of the eigen values are far away from the origin with CSO when compared to PSO. And, with the TLBO technique, two roots are very far away from the origin when compared to that of both PSO and CSO. So, the eigen values indicating that the CSO technique is somewhat effective that PSO. Also, the TLBO technique is still effective than both PSO and CSO techniques.

Next, the system response can be observed with bode plots and stability can be analyzed with gain margin and phase margins. The bode plots for the system with PSO, CSO and TLBO techniques are shown in Fig. 10, Fig. 11 and Fig. 12 respectively.

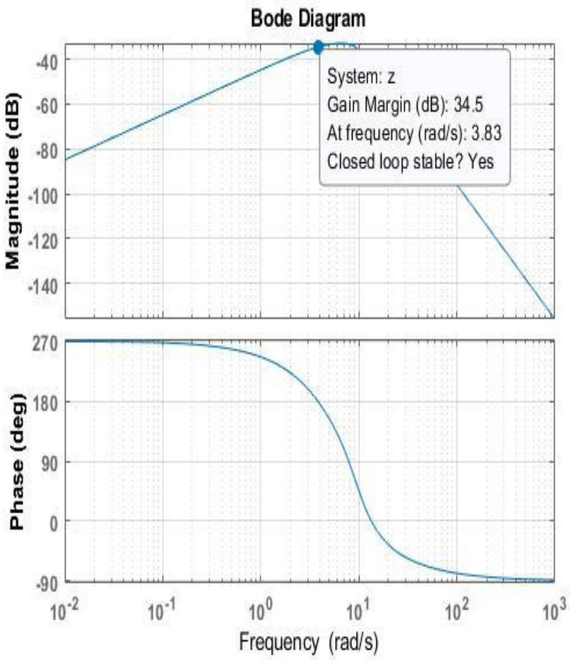

Fig. 10. bode plot with PSO parameters

From the bode plots, it can be observed that for all PSO and TLBO techniques, the gain margin is same i.e. 34.5dB and with CSO technique, the gain margin is 34.7dB. But in all cases, the closed loop response is stable only.

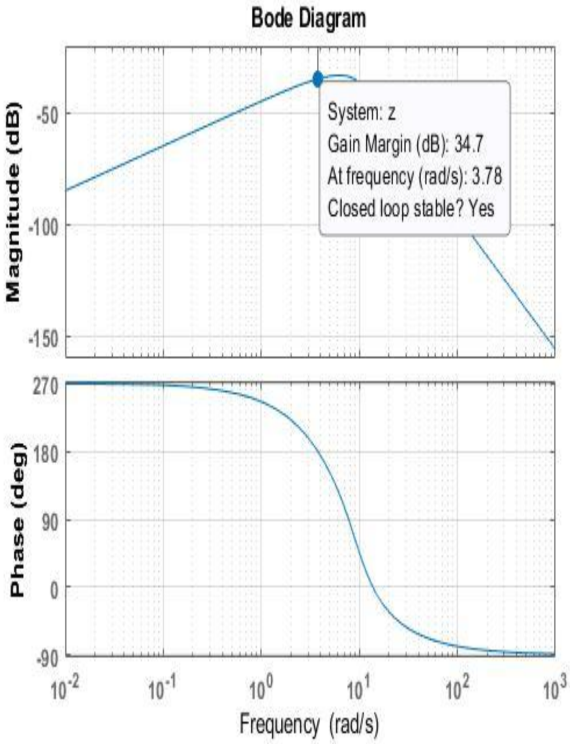

Fig. 11. bode plot with CSO parameters

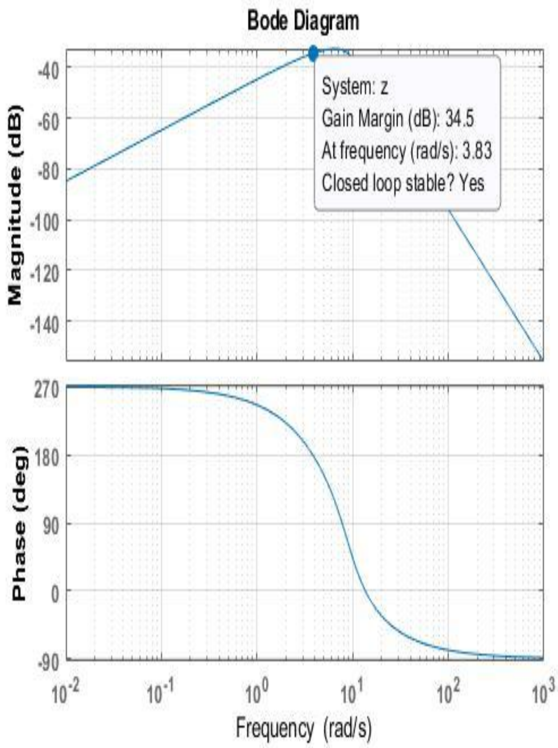

Fig. 12. bode plot with TLBO parameters

The fitness function evaluation with respect to iterations can be compare with PSO, CSO and TLBO techniques is shown in Fig. 13.

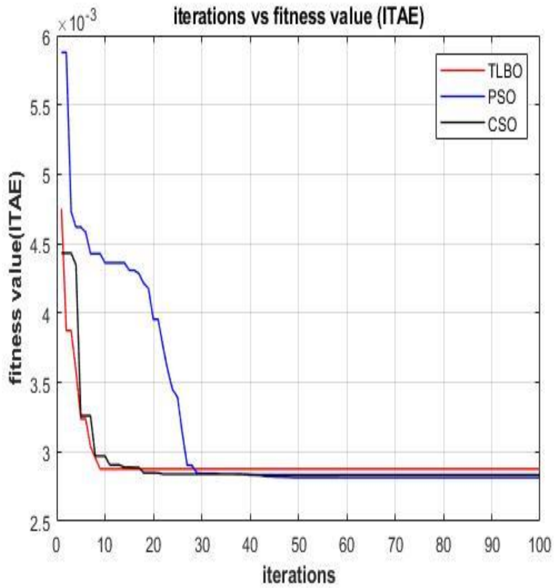

Fig. 13. Fitness graph comparing PSO, CSO and TLBO

The Fig. 13 is obtained for all techniques with population = 30 and maximum iterations =100. The running time taken by PSO algorithm is around 500 sec, CSO running time is around 900 sec and TLBO running time is around 1100seconds. It can seen that, even though the TLBO technique is slower than PSO and CSO algorithms, it is taking less iterations for converging to optimal value. In this the fitness function is Integral Time Absolute Error (ITAE) which is more efficient for oscillations problems. The error with PSO is 0.002814, with CSO is 0.002834 and with TLBO is 0.002876. Therefore, the optimal value is almost same for all techniques which is representing that all PSO, CSO and TLBO techniques are giving almost same response in tuning the PSS parameters.

V. CONCLUSION

The power system stabilizer plays a crucial role in maintaining the system stable by giving required damping torque TD. But optimizing the stabilizer parameters is very important for getting better response. In this work, a step disturbance in reference voltage of SMIB system is considered for studying the stability of the system. The corresponding system is simulated without PSS and with optimization techniques PSO, CSO and TLBO. Firstly, the system is simulated without stabilizer and the system is becoming unstable with increasing oscillations. Then by placing the stabilizer, the system is becoming stable and in order to get the system into stable condition more quickly, the stabilizer parameters are optimized. The PSO, CSO and TLBO techniques all are giving almost same response but TLBO is somewhat effective than others. But the PSO is giving very fast response compare to other techniques. So, the simulation results are clearly indicating that all the considered techniques are effective in tuning the stabilizer parameters.

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