Using A Novel Method To Improve Various Stages Of Machines In The Power System

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***Abstract*—The aim of this research is to utilize the particle swarm approach to examine the coordinated design of the unified power flow controller (UPFC) and two power system stabilizers (PSS) in a multi-machine power system. The synchronized proposed control challenge has been presented as an optimal solution with an objective function and constraint equations to complete this goal. Period models in a multi-machine power system were used to assess the effectiveness of the proposed design under distinct operating situations. It has been shown that, even if both PSSs and UPFCs perform well in their own right, power networks stability is adversely affected by an unfavorable impact or negative interaction between controllers if they are not coordinated. Inter-area oscillations have been efficiently dampened thanks to integrated layout.**

Keywords— Inter-Area Oscillation, Transient Stability, Particle Swarm Optimization

I.INTRODUCTION

The demand for electric energy has risen at a fast rate, therefore, the request of complex power systems have been continuously increasing. Today, the power system was under a big stress load than ten years ago [1]. This case causes a bad behavior of work and decrease the limits of transient stability. Additionally, the interconnections among distantly placed power system these days are a public practice that provides an increase in the oscillations in the range of 0.1-0.3 Hz. If these oscillations are not damped well and also the amplitude of oscillations may rise until it approaches black steadiness. The stability of the electrical supply is among the most pressing concerns. In the few decades ago, a new technique has been found to serve a function of damp the low frequency oscillations and it is called power system stabilizer PSS [2-4]. Today, the new advance technologies appear for trustworthy and power systems operation. To reach monetary success and the operation dependability, more well organized operation and surviving transmission control will become very clear that the substructure of the system are required. Recently, a better application of power system existing has been provided via using the development advance technologies of power electronic devices which are called FACTS controllers. These regulators have the capacity to precisely manage network circumstances, This Facts device feature could be exploited to enhance voltage instability, power system transient stability, and steady-state consistency [5-7]. PSS is now utilized in conjunction with a generation excitation current, with PSS's job being to supply suitable damping signals to the generator excitation system in order to deal with parameter oscillations. The frequency difference may be used as the PSS input signal [8]. Between the generator's mechanical input power and its final power production is a gap. As a second input, the output signal is delivered to the excitation system, which has been proved to be successful in performing the tasks assigned to it. On the other hand, PSSs offers an additional feedback signal, and they hurt a disadvantage of liable to make a big difference in the voltage. For activate professionally operation, the design of contemporary power systems is becoming robustness to supply the demand power to many load centers with a best dependability [9]. Generation units are frequently placed, their positions to produce an economic situation to safety reasons and environmentally favorable. For carrying power by transmission lines from the generation units to loads, in a present day, a power systems have a high interconnected points for economical states. And the benefits of these points are: Sharing the reserves of generating units, abusing load variation and increasing economy via using the units with great effect without losing the reliability. Recently, the power request has been increased than before considerably, where the growth of a generation of the power and transmission lines stays in limited situations [10]. The research is aimed at how to use regulated active power, reactive power, bus voltage, and speed deviation in multi-machine power systems at two separate sites to improve the damping of electro-mechanical oscillations. Using intelligent approaches such as particle swarm optimization to coordinate various power system stabilizers and unified power flow controllers is critical. The major goal is to determine the essential constraints and capabilities of the resultant damping system, as well as to provide explanations and interpretations into the complicated power system dynamics. The study aims to examine the oscillation damping by using coordinated design between the UPFC and multiple PSS to obtain improvement in the systems stability when added PSS to automatic voltage regulator AVR of generators. Therefore, The profitability of 2PSS is better. And with an extents lineup that includes analogue, digital, and P, w, and input type models. Both controllers should be converting their issues to an optimized problem when solving a problem. To do this, the settings of the best controller are examined using a newly created approach called particle swarm optimization PSO [11-12]. On a multi-machine power system with an unlimited bus, it can assess these current controllers. The effectiveness of coordination between UPFC and 2PSS for dampening these oscillations under fault in a

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rapid and resilient manner in order to gain additional stability for the power system will be shown using nonlinear time domain simulation. In this research, the coordinated controller design for UPFC and 2PSS carry out using a new intelligent technique to optimize the problems. To do this, the coordinated design problem will be expressed as an optimization problem by reducing the objective function. It is expected that the interactions among these main controllers will be improved. The effectiveness of the propose design will be tested through time domain simulations under fault, the effect of fault on the stability of power systems will also be tested.

II.LITERATURE REVIEW

The stability of an electric power system following a physical disturbance is defined as the capacity of the power system to remain at the equilibrium point under an initial state of operation [13]. The stability of a power system demonstrates the ability of an electrical power system to restore the state of the operating balance after suffering a physical disturbance with all variables of a system being bounded, thus maintaining the system's safety, and it is maintained in practice, the entire power system intact remnant without any faltering to back from loads or generators to balance the condition of stability be. In order to get the continue power under all conditions, especially in modern cities because of the large requirement of electricity and power, this case leading to increase the needing for electricity. This need is very important to work at limit level of power system by keeping the stability in balance case in both quality and reliability of this power, also this increasing of requiring power depends the sensitive industries of electric power such as, technology information, electronics and communications. In this case, this will put a big challenge of engineers and also a big responsibility to provide and deliver this power to consumers were needed the power which has the characteristics of stable and quality, in this chapter we will try to understand how to evaluate the stability of power system [14-17]. Several researches have concentrated on using various kinds of regulators to dampen inter-area oscillation in the power source. This part presents a thorough and up-to-date review of related research survey. A.R. Messina. (2021) provided a frequency domain technique implementation of control theory that was designed to synchronize Insight into various and reduce the undesirable interaction among loops; The first is a discussion of dynamic loop contact in multiple-input multiple-output control systems that created PSS and SVC's coordinated parameters. First, create an issue, then transform it to an optimization problem, and solve it via a new algorithm which called PSO [18]. H. Shayeghi. (2020) because of the established damping oscillations of the power system, we tackled and investigated the selection issue of the UPFC finest input signal and built the best UPFC made damping controller. This controller is set to move the un-damped modes to a preferred s-plane area as quickly as possible. The damping ratio of the electromechanical modes is addressed utilizing a novel approach called (PSO) method, which has a hard competence to locate the most optimistic results. To ensure the robustness of the damping controller method, he devised a process that takes into account a broad variety of operating conditions and system configurations [19]. L. H. Hassan. (2019) Using an optimizer (GA) and an involvement ratio, a way to regulate the best locations and number of (PSSs) of multi-machine (PF). The PF method to predict and determine the positions of the power system stabilizer, While the GA approach is primarily used to reduce the number of PSSs, it also allows for the improvement of command limitations and deployments under various scenarios [20].

III. PROPOSED METHOD

The proposed PSO method is applied in this research to tackle optimization issues of a UPFC and three PSS controllers. In the FACTS family of power systems concepts, the interline power flow controller is the most versatile device. This controller can operate with STATCOM and SSSC in an efficient manner. This combination gives the UPFC both of those devices' benefits, and it necessitates the completion of a number of tasks in the power transmission system, such as improving transient stability, damping oscillations, and controlling voltage. It seems to optimize and manage the power flow in transmission systems, and it is the greatest and most helpful controller from FACTS devices. It offers a lot of promise in terms of dynamic and static transmission line functioning. Where the fundamental functionalities of both STATCOM and SSSC are combined.

Every one of the parameters that impact power flow in the transmission line, such as phase angle, voltage, and impedance, may be controlled in real time by the UPFC. On the other side, it can autonomously control both the actual and reactive power flow in the transmission line. The UPFC combines static series compensation and a static compensator into one device. Its dual function as a shunt compensation and a phase shifting device. UPFC is usually coupled to the power sources in long transmission lines. And it works in an efficient way, to damp power system oscillation. Today, a new method called Particle Swarm Optimization PSO is very general technique to coordinate designing PSS and UPFC controller. Because of the advantages of PSO, a robust of PSO to find a better solution and capability to supply a close best solution.

A. Particle Swarm Optimization

The PSO as a novel optimization approach [21]. This algorithm is relevant to the social behavior of birds. The system via informing the generations can initialize with a population of arbitrary results and searches. On the other hand, it has no crossover and mutation operators. In PSO, the particles word means: the solutions of potential and it has the ability to fly across space of the problem using the result of present optimal particles. By making some compares with Genetic Algorithm GA, PSO has many advantages such as, it is easy to complete, and it has a few number of operators which needs to adjust. Also, it has the ability to implement in numerous zones.

The PSO is a standard algorithm works with a particle population. By flying across the infinite number of spaces, the particles looking for the functions and try to be optimize them. Any particle has a state and it can be signified by its location $Xi = (Xi\ 1, Xi\ 2, \ldots Xi\ n)$and its velocity $Vi = (Vi\ 1, Vi\ 2, \ldots, Vi\ n)$, that's will lead to updating the particle states. To get updates of velocity, there are three parameters can be used as a key, the first parameter is the component of momentum, here, its check the ability of the particle to remember and control its earlier velocity, the second one, itis the component of cognitive. In this component, it is check the capability of the acceleration constant $C1$ to control the particle better position and the third one; mentioned to the component of social, the constant acceleration $C2$ will control this propensity, where try to put the particle near swarms best position according to the equations below [22]:

$$xk+1 = xk + \mu \,.\, vk+1 \qquad (3.1)$$

$\mathrm{I}d \qquad \mathrm{i}d \qquad \mathrm{i}d$

$$|vk\,| \leq Vmm. \qquad (3.2)$$
$$|xk\,| \leq \mathrm{X}mm \qquad (3.3)$$

In the expression above, vk stands for: k-th iteration, i-th particle, v – velocity, and d – dimension. The formula xk stands for k-th reproduction, i-th particle, x-th position, and d-dimensionality. W is the inertia factor. μ is the speed ratio constraint factor. P^k is the position optimal valueof each particle. P^k is the $\mathrm{i}d$ group location optimal value. C_1,C_2arethe accelerating factors. The speed range, or Vmm, is what defines the unique trend. The population range is Xmm. The stimulus from this model may be utilized by the PSO to explain the difficulties. In theparticle swarm optimization, each solution can consider it as a bird in the space.These particles have a value that could be optimized by function, and the fitnessvalue can be determined by the integral equation of performance index equationgiven in (3.1).

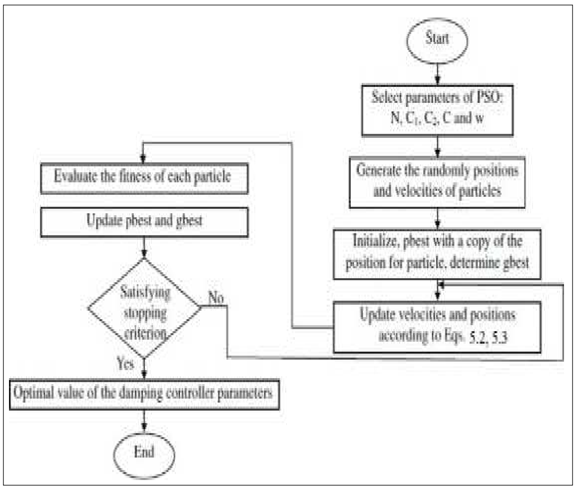

Figure 1: Flowchart of PSO [23]

B. PSO ITERATION

PSO algorithm has iteration state when a particle population is looking for a better solution, updating their positions depending on three components. At each iteration, any particle evaluates its velocity via its earlier velocity, its best earlier position and its neighborhood best position. The earlier established the component of momentum, the earlier best position founds the reasoning component, and the neighborhood's best earlier position creates the common iteration component. The iteration algorithm has different variations as shown in Figure 2.

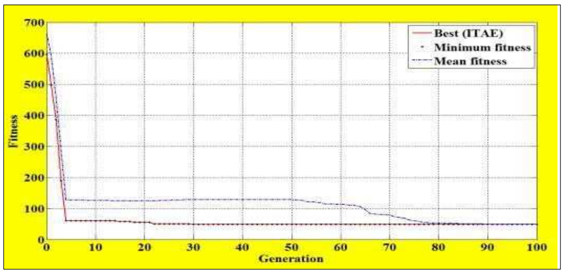

Figure 2: Decreasing the cost function by iteration

C. INTEGRATING M-FILE WITH THE POWER SYSTEM SIMULINK MODEL

In this model the optimization 17 parameters of 3PSS. When the PSO program run, itwill generate a value for the variables above as well as K_P, K_I for power regulating of UPFC and It compensates these values in the simulation model by utilizing the acceleration power Pa (the difference between mechanical and electric power) as an input signal to the model's Integral Time Absolute Error (ITAE), this value is representthe fitness value of PSO, this value will return to PSO program, and using it as an initial value in order to improve the values that we need to find the optimal situation of them, then PSO starts repeating this process based on the maximum iteration number, then it stops, and we have the optimum values of variables at the conclusion of the iteration.

To determine the best values, the PSO starts with the values that fall within the lowest and maximum ranges of all values. and when the particle of each parameter fix the suitable value as shown in Table 1. That have the same value of previous attempt (position and velocity), this value will use as a reference value by fitness order in PSO algorithm. We got these values under fault (single phase line - ground) condition where applied in middle distance of 2- areas power systems with UPFC and 2PSS.

Table 1. Optimal parameters of controllers

		Initial values of parameters	**Converged values**
PSS parameters of G1	K	0 – 1.5	1.3160
	T_1	0 – 0.5	0.4649
	T_2	0 – 1.0	0.9367
	T_3	0 – 0.5	0.3460
	T_4	0 – 1.0	0.9166
PSS parameters of G2	K_a	0 – 1.5	0.2269
	$T1a$	0 – 0.5	0.3921
	$T2a$	0 – 1.0	0.0654
	$T3a$	0 – 0.5	0.0139
	$T4a$	0 – 1.0	0.4385
PSS parameters of UPFC	K_b	0 – 1.5	0.2778
	$T1b$	0 – 0.5	0.0798
	$T2b$	0 – 1.0	0.3805
	$T3b$	0 – 0.5	0.4437
	$T4b$	0 – 1.0	0.2282
UPFC real power control parameters	K_p	0.01 – 0.05	0.0344
	K_i	5 – 7	6.8507

IV.RESULTS

Figure 3 shows a 2-area power system with a UPFC and 2-PSS for controlling power flow in a transmission system 500 KV/230 KV and dampening electro-mechanical oscillations. UPFC is utilized when the system is arranged in loop mode, with five buses linked by three lines and two transformer banks of 500 kV/230 kV. (Tr1 and Tr2). A total of 1500 MW is generated by two generators, which is transferred to a 15000-MVA 500-KV equivalent and a 200-MW load linked at bus B3. Each generator has a power system stabilizer (PSS), an excitation system, and a speed regulator. In normal operation, the majority of generator #2's 1200-MW generating capacity is converted to 500-KV equivalent through three 400-MVA transformers. We're examining a scenario in which only two of the three transformers are accessible (Tr2= 2*400 MVA = 800 MVA). The variables of the simulations model as follows; 1. Two power generating units of 13. 8 KV, 1000 MVA and 13.8 KV, 1200 MVA, the type of rotor is Salient pole and a couple of transformers they have the same rating. 2. Two transformers 800 MVA and 1200 MVA of UPFC. 3. Three lines L1, L2, L3, each of 100 Km. 4. Five buses (B1 to B5) and UPFC controller. 5. Three phase load of voltage 500 KV and power of 200 MW at B3 and UPFC. 6. Three phase fault breaker in middle point of line. 7. Equivalent three phase source 500KV, 15000 MVA.

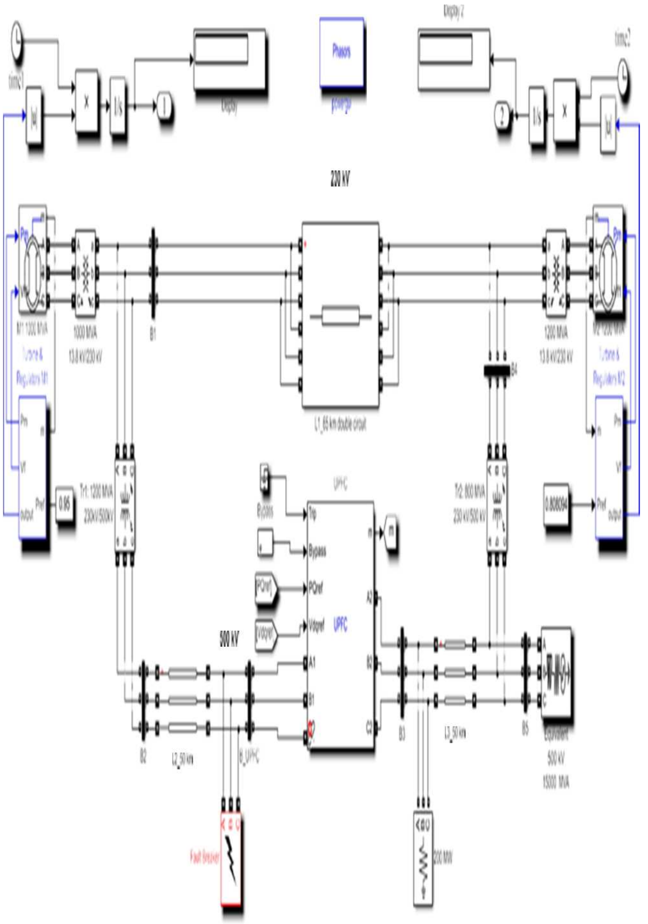

Figure 3: Proposed Simulation Model

A. MODELLING EXPERIMENTS

In four case studies, the system model in Figure 6.1 is tested under various conditions: uncoordinated design (with UPFC and without 2PSS), coordinated design during faults duration 0.1-0.2sec (with UPFC and without 2PSS), robustness test with fault duration 0.1-0.3sec, and robustness test with fault duration 0.1-0.3sec. The following are the various case study test conditions:

Case Study 1: Uncoordinated designed 2PSS and UPFC controller simulation results.

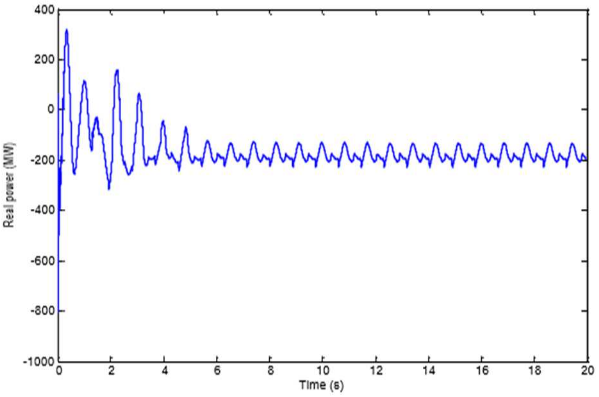

Figure 4: The oscillations in real power under fault without multiple PSS

Big oscillations will appear in line power after a fault (duration 0.1-0.2sec), (Phase A with Ground) and this power will reach 650MW in an unstable state and these oscillations will damp gradually (about 565 MW) after UPFC controller starting and stay at the same value after 6sec until end of iteration at 20 sec and this power will stay in unstable case, the controller will damp the oscillations and the power will fix about 85 MW (between -125 and -210 MW). The oscillations are shown in Figure 4.

Case study 2: Simulation results of coordination, design 2PSS and UPFCcontroller.

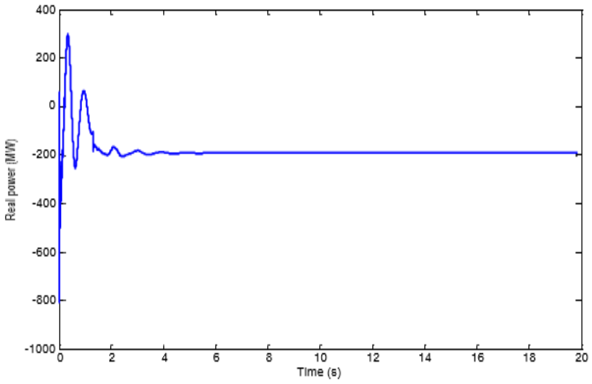

FIGURE 5: THE OSCILLATIONS IN REAL POWER UNDER FAULT WITH MULTIPLE PSS

Figure 5, shows the good dampening of inter-area oscillations between two regions when a fault disturbance is applied (0.1 - 0.2 sec), the oscillation in the increase rapidly 650 MW from -350 MW to +300 MW about, at this moment the damping controller start to damp this oscillation (1sec - 5sec), when the wave reach 5sec, the controllers will make those oscillation to be zero with no oscillations and the system will be stable after 5 sec and it will continue in stable state until end of simulation time. The oscillations are shown in Figure 5 and the load will reach - 190 MW.

Case study 3: Simulation results of double phase with ground fault.

We used a double fault with ground (phase A, B) to test the robustness of the model and PSO algorithm With 2-area power systems, to dampen inter-area oscillations. We can show the results and Figures that relate to real power, reactive power, speed deviation of two generators, voltage and phase angle of two buses.

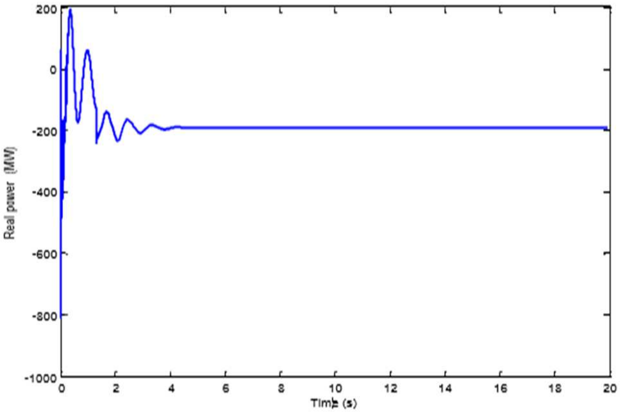

Figure 6: The oscillations in real power under fault with multiple PSS

Figure 6, shows the robust damping of inter area oscillations between two areas, when fault disturbances applied (0.1 - 0.2 sec), we can see the oscillation in the real power wave where it increase suddenly 650 MW from (-450 MW - 200 MW), at this moment the controllers will start to damp this oscillation and when the wave reach 4.2 sec the controllers will make those oscillation to be zero and the load will reach - 190 MW with no oscillations and the system will be stable.

Case study 4: Simulation results with 0.1-0.3sec fault.

The second robustness check we used the fault duration (0.1- 0.3sec) (Phase A - Ground fault). We can see the robust damping of oscillations in figures which related to real and reactive power, speed deviation, voltage magnitudes and phase angles for buses 1 and 4 of transmission line.

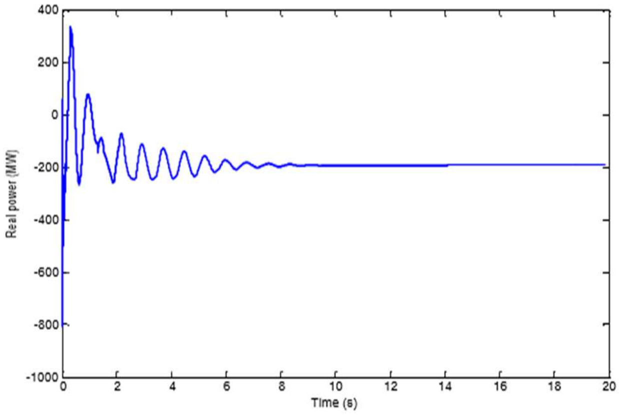

Figure 7: The oscillations in real power under fault with multiple PSS

V. CONCLUSION

According to the analytical model, coordination between UPFC and multi-PSS was performed in order to attenuate the oscillations of the multi-machine power system and boost the reliability of the power. Not only does combining a Power System Stabilizer with a unified power flow controller reduce system oscillations, but it also reduces real power oscillations, as well as phase voltage oscillations.

Through the results obtained, the following conclusions can be made: 1-A presentation was given on designing UPFC-based controllers for mitigating power system oscillations. This research focuses on the design of numerous PSS and UPFC damping controllers and their contributions to damping system oscillations under adverse situations. UPFC's location is maintained constant in the midway distance between two regions throughout simulation investigations in this thesis. The simulation experiments demonstrated that following PSS and UPFC synchronization, oscillations that occur after the development of a defect are considerably decreased. 2-Coordination between the controllers is very important process in order to get the excellent performance and discussing the importance of coordination style between Using an intelligent optimization approach known as particle swarm optimization, a unified power flow controller and power system stabilizer was created. Thank you, PSO, for coordinating, this algorithm has an advantage like easy to complete as well as it need a few parameters for optimization and adjusting and also the ability to implement in different regions. The 17 parameters used to do this coordination to reach the wanted goal by solving the problems, where each bird (particle) is corresponding one individual solution of one problem in the fitness value is determined by index performance. PSS is used to dampen electromechanical oscillations and increase the power system's dynamic stability, while UPFC is used to optimize and manage the power flow in transmission lines as well as to dampen line oscillations. 3-Four different case studies, simulation work and figures which related to real power, reactive power, speed deviation, phase angle for two buses and voltage magnitude also for 2 buses, it shows the figures from the first case study where uncoordinated design is used and the big effect of oscillation appears in the line and this oscillation remains with the waves from zero time until 20sec and the system is unstable system for all time duration. And when applied a second case study; coordinated design 2PSS with UPFC it can be shown the fast damping of these oscillations that occurred after a fault, and it can illustrate the oscillation when it became a zero value and it's still in zero magnitude until the end of the optimization process. 4-In the third case study a double phase to ground fault is applied, this case will check the robustness of model to damp inter area oscillations and the excellent damping of the oscillations which occurred because of the double fault will take a time duration more than one phase fault. Another robustness test is the fourth case study were used the fault duration 200 msec from 0.1 to 0.3sec and in this test it can show the robustness of model to damp these oscillations in rapid and good way and makes the oscillations in zero magnitude and get the stable system.

In future work,1- Simulation model using another type of controllers from FACTS devices with multiple PSS using PSO. 2-Simulation model to improve power system stability using multiple PSS with another type of controller from FACTS devices using another intelligent technique such as Genetic Algorithm, Fuzzy-Neural, etc. 3- Utilizing Genetic Algorithm as an intelligent approach, create a simulation model to create an energy system more reliable by employing UPFC and PS.

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