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Transient Stability Enhancement using PSS Based on PSO Algorithm

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***Abstract**: Transient stability is a very important study that we must focus on; if the importance of improving the power system takes place; this problem may lead to loss of synchronism. To solve such a problem or reduce it there are various ways to do that, the famous way is to insert the compensation devices such as; SVC, STATCOM, UPFC, AVR and PSS. Here in this paper Power System Stabilizer (PSS) has been used because of its tremendous work for damping oscillations and reduce the overall time response for machines to return back to its new position after the three phase fault occurs in transmission lines. Finally after seeing the plots and make comparisons it found that the PSS reduces the overall time response by more than 50%. The difficulty that arises from how to get the optimum values of PSS parameters and optimum location of PSS; was solved by using Particle Swarm Optimization (PSO) technique.*

Keywords— Transient Stability, Transmission Line short circuit, power system stabilizer (PSS), IEEE 9 bus system, Particle Swarm Optimization (PSO).

1. INTRODUCTION

The electrical network founded in one of three cases: steady state case, dynamic state case and transient case. The system being in steady state case if the generation is more than consumption or equal to it. If the above condition is not attaining the network then being in the dynamic state case and the dynamic state means there are small change in loads. if there are large change in loads ,switching and case of short circuit this case called transient case , this transient case impact on network so it must damp it before the units(generators) of system gets out of system and that leads to make blackout happens. , so it must reduce or solve this problem of transient case.

Transient stability studies are related to the effects of transmission line faults on generator synchronism. During the fault the electrical power from the nearby generators is reduced and the power from remote generators remains relatively unchanged. The resultant differences in acceleration produce speed differences over the interval of the fault and it's important to clear the fault as quickly as possible. The fault clearing eliminates one or more transmission elements and make the system weakens. The change in the transmission system produces change in the generator rotor angles. If the changes are such the accelerated machines devour additional load, they hamper and a replacement equilibrium position is reached. The loss of synchronism is going to be evident within one second of the initial disturbance. the transient stability issues generates from large disturbances that happened in the grid due to sudden change in loads, loss of generators, switching or faults; this disturbances take place at the generator shafts and causes the rotors to oscillate until anew steady state operating point is reached or until the rotors continue to oscillate and deviate from each other and finally some generators loss synchronism. [1]

2. METHODOLOGY

In this paper the impact of three phase fault on transmission lines was studied. In addition to the digsilent software has been used as a simulation program to carry out the scenarios on IEEE 9 Bus test system. And the following steps were followed:

A. IEEE 9 Bus System:

This network consist of three machines and nine buses the machine number one connected to swing busbar while machines two and three connected to PV bus bar. Moreover this network included three loads A, B and C are connected in bus bars 5,6 and 8 respectively. The total generation is 567MVA and total load is 321MW. [2]

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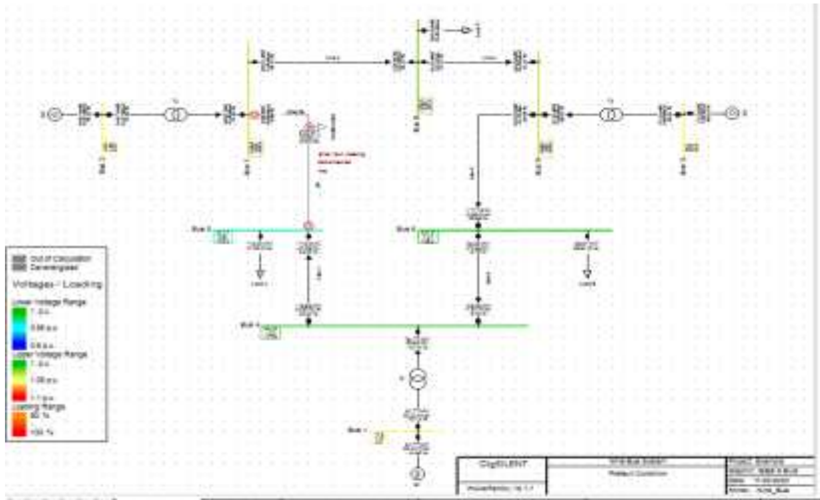

Fig.1. single line diagram of IEEE 9 bus system

B. Power System Stabilizer (PSS):

- **Introduction**:

When the disturbances happened in the grid due transient case it included oscillations of generators. This oscillation must be damped to maintain the system stability.

For damping these oscillations the power system stabilizer was used. The PSS was used to extended the angular stability limits of an influence system by providing supplemental damping to the oscillation of synchronous machine rotors through the generator excitation.

To provide damping, stabilizers must produce a component of electrical torque on the rotor which is in phase with speed variations this supplementary control is extremely beneficial during line outages and large power transfers. [3, 4]

- **Structure of Power System Stabilizer:**

The block diagram of the PSS is showed below in Figure 2; it consists of a signal washout block, phase compensation block and a gain block.

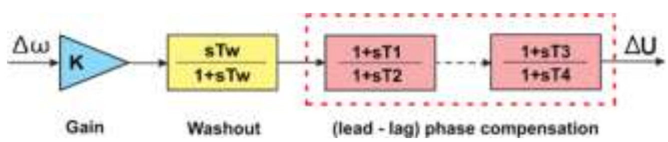

Fig.2. block diagram of Power System Stabilizer

i. Gain block:

The stabilizer gain determines the quantity of damping introduced by the PSS.

ii. Washout Circuit:

The signal washout block is a high-pass filter, with the time constant high enough to permit signals related to oscillations in to pass unchanged. It allows the PSS to reply only to changes in speed. the worth of isn't critical and should be within the range of 1 to twenty seconds.

iii. Phase Compensation Block:

The phase compensation block supplies the acceptable phase – lead characteristic to catch up on the phase lag between the exciter input and therefore the generator electrical torque.

iv. Input Signals:

The input signals that are identified as valuable include deviations within the rotor speed, frequency, electric power and therefore the accelerating power . Since the most action of the PSS is to regulate the rotor oscillations, the input of rotor speed has been the foremost frequently advocated within the literature. [5, 6, 7]

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C. Particle Swarm Optimization Algorithm:

PSO algorithm is an optimization technique taken from natural movement and intelligence of bird flocks and fish schooling. The essential idea of the PSO consists in moving a pre-defined number of particles throughout the searching space so as to seek out the simplest solution. The movement pattern of the particles towards the simplest solutions is defined by the social interaction between the individuals from the population. Figure 3 represented the most steps for implementing the PSO algorithm. For mathematical representation of the flock, the particles are modeled as vectors during a multidimensional search space. The optimization process starts by randomly generating the population and therefore the velocities of the particles. To assign a particular measure of performance, the particles are evaluated consistent with an objective function. In this way, the private better of each particle also because the global better of the whole population are determined. With this information, the speed of each individual is computed taking under consideration its previous velocity, personal best and global best (1). The new positions of the individuals are then updated by adding the computed velocities to the particular position consistent with (2). [8]

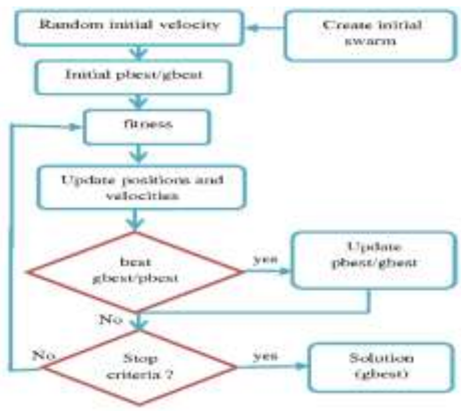

Fig.3. PSO Algorithm Flowchart

$$V_i^{k+1} = wV_i^{k+1} + c_1 \,.\text{rand.}\left(\text{pbest}_{i-{s^k}_i}\right) + c_2 \,.\text{rand.}\left(\text{gbest}_{i-{s^k}_i}\right) \qquad (1)$$

Where:

V_i^k Velocity of the i^{th} particle at iteration k
w Inertia coefficient
c_1 ,c_2 weighting coefficients
pbest_i Personal best of the i^{th} particle
gbest_i Global best of the population
S_i^k Position of the i^{th} particle at iteration k

$$S_i^{k+1} = {S^k}_i + V_i^{k+1} \qquad (2)$$

Where:

S_i^{k+1} The position of the i^{th} particle at iteration $k+1$
V_i^{k+1} Velocity of the i^{th} particle at iteration $k+1$

3. RESULTS AND OBSERVATIONS

The PSO Algorithm used to find the optimum parameters of PSS and the parameters were:

Table.1. Optimum parameters of PSS:

Names of Parameters	Values
Kpss Stabilizer Gain (pu)	25
Tw Washout Integrate Time Constant (s)	10
T1 First Lead/Lag Derivative Time Constant (s)	0.072756
T2 First Lead/Lag Delay Time Constant (s)	0.016978
T3 Second Lead/Lag Derivative Time Constant (s)	0.157885

T4 Second Lead/Lag Delay Time Constant (s)	0.153253
Vmin Signal pss Minimum(pu)	-0.03
Vmax Signal pss Maximum(pu)	0.03

- ❖ **Generator One:-**
  - ➢ **Rotor Angle**

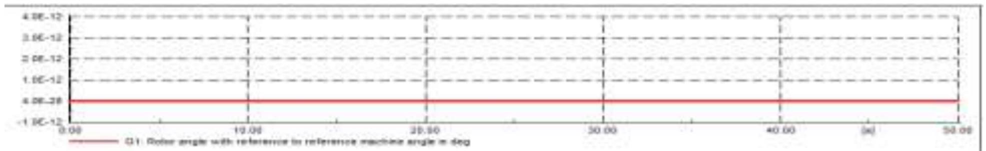

Fig.4. Rotor Angle Normal Case

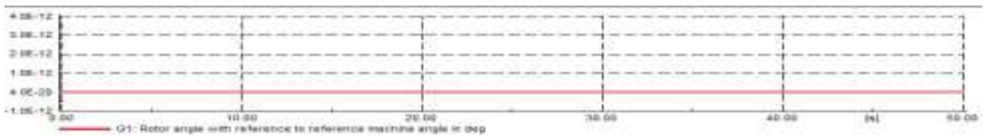

Fig.5. Rotor Angle without PSS (Fault in Line 2b)

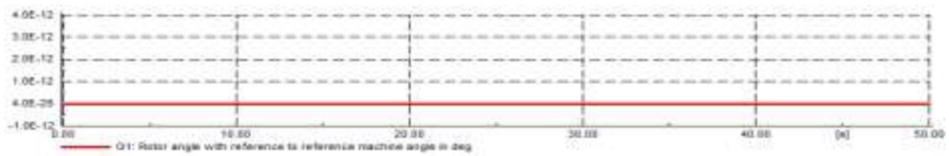

Fig.6. Rotor Angle with PSS (Fault in Line 2b)

- ➢ **Excitation voltage**

Fig.7. Excitation Voltage Normal

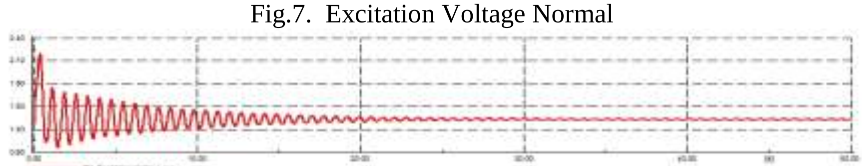

Fig.8. Excitation Voltage without PSS

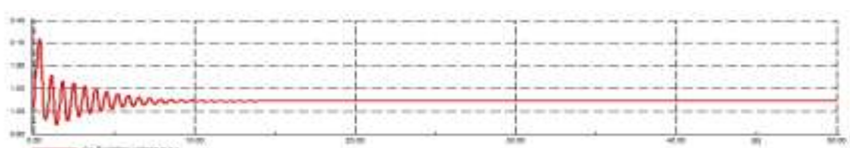

Fig.9. Excitation Voltage with PSS

- ❖ **Observations:-**

- ➢ From figure 4, 5, 6 we noticed that the power angle is zero because the machine one is connected to slack bus bar.
- ➢ From figure 7 we noticed that the excitation voltage is stable in normal condition.
- ➢ From figure 8 we noticed that after three phase fault occurs on line 2b, Excitation voltage is oscillate and system return back after 30 sec.
- ➢ From figure 9 we noticed that after adding PSS and three phase fault occurs on line 2b, the Excitation voltage is oscillate and system return back after 14sec.

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- **Generator Two:-**

  - **Rotor angle**

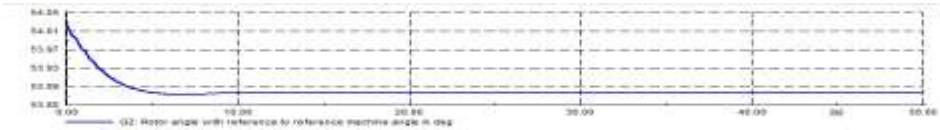

Fig.10. Rotor Angle Normal

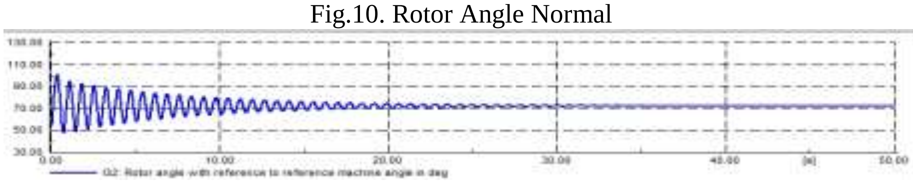

Fig.11. Rotor Angle without PSS

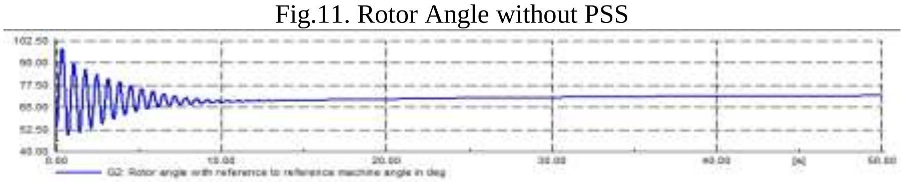

Fig.12. Rotor Angle with PSS

  - **Excitation voltage**

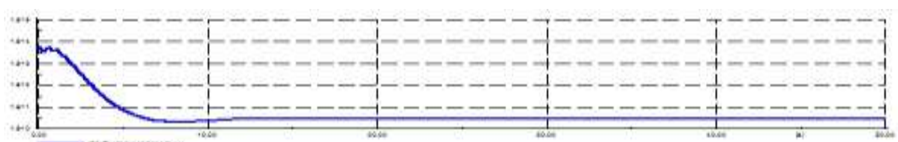

Fig.13. Excitation Voltage Normal

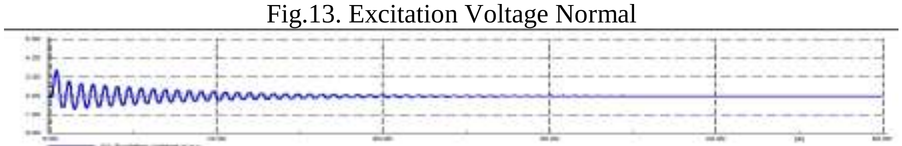

Fig.14. Excitation Voltage without PSS

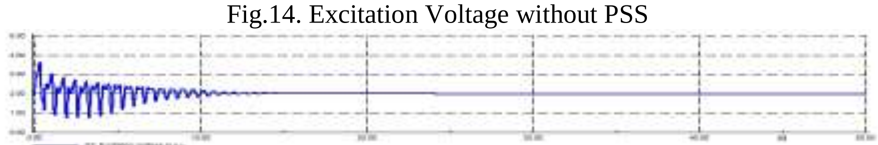

Fig.15. Excitation Voltage with PSS

- **Observations:-**

- From figure 10 we noticed that in the normal condition the power angle is stable.
- From figure 11 we noticed that after three phase fault occurs on line 2b, the power angle oscillate and system return back after 31 sec.
- From figure 12 we noticed that when PSS is adding by optimum location and tuning to machine 2 the power angle oscillate and system return back after 14 sec.

- From figure 13 we noticed that the Excitation voltage is stable in normal condition .
- From figure 14 we noticed that after three phase fault occurs on line 2b, Excitation voltage is oscillate and system return back after 35 sec.
- From figure 15 we noticed that after adding PSS and three phase fault occurs on line 2b, the Excitation voltage is oscillate and system return back after 15sec.

- **Generator Three :-**
  - **Rotor Angle**

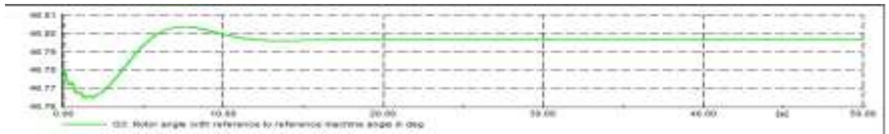

Fig.16. Rotor Angle Normal

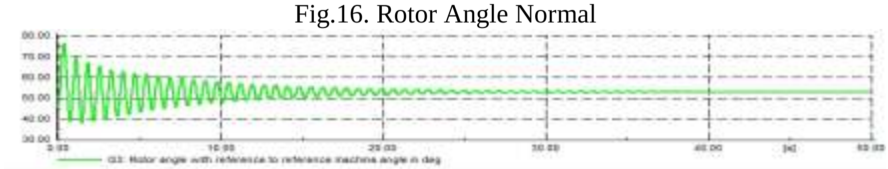

Fig.17. Rotor Angle without PSS

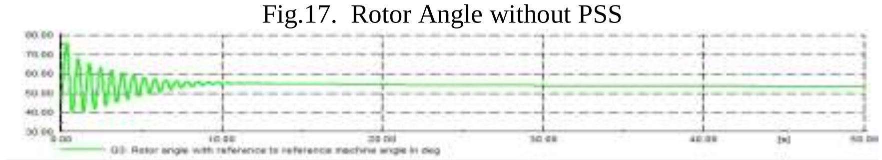

Fig.18. Rotor Angle with PSS

- **Excitation voltage**

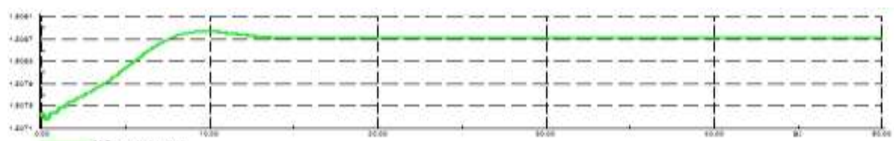

Fig.19. Excitation Voltage Normal

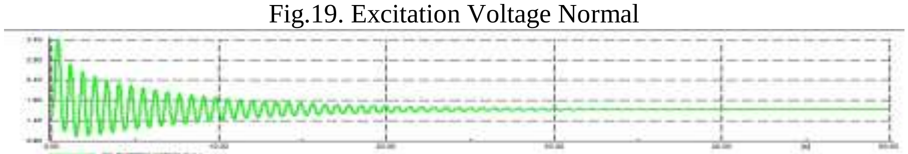

Fig.20. Excitation Voltage without PSS

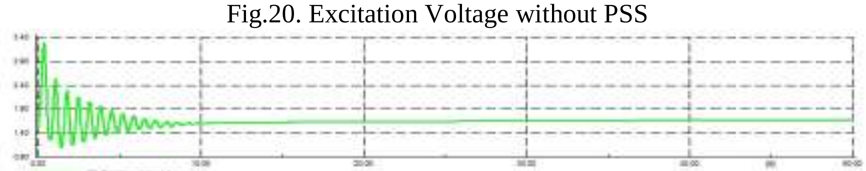

Fig.21. Excitation Voltage with PSS

- **Observations:-**

- From figure 16 we noticed that in the normal condition the power angle is stable.
- From figure 17 we noticed that after three phase fault occurs on line 2b, the power angle oscillate and system return back after 38 sec.
- From figure 18 we noticed that when PSS is adding by optimum location and tuning to machine 2 the power angle oscillate and system return back after 13 sec.
- From figure 19 we noticed that the Excitation voltage is stable in normal condition .
- From figure 20 we noticed that after three phase fault occurs on line 2b, Excitation voltage is oscillate and system return back after 34 sec.
- From figure 21 we noticed that after adding PSS and three phase fault occurs on line 2b, the Excitation voltage is oscillate and system return back after 11sec.

4. CONCLUSION

In this paper, power system stability enhanced by using power system stabilizer was presented. For the proposed controller design problem PSO technique was used to develop the lead lag compensation technique is implemented to calculate PSS controller parameters .the effectiveness of this technology was appeared clearly in power system response by adding damping torque for mechanical power input to the rotor of synchronous machine. However, power system stabilizer (PSS) work side by side with (AVR) system by adding moderated voltage signal by power system stabilizer to the (AVR) system to help of damping electromechanical modes and reducing overall time response. And that appeared in curves for overall time response when we represented it without PSS and with PSS and we noticed that the time reduced more than **50%.** Improving power system stability becomes an important issue in last year's due to complexity of power system. As the system become more complex by interconnected systems maximize the need of using (PSS) and other controllers to help in adding of damping torque for the rotor of synchronous machine.

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