DESIGN OF OPTIMAL DUAL INPUT POWER SYSTEM STABILIZERS (DIPSS) AND CAPACITIVE ENERGY STORAGE (CES) USING PARTICLE SWARM OPTIMIZATION (PSO)

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Design of Optimal Dual Input Power System Stabilizers (DIPSS) and Capacitive Energy Storage (CES) using Particle Swarm Optimization (PSO)

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Abstract— **This paper discusses about the instability in electric power system and its importance in overcoming instability rapidly. This problem is generally solved using a stabilizer such as Conventional Power System Stabilizer (PSS). However, the use of PSS is limited to the retrieval speed signals that do not have the relatively large noise. Large noise will affect in the generator excitation system. Reducing of signal noise in the speed signal, so Dual Input Power System Stabilizer (DIPSS) is used to overcome this problem. DIPSS can reduce signal noise by taking another input signal in system model. It can increase or decrease level in value for input of excitation system, so the excitation system can avoid of mistakes in decision-reference signal. Deviation in electrical power (ΔPe) and deviation in speed (Δω) in generator is used as an input signal DIPSS. Improvement stability in power system usually using more than one device. CES (Capacive Energy Storage) is choosen become second device to handle this problem. CES usually used to overcome frequency oscilation. This equipment is added to reduce the little overshoot from DIPSS. Optimal coordination between two device is needed to obtain good results and does not exacerbate the addition of extra equipment. it needs the appropriate parameter value of each equipment in order to overcome problems quickly. Particle Swarm Optimization (PSO) is method in order to find value of time constant in block diagram parameter lead lag DIPSS and gain in CES. From the simulation result show that the use of CES DIPSS PSO can speed up settling time to 12.302 second better than uncontrolled, 9.612 second than PSS, and 0.563 second when using DIPSS PSO.**

Keywords— **Dual Input Power System Stabilizer (DIPSS), Particle Swarm Optimization (PSO), Power System Stabilizer (PSS), Capacitive Energy Storage (CES)**

I. INTRODUCTION

Stability in power system is very important. To maintain stability, it necessary select of appropriate control strategies. Furthermore, this control is necessary for power system reliable and can overcome the problems quickly when exposed to disturbances. The bad response caused load changes can lead to a long oscillation frequency. Oscillation frequency will affect the terminal voltage and will indirectly affect the power transfer performance if not corrected quickly.

Another thing that also must be considered in the operation of power systems is the instability. Instability is one of the problems of direct impact in load power system changes. This disturbance can be transients or dynamic instability. In dynamic instability changes in load can result in oscillations in the system and can bring the system into an unstable region. To overcome this problem we can use PSS equipment. However, PSS equipment can not reduce the noise that appears when getting speed signal which is used as input signal [1]. This noise can effect into excitation system, so the excitation system will increase. This can cause oscillations in the electric power system, so PSS is only limited to systems with small noise.

In this paper proposed the use of equipment which is the development of PSS to overcome the problems of power system instability. This Equipment is DIPSS which type of PSS can reduce signal noise from getting velocity signal. Noise signal along with speed signal will be reduced so that the excitation system to avoid mistakes in decision-reference signal. Development done on this DIPSS is the use of two input signals. The source of signal is electrical power deviation (ΔPe) and velocity deviation (Δω).

In operating DIPSS, The first amplitude value of speed deviation is high enough, so second device is used to overcome that problem. One of device is CES. CES is device can reduce frequency oscilation. In order to obtain optimal control, then DIPSS parameters and gain of CES should be optimized by the optimization method. Optimization method which is used in this paper is Particle Swarm Optimization (PSO). This algorithm is based on the pattern of foraging by a bird or fish. This algorithm was chosen because of the speed of computation to obtain the value of the optimized parameters [2].

II. FUNDAMENTAL THEORY

A. Power System Stability

The stability of power systems is abilities to keep the value of the system in case of disruption output [3]. This stability is classified into steady state stability and transient stability. The stability of steady state electric power system is ability to achieve a stable condition at the same new condition with initial conditions without interference. The analysis used in steady state stability is using linier model approach. While the transient stability of power system ability to achieve a new stable state after a system big disturbance.

B. *Single Machine Infinite Bus (SMIB)*

Single Machine Infinite Bus (SMIB) is model of system which transfers electric power to unlimited bus. Unlimited bus in this paper meaning that distance of machine and load is very far, so the voltage in unlimited bus is assumed not change. Generator is represented by single machine which represented one of electric power plan. Value of frequency and phase is assumed not change in this system. For this paper, SMIB Modeling here refers to the model transfer function of Heffron and Phillips [4]. In this model there are two block diagrams that linearized namely mechanical loop at the top and electric loop at the bottom. Linearized SMIB based here since only a low frequency oscillation analysis in operating conditions. This model there is two enhancer function into the model system for testing the mechanical torque deviation (ΔTm) and additional excitation (Ue) Signal (ΔVt) represent of generator voltage which have disturbance. Complete block diagram of SMIB is shown in Fig. 1

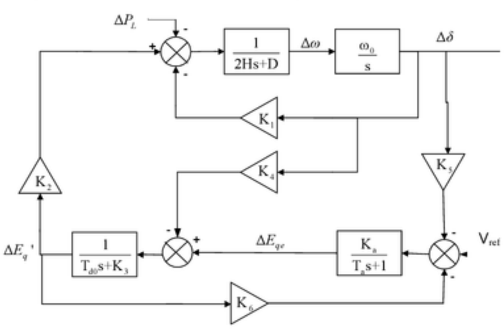

Fig. 1. Single machine infinite bus [4]

C. Conventional Power System Stabilizer (PSS)

Conventional Power System Stabilizer (PSS) is additional equipment which is used to produce components of damping by adjusting the excitation by way of electrical torque in accordance with the deviation in rotor speed. PSS design methods generally involve frequency response based on the concept of increasing the damping torque. The block diagram of PSS consists of washout, dynamic compensator, and filter torque diagram. Washout block diagram represent filter and is used to pass high frequency. Compensator block diagram is used to provide a phase lead and lag for the input signal. Input PSS is speed change and output is voltage signal, the voltage signal is used in the excitation system. Complete block diagram of PSS is shown in Fig. 2.

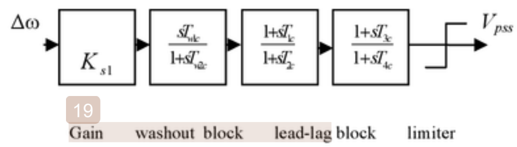

Fig. 2. Diagram block of PSS [5]

D. *Dual Input Power System Stabilizer (DIPSS)*

Dual input Power System Stabilizer (DIPSS) is one of the model PSS which is able to reduce the noise signal along with signals. Noise signal which is generally in conjunction with the speed signal and used as input PSS can be derived from the shaft motion component. This shaft motion component such as the lateral shaft run-out that causes excessive in modulation generator excitation system or oscillations torque resulting from changes in electrical torque[1]. The components of this noise will affect the excitation of the generator and cause an influence on the electrical torque variations. Complete block diagram of DIPSS is shown in Fig. 3. Input in this stabilizer is the deviation of rotor angular velocity and deviation electrical power. Each input has series of washout and transducer. Washout circuit serves to provide a continuous condition at output stabilizer while the transducer is used to change the input signal into voltage. Model of dual input power system stabilizer take from IEEE type PSS2B. Each input has two washout block diagram (Tw1-Tw2) and one transducer (T6-T7). Time constant of torque filter is signed T8 and T9.

E. *Capacitive Energy Storage (CES)*

Capacitive Energy Storage is device that can overcome frequency oscillation. The storage capacitor is connected to the AC grid. Equipment in CES device have inverter and rectifier with 12-pulse configuration, capacitance, and resistance connected in parallel that represent losses of capacitor bank. The workings of this equipment that is charged when the voltage is less than a full charge and discharge voltage when during peak load operation.

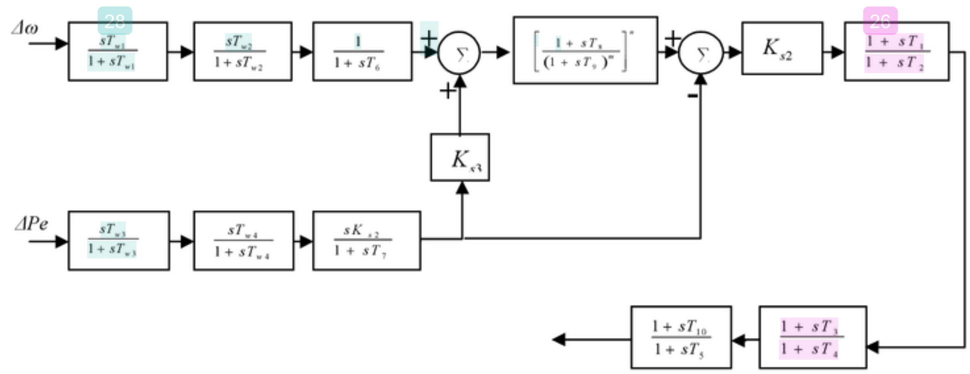

Fig. 3. Block diagram of dual input power system stabilizer (IEEE type PSS2B Model)

III. Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO) is method used in DIPSS and CES optimization system parameter. PSO method was introduced by Kennedy and Eberhard in 1995 [2]. This method is one of the intelligence methods. These algorithms use population base as a method of finding a solution where each particle represents a solution. Each particle of the PSO method is moving with speed changes based on its own flying experience and flying experience of other particles. Each particle has a memory and can remember the location of the best I've visited. The best position associated with the best fitness value is symbolized with p_{best} whereas the best value of the entire population is symbolized by g_{best}. In PSO each particle moves in the search area with a speed that is based on previous experience from the best solution. Velocity (v_i) in PSO method has three parts, namely the momentum, cognitive, and social parts. The balance between these will be determining the performance of this PSO. Parameter c_1 and c_2 determine the value of taking p_{best} and g_{best}, while value of r_1 and r_2 help in getting variation value p_{best} and g_{best}. If a particle reaches the best position to produce the optimal value of the other particles will move directly toward the best position. Based on the concept of the PSO, the mathematical equations can be formulated as follows

update particle velocity:

$$v_i^{k+1} = v_i + c_1 r_1 \left(p_{best-i} - x_i^k \right) + c_2 r_2 \left(g_{best-i} - x_i^k \right) \quad (1)$$

update particle velocity:

$$x_i^{k+1} = x_i + v_i^{k+1} \quad (2)$$

k is the value of the iteration or generation of particles, whereas i indicates the ith particle of a collection of particles. To better know the PSO optimization method then created a flowchart shown in Fig. 4.

The reason of using algorithm is based on the problems related of using stabilizer in that own operating conditions. Another reason is that parameters very large in power systems and mathematical models of power system are not linear and not known in detail [6]. To overcome that problem above, manual tuning or using algorithm is used to get solution. The use of PSO method is to find the value of the parameter DIPSS and CES which is used to accelerate the acquisition value of the stabilizer parameters.

Parameters of DIPSS will be seek is time constant of the block circuit diagram lead-lag, while a constant value of the transducer circuit and tuned washout block diagram own until getting good grades. In CES device only Kces will be optimized by PSO.

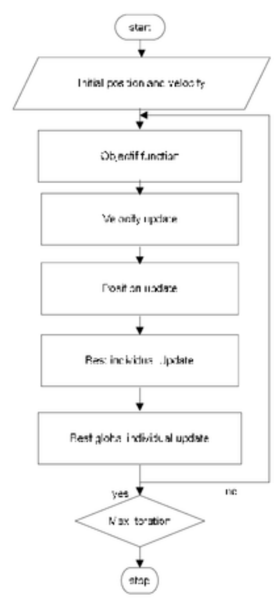

Fig. 4. Flowchart PSO

IV. SIMULATION AND RESULT

Single Machine Infinite Bus (SMIB) is used in system test. To test effectivity of CES DIPSS that have been optimized using PSO, then system is given disturbance. The disturbance in this system is load change at 0.03 p.u. Index performance which used to test stability system is Integral of Time multiplied Absolute Error (ITAE). ITAE defined as

$$ITAE = \int_0^\infty t\,|\Delta\omega(t)|\,dt \qquad (3)$$

The simulation results only consider the overshoot and settling time of response changes in speed SMIB. The simulation was taken from the best with 20 times trials. Each simulations in this systems model only 20 seconds. Fig. 5 shows the graph of the convergence of all particles. Convergence is achieved at iteration 42. This shows that the minimum error is achieved or optimum value of DIPSS parameter is obtained in 42th iteration.

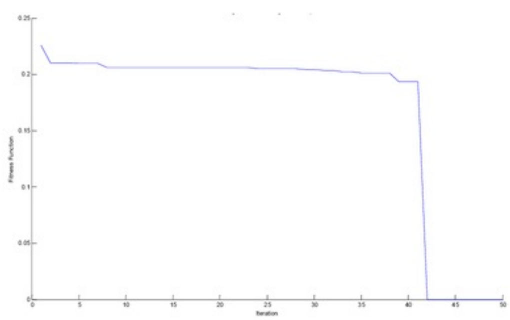

Fig. 5. Convergence of PSO graphic

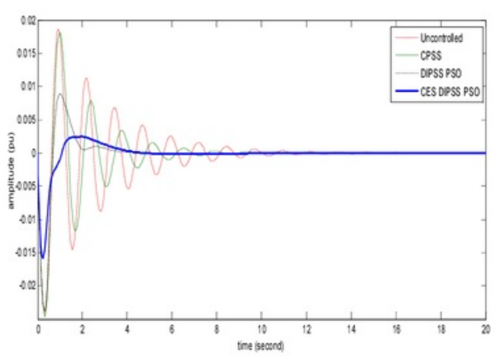

Fig. 6. Speed deviation

From Fig. 6 indicated that the response of changes in speed between using CES DIPSS PSO, DIPSS PSO, PSS and without control. The response of the system once installed CES DIPSS who tuned by PSO showed the best performance of the other. This can be seen from the overshoot and settling time for speed change system. Systems with uncontrolled has -0.02387 p.u in overshoot and has settling time in 16.37 seconds. Systems using PSS has - 0.02402 p.u overshoot and settling time in 13.68 seconds. Systems that use DIPSS which have been optimized using PSO showed a response overshoot and settling time that is equal to -0.02459 p.u and 4.631 seconds. While systems that use CES DIPSS which have been optimized using PSO showed a response overshoot and settling time that is equal to -0.01587 p.u and 4.068 seconds. Results of simulation for the overshoot and settling time of speed deviation shown in Table I

Table 1. Overshoot and Settling Time

System	Overshoot (pu)	Settling Time(s)
uncontrolled	-0.02405	16.37
PSS	-0.02458	13.68
DIPSS PSO	-0.02385	4.631
CES DIPSS PSO	-0.01587	4.068

V. CONCLUSION

Results obtained from the use of CES DIPSS which tuned using PSO in SMIB very effective and speed up the system stability. This can be seen from the overshoot and settling time of response to changes in speed. Application of CES DIPSS PSO to reduce the overshoot of 0.008 p.u when compared with uncontrolled and has 0.000798 p.u and when compared with the DIPSS PSO. Improvements to the settling time by using CES DIPSS PSO very good that is equal to 12.3 seconds faster with uncontrolled , 9.049 seconds with PSS, and 0.563 seconds with DIPSS PSO.

VI. REFERENCES

[1] [1]Michael J. Basler and Richard C. Schaefer,"Understanding Power System Stability". Basler Electric Company.

[2] [2] Kennedy,J.and Eberhart,R.C, "Particle swarm optimization," in proc. IEEE intt'l conf. on neural Network, pp.1942-1948.

[3] [3] Imam Robandi, Modern Power system kontrol, Yogyakarta: Andi Offset, 2009.

[4] [4] C.S.Chang, H.B. Quek, J.B.X , Devota, "Power system excitation control using master slave fuzzy power system stabilizers," in Proc. 1999 ELSEIVER Fuzzy set and system, pp. 85-94.

[5] [5] Sidhartha Panda, N. P. Padhy, "Robust Power System Stabilizer design using Particle Swarm Optimization Technique," International Journal of Electrical and Electronics Engineering", 2008.

[6] [6] Adhesh Sharma and M.L.Kothari, "Intellegent Dual Input Power System," in proc.2003 Elseiver Electric Power System Research Conf., pp.257-267.

[7] [7] B. Sumanbabu, S. Mishra, B.K. Panigrahi, and G.K. Venayagamoorthy, "Robust Tuning of Modern Power System Stabilizers Using Bacterial Foraging Algorithm". In 2007 IEEE Congress on Evolutionary computation. pp. 2317-2324.

[8] [8] T C Yang, " Applying optimisation method to power system stabilizer design Part 1: single-machine infinite-bus systems." In Elseiver Electrical Power Energy and System, vol. 19 pp. 29-35, 1997.

[9] [9] S.P. Ghoshal , A. Chatterjee, V. Mukherjee, "Bio-inspired fuzzy logic based tuning of power system stabilizer." In journal 2009 Elseiver Expert system with application, pp.9281-9292.

[10] [10] S.C Tripathy,"Improved Load Frequency Control with Capacitive Energy Storage." In journal 1997 Elseiver Energy Convers, vol.38, pp 551-562

APPENDIX

PSO parameter

Number of particle : 100

Number of variable :5

$c_1= 2$; $c_2= 2$; $w = 0.9$

SMIB parameter

$K_1 = 0.5995$; $K_2 = 0.9263$; $K_3 = 0.5924$; $K_4= 0.4319$; $K_5= -0.087$; $K_6= 0.6004$; $H= 4$; $D= 0$;$T_{d0}= 5.044$; $T_a= 0.05$; $K_a=50$

PSS parameter

$T_{wc1}= 0.381$; $T_{wc2}= 0.5$; $T_{1c}= 0.05$; $T_{2c}= 0.35$; $K_{s1}=12$; $V_{max}= 0.15$; $V_{min}= -0.15$

DIPSS parameter

$T_1= 1$; $T_2= 1.1$; $T_3=0.005$; $T_4= 0.037$; $T_6= 0.3$; $T_7= 7$; $T_8 = 0.05$; $T_9= 0.02$;$T_{W1}=T_{W2}=T_{W4}= 10$; $T_{W3} =0.9$; $K_{S2}=0.95$; $K_{S3}=0.05$; $n=1$; $m=5$;

NUMENCLATURE

CES parameter

Kvd=0.1; Tdc=0.05;C=1; R=100; Edo=0.5; Ka=46.9613; Kces=58.9286 Particle swarm optimization (PSO)

vi = particle velocity in i
xi = particle position in i
r1, r2 = random constant
w = particle weight
pbest = local optimum in i
gbest = global optimum in i
c1 = cognitif accelerate coefficient
c2 = social accelerate coefficient

Dual input Power System Stabilizer (DIPSS)

T1,2,3,4,5,10 = time constant lead-lag circuit
ks3, ks2 = multiplied gain of DIPSS
n, m = value of grade filter torque

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