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Enhancement of multi-machine power system stability by using Power System Stabilizer

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ABSTRACT

In this paper, we are going to deal about the enhancement of system stability, by using Eigen-values we can say how system stability is varying. We can use different devices like Facts controllers, Power system stabilizers, and automatic voltage regulators to improve system stability. Power system stabilizer had been used for improving two machine three bus system stability. We have different linear and nonlinear methods to design controller parameters for power system stabilizers. Genetic algorithm technique had been used to design PSS for two machine three bus system.

Keywords— *Two machine three bus system, Power System Stabilizer, Genetic algorithm technique*

1. INTRODUCTION

In electrical power system operation stability plays a major role, Due to great demand of power and fast development of micro grids in integrated power system creates an imbalance between generating and transmission capacities, leads to affect power transfer capability, synchronism loss, affecting system stability etc.so we have to take some control measures to detect and wipe out these factors affecting system stability.

We can use facts devices, Power system stabilizers, and fuzzy logic design based controllers, automatic voltage regulators to improve the stability of the system. However, the high gain and the fast acting nature AVR will show an adverse effect on system damping and leads to electromechanical oscillations which limit network power transfer. If electromechanically oscillations magnitude increase then it causes system separation so we use the pass to damp these oscillations. To improve the transient stability of system AVR is used. PSS are generally used to improve dynamic stability of the system.

In this paper for the two machine three bus system, power system stabilizer is designed by using the genetic algorithm technique. From the Eigen values obtained after connecting controller (PSS) The stability of the multi-machine system is observed.

2. SYSTEM MODELLING

In multi machine system modelling, we have to consider mechanical input power as constant and loads are represented by passive impedances. At present two machines, three bus system is used to study multi machine system enhancement.

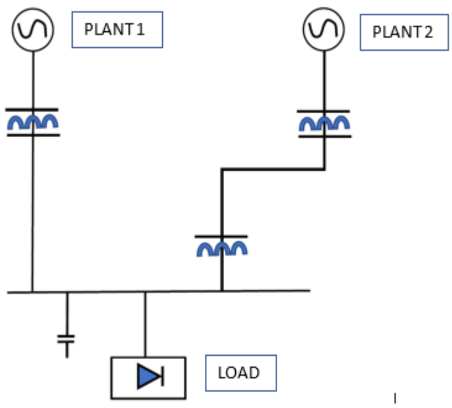

Fig. 1: Two machine three bus system

Each machine is represented by four state space equations, to form a matrix we use Heffrons-Phillips constants model block diagram in figure 2.

$$X(t)^{\bullet} = A\cdot x(t) + B\cdot u(t) + P(t)$$

$$X(t)=[\Delta\delta_1, \Delta\omega_1, \Delta E'_{q1}, \Delta E'_{fd1}, \Delta\delta_2, \Delta\omega_2, \Delta E'_{q2}, \Delta E'_{fd2}]$$

Where $\Delta\delta_i$ *denotes torque angle*
$\Delta\omega_i$ represents speed
$\Delta E'_q$ represents voltage proportional to direct axis flux linkages
Δ represents deviation from operating point

Where x (t), u (t), p (t) are state, control and perturbation vectors, respectively and they are expressed as follows.

State space equations of multi machine system from these state space equations we can form a matrix, to analyze system stability.

$$\Delta\delta_i = \omega_\circ \Delta\omega_i$$

$$\Delta\omega_i = \frac{1}{M_i}[-k_{1i}(\Delta\delta_j - \Delta\delta_i) - -k_{2ii}E'_{qj} - D_i\Delta\omega_i]$$

$$\Delta E'_{qi} = \frac{1}{T'_{doi}}[-k_{4i}(\Delta\delta_j - \Delta\delta_i) - -k_{3ii}E'_{qi} - k_{3ij}E'_{qj} + \Delta E'_{fdi}]$$

$$\Delta E'_{fdi} = \frac{1}{T_{Ai}}\, \Delta E'_{fdi} + \frac{K_{Ai}}{T_{Ai}}\, [-k_{5i}(\Delta\delta_j - \Delta\delta_i) - -k_{6ii}E'_{qi} - k_{6ij}E'_{qj}]$$

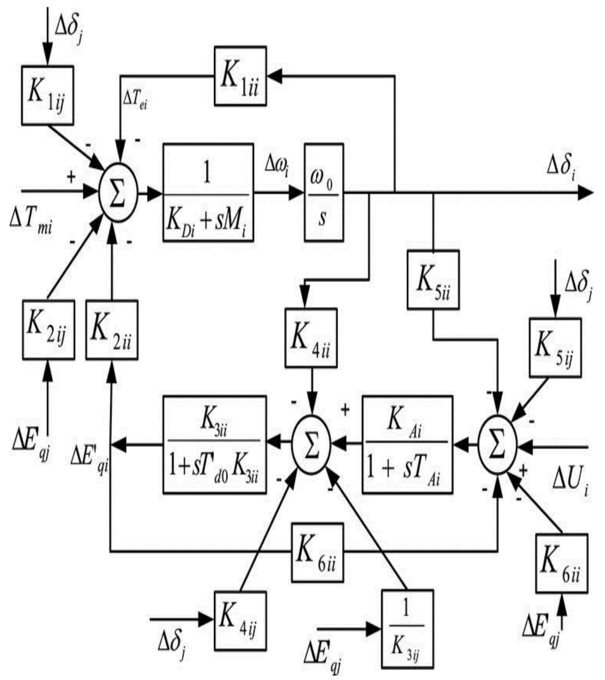

Fig. 2: Representation of Heffrons-Phillip model for the multi-machine configuration of power system

3. POWER SYSTEM STABILIZER

For synchronous machines the angular stability can be controlled by using highs speed exciter, voltage regulators, by 1960's PSS is used to add damping to electromechanical oscillations, by producing electric torque in phase with speed deviations of the rotor. Generally, PSS is a lead lag compensator, its installations were based on input signals, which are proportional to electromechanically oscillations formed due to speed variations. We have different types of power system stabilizers based on inputs signals like Speed, frequency, power etc. At gas turbines PSS1A takes single electrical input signal power and makes reverse action to maintain system stable, PSS2A and PSS2B use accelerating power as the input signal but parameter setting is difficult in these controllers due to ultra-low frequency oscillation.

In PSS4B we can easily adjust frequency independently, so it produces a good response to stability enhancement problems in the interconnected system. In this paper PSS based on speed is used, rotor shaft speed is taken as input to produce damping torque in phase with speed change, and basic PSS figure is shown below

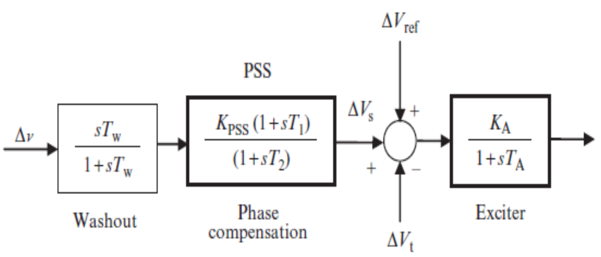

Fig. 3: Power system stabilizer block diagram

PSS basic function is to add damping for rotor oscillations of the generator by regulating the excitation with help of input signal speed so that it produces electric torque component in phase according to rotor speed deviations.

Speed is taken as an input signal to compensate phase lag forms between generator and excitation. Prominence for PSS application is increasing in the modern multi machine power network. In multi machine system representation with PSS had been formulating by adding PSS associated state variables.so that system matrix and order is increased by adding state equations. Power system stabilizer consists of mainly.

(a) Gain
(b) Washout circuit
(c) Dynamic compensator
(d) Torsional filter
(e) Limiter

3.1 Stabilizer gain

It effects on rotor oscillations, by increasing in gain value the stabilizer can improve system stability and reduce the magnitude of oscillations of the rotor.

3.2 Washout circuit

It is a high pass filter. The gain should be high. By modifying the terminal voltage of the generator it eliminates steady state bias in PSS output.

3.3 Dynamic compensator

It consists of two lead lag stages, Phase lags formed due to AVR and the field circuit of the generator will be compensated by using the lead stage. The parameters are tuned to limit rotor oscillations, so the phase lag introduced between electrical torque and exciter input circuit will be compensated by this block. Gain values in this block provide adequate damping at all operating conditions and for every generator.

We have to determine the variables of power system stabilizer separately due to the dependence of machine parameters. PSS values will be influenced by the dynamics of the power system.

3.4 Torsional filter and limiter

Due to frequency offset voltage errors occur. This can be eliminated by using a torsional filter if rotor speed raises, then the terminal voltage at generator will decreases due to AVR actions so PSS has to counteract to produce more positive output, limiter is used to limits the output of PSS to improve transient stability.

4. METHODS TO DESIGN PSS

To design power system stabilizer parameters we have different linear and nonlinear methods. In linear methods we have different techniques like pole placement method, pole shifting method, Linear quadratic regulation, eigen value sensitivity analysis, quantitative feedback theory, sliding mode control, reduced order model,h2 control etc.

In pole placement technique participation factor is used to determine the number and size of stabilizers required for multi machine system. Root locus technique can be used to design gains separately and to adjust the gains. In pole shifting method input and output related parameters are continuously estimated. Poles can be shifted to any desired location using PID stabilizer. In linear quadratic regulation, the secondary bus is used as a reference bus instead of the infinite bus and takes Fan input signal from the internal generator bus and secondary bus. In Eigen value sensitivity analysis objective function brings coordination between power system stabilizer and facts device stabilizers and uses the Levenberg-Marquardt method and genetic methods at various operating conditions.

We can use the power system stabilizers at the various system operating conditions by using quantitative feedback theory. The control objective will be chosen to track the desired output control signal in Sliding mode control designs Reduced order model is based on open loop matrix .we can obtain accurate results by using this technique, with help of analytical tools we can optimize reduced order models.

H2 adaptive control technique can be used to control the nonlinear system like synchronous generators, and we can use the for disturbance attenuation. In nonlinear methods by using adaptive control technique adaptability for PSS becomes easy and it can operate at different operating conditions. In the genetic algorithm, the objective function is specified and finite bound limits are placed to optimize the parameters.

Fuzzy logic controllers don't need a mathematical model of the control system. By using neural networks tuning of conventional PSS and their implementation in inverse mode control, direct control, and indirect adaptive control is easy and it is an extremely fast process. Like other heuristic algorithms due to easy implementation and computation, the convenience makes PSO technique easy to design PSS parameters. Simulated annealing provides free optimization to evaluate the objective function. We can eliminate sensitivity factors and Eigen vectors during stabilizer design during tabu search. Gps based phasor measurement units provide paths to design stabilizers (PSS) in the global control of the power system. With properly chooses control gains we can use lyapunov method.

In PSS design dissipating rotor energy and quantify energy dissipation theory is used in the dissipative method. Gain scheduling model is using to provide time delays if necessary during PSS design.

5. GENETIC ALGORITHM

It is based on heuristic search inspired by natural genetic and evolution .information is exchanged between the individuals with help of fitness principle. Genetic algorithm is a powerful optimization tool and has wide applications. Similar to Darwin's fitness hypothesis.in genetic algorithm candidate solution with respect to the problem is the same as individuals population.in search space individual population is maintained indicating the best solution to the existing problem**.**at first, the individuals are gathered to form an initial population to produce a better result based on the fitness level individuals are selected in the existing problem domain area and similar type of individual are placed together. From the natural genetic operators are taken to produce future offspring's from previous generations. The basic components exist in all genetic algorithms they are fitness function to do optimization, chromosomes populations, selection of chromosomes to reproduce, crossover to produce next generation. Mutation of chromosome sin new generation. Different stages involved in the genetic algorithm is explained Each search space has some set of values for all parameters with respect to an existing problem, every parameter has been coded with a string of bits called as gene, and content present in each gene is called as an allele.

We write all parameters genes in a sequence called as chromosomes.in search space chromosomes exists for every search point. Some set of points are selected we call them as population .population is a set of chromosomes, we call chromosomes number in population as population size. A total number of genes in the string is termed as string length. The process is carried out until global point is reached, which consist of three stages called generation, evaluation and genetic operation. Flow chart of ga technique is shown in the figure.

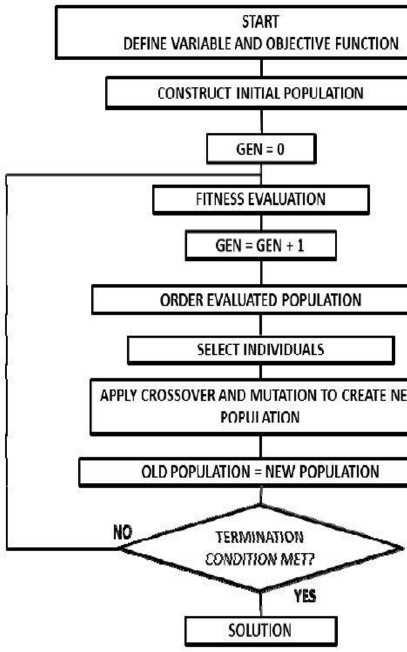

Fig. 4: Genetic algorithm flow chart

It involves four stages mainly
(a) Selection
(b) Recombination
(c) Mutation
(d) Replacement

5.1 Selection

It is also known as the reproduction stage from the existing population individuals are selected based on fitness value received from the objective function. Roulette wheel technique is used to select the individuals in search.

5.2 Crossover

Individuals selected from the above stage will exchange genetic information to form new individual .it is also called as recombination.it is done by choosing randomly a cutting point where parents are divided into two to exchange information.

5.3 Mutation

Strings formed will be subjected to mutation it blocks algorithm to trap local minimum. Lost genetic materials will be recovered in this stage.it is a simple search operator. If crossover phenomena are disturbed.

5.4 Replacement

Replacement is the final stage in this cycle. The next generation is formed by replacing parents and reinsertion is based on fitness all operations are carried at Genetic Algorithm toolbox by defining fitness function and it calculates for power system stabilizers at different operating points in which the following fitness.

6. CONCLUSION

Two machine three bus system is considered and by using Eigen values, stability is determined without connecting a controller and after adding controller existing system. Multi Machine power system Stability was enhanced by using power system stabilizer designed based on genetic algorithm technique will be used at different loading conditions and is functioning for system small disturbances like voltage, power and reactive power variations**.**

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