REDUCE THE POWER SYSTEM LOSSES BY THE PLACEMENT OF TCSC USING PARTICLE SWARM OPTIMIZATION

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ABSTRACT

Power losses are major problem in present Power System. It increases rapidly in day by day. Flexible Alternative Controllers in Power Systems (FACTS) are used to solve various active and reactive power problems. Flexible Alternative Controllers in Power System provides regulate power flow in critical lines. Thyristor Controlled Series Capacitor (TCSC) is the fast advancement in thyristor devices and associated switching control technology, the Capacitance of the series capacitance bank can be controlled much more effectively. Particle Swarm Optimization (PSO) is a heuristic global optimization method and also an optimization algorithm, which is based on swarm intelligence. This paper presents in Particle Swarm Optimization (PSO) compared with genetic algorithm. The suggested algorithm has been applied to IEEE-30 bus system.

KEYWORDS: Flexible Alternative Controllers in Power Systems (FACTS), Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Thyristor Controlled Series Capacitor (TCSC), Power System Stability

INTRODUCTION

The number of transmission networks increased day by day. It affects complexity to maintain the stability of the Power Systems. Conventional planning and operating methods can leave systems showing to instability. Voltage instability occurrence is major blackout. Power flow shows different variations. To control the power flow appropriate to have reliable, secure system is in the interest of the transmission system operator (TSO). To overcome this condition, FACTS devices are introduced.

FACTS devices can be effectively used for power flow control, enhancement of transient stability and mitigation of the system oscillation by giving additional flexibility, FACTS controllers can enable a line to carry power closer to its thermal rating. It employs high speed thyristors for switching in or out transmission line components such as capacitors, reactors or phase shifting transformer for some desirable performance of the systems. [3] Thyristor controlled series capacitor (TCSC) is the one of the family member of FACTS controllers. It acts as the capacitive or inductive compensator by the modifying reactance of the transmission line.

Genetic Algorithm (GA) is a family of computational models inspired by evolution. It is the population based model that uses selection and recombination operators to generate new sample points in a search space. Particle Swarm Optimization (PSO) technique is used to solve various optimization problems in Power Systems. In Particle Swarm Optimization (PSO) is developed from swarm intelligence and is based on the research of bird and fish flock movement behaviour. PSO is used to find out the best particle (solution) of the system.

Genetic Algorithm and Particle Swarm Optimization techniques are similarity study of each other. GA is the selected from population and PSO is the selected from the overall best particle (solution). Compare to GA, PSO is some initial parameters are adjusted.

MODELLING OF TCSC

Thyristor controlled series capacitor (TCSC) is an important device in the FACTS family. It consists of a fixed capacitor in parallel with a thyristor controlled reactor. It acts as the capacitive or inductive compensator by modifying reactance of transmission line. Figure 1 shows the single line diagram of a TCSC.
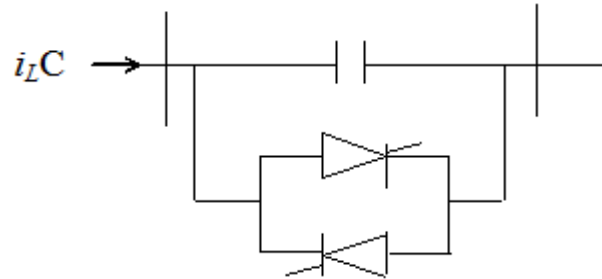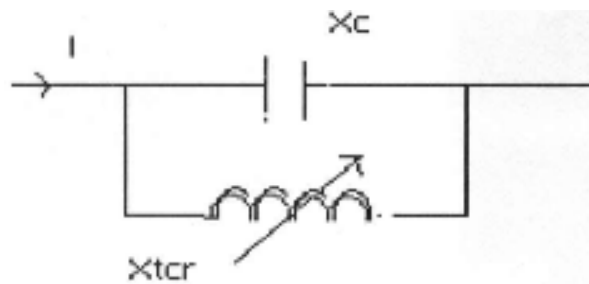

Figure 1: Basic Diagram of a TCSC

In this paper TCSC is modelled by changing transmission line reactance below:

$$X_{ij} = X_{line} + X_{TCSC} \tag{1}$$

$$X_{TCSC} = r_{TCSC}.X_{line} \tag{2}$$

Where X_{line} is reactance of transmission line and r_{TCSC} is compensation factor of TCSC. TCSC reactance is chosen between $-0.7X_{line}$ to $0.2X_{line}$.

Figure 2: Equivalent Circuit of TCSC

In a practical TCSC implementation, several such basic compensators may be connected in series to obtain the desired voltage rating and operating characteristics. This arrangement is similar in structure to the TSSC and, if the impedance of the reactor, X1, is sufficiently smaller than that of the capacitor, Xc, it can be operated in an on/off manner like the TSSC. However, the basic idea behind the TCSC scheme is to provide a continuously variable capacitor by means of partially cancelling the effective compensating capacitance by the TCR.

POWER SYSTEM STABILITY

Stability is the ability of the system to develop restoring forces equal to or more than the disturbing forces and remaining original stage when subjected to the disturbance. At any point of time, a power system operating condition should be stable, meeting various operational criteria, and it should also be secure in the event of any credible contingency.

- **Voltage Stability (PV Curve)**

This is one of the widely used methods of voltage stability analysis. This gives the available amount of active power margin before the point of voltage instability. In this method Real power transfer through a transmission interface or interconnection also can be studied.
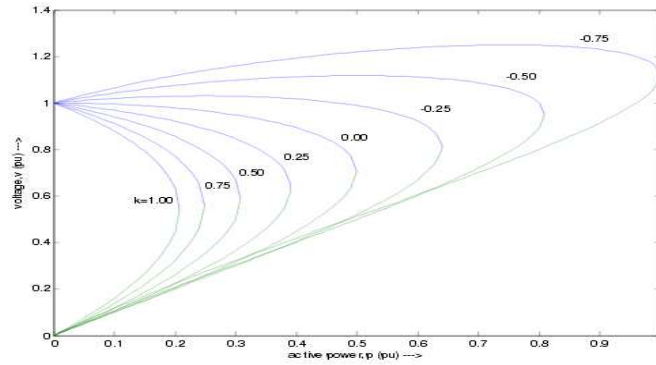
Figure 3: Normalized P-V Curves for 2-Bus Test System

GENETIC ALGORITHM (GA)

Genetic algorithms are a family of computational models inspired by evolution. GA of evolutionary computation is inspired by Darwin's theory of evolution. It is often viewed as function optimizers, although the range of problems to which genetic algorithms have been applied is quite broad. An implementation of a genetic algorithm begins with a population of chromosomes. Genetic algorithm operates using genetic operators (i.e. selection, crossover and mutation).

- **Selection**

In proposed GA, method of tournament selection is used for selection. This method chooses each parent by choosing n_t (tournament size) players randomly and choosing the best individual out of that set to be a parent. In this paper n_t is chosen $n_t = 4$.

- **Crossover (Recombination)**

After the selection, we go for crossover. Crossover point will be chosen for each pair. The information after the crossover point will be exchanged between the two individual of each pair.

- **Mutation**

The last step is the mutation, with the sense of adding some effect of exploration of the phase-space to the algorithm. To implementation of Mutation is compared to other modules-fairly trivial. Each bit in every gene has a defined probability P to get inverted.

Algorithm for Genetic Algorithm

- **[Start]** Generate random population of *n* chromosomes (suitable solutions for the problem)

- **[Fitness]** Evaluate the fitness *f(x)* of each chromosome *x* in the population

- **[New Population]** Create a new population by repeating following steps until the new population is complete

  o **[Selection]** Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected)

  o **[Crossover]** With a crossover probability cross over the parents to form a new offspring (children). If no crossover was performed, offspring is an exact copy of parents.

  o **[Mutation]** With a mutation probability mutate new offspring at each locus (position in chromosome).

  o **[Accepting]** Place new offspring in a new population

- **[Replace]** Use new generated population for a further run of algorithm

- **[Test]** If the end condition is satisfied, stop, and return the best solution in current population

- **[Loop]** Go to step 2

PARTICLE SWARM OPTIMIZATION (PSO)

Particle Swarm Optimization(PSO) is a population-based stochastic approach for solving continuous and discrete optimization problems. In particle swarm optimization, simple software agents, called *particles*, move in the search space of an optimization problem. The position of a particle represents a candidate solution to the optimization problem at hand. Each particle searches for better positions in the search space by changing its velocity according to rules originally inspired by behavioural models of bird flocking.

Each particle is treated as a point in a D dimensional space.

The ith particle is represented as

$$X_i = (X_{i1}, X_{i2}, \ldots . X_{id})$$

The best previous position of the ith particle is recorded and represented as

$$P_{besti} = (P_{besti1}, P_{besti2}, \ldots \ldots \ldots P_{bestid})$$

The index of the best particle among the entire particle in the population is represented by the symbol $g_{best\ id}$. The rate of the position change (velocity) for the particle is represented as

$$V_i = (V_{i1}, V_{i2}, \ldots \ldots V_{id})$$

After the search procedure for the P_{best id} and g_{best id} the modified velocity and position of each particle can be calculated using the current velocity and the distance from P_{bestid} to g_{bestid} as shown in the following equation.

$$V_{id}(t+1) = W * V_{id}(t) + C_1 * rand(\ ) * (P_{best\ id} - X_{id}(t)) + C_2 * rand(\ ) * (g_{best\ id} - X_{id}(t)) \tag{3}$$

Where

i = 1, 2, 3…n

d = 1, 2, 3….m

n: number of particles

m: solution's dimensions i.e., the number of control variables

$V_{id}(t)$: Current velocity of the i at iteration t

$V_{id}(t+1)$: modified velocity of particle i

Rand: random number between 0 and 1

$X_{id}(t)$: Current position of particle i at iteration t

$P_{best\ id}$: P_{best} of particle i

$g_{best\ id}$: g_{best} of particle i

W: weight function for velocity of particle i

C_i: weight coefficient of each term

Algorithm for Particle Swarm Optimization (PSO)

The following PSO algorithm is used to obtain the optimal location of TCSC for loss minimization.

Step 1: Initial searching points and velocities are randomly generated within their limits.

Step 2: P_{best} is set to each initial searching points. The best evaluated values among the P_{best} are set to g_{best}.

Step 3: New velocities are calculated using equation (5)

Step 4: If $V_{id}(t + 1) < V_{dmin}$

Then $V_{id}(t+1) = V_{dmin}$ and if $V_{id}(t + 1) > V_{dmax}$

Then $V_{id}(t + 1) = V_{dmax}$

Step 5: New searching points are calculated using equation (7)

Step 6: Check the capacity limits constraints

If $P_{id}(t + 1) > P_{dmax}$

Then $P_{id}(t + 1) = P_{dmax}$ and if $P_{id}(t + 1) < P_{dmin}$

Then $P_{id}(t + 1) = P_{dmin}$

Step 7: Evaluate the fitness value for new searching point. If evaluated value of each agent is better than previous P_{best} then set to P_{best} if the best P_{best} is better than g_{best} then set to g_{best}

Step 8: If the maximum iteration is reached stop the process otherwise go to step 3.
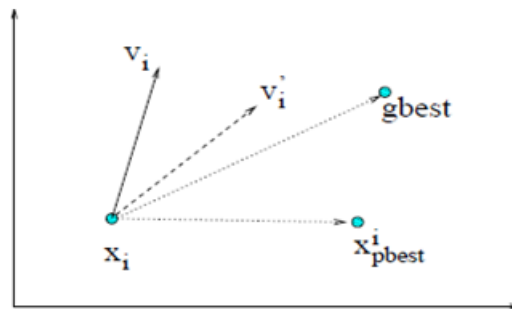

**Figure 4: Concept of Modification Searching Points in PSO**

RESULTS

Simulation studies were done for different scenarios in IEEE 30 bus power system.

- **Scenario 1:** Power system normal operation (without FACTS devices installation).

- **Scenario 2:** TCSC-GA operation

- **Scenario 3:** TCSC-PSO operation

The first scenario is normal operation of network without installation any device. In second TCSC-GA was installed. And finally TCSC-PSO was installed.
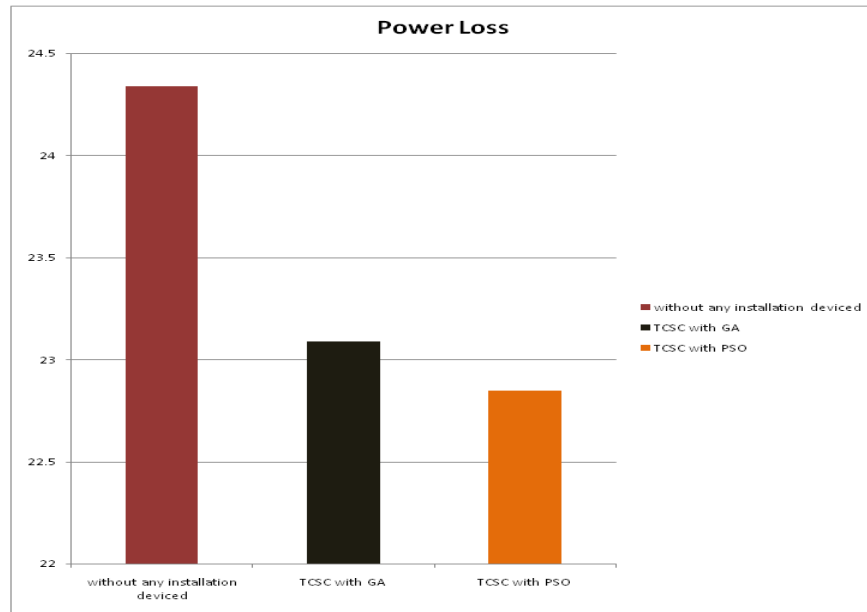
Figure 5: Real Power Losses with and without TCSC
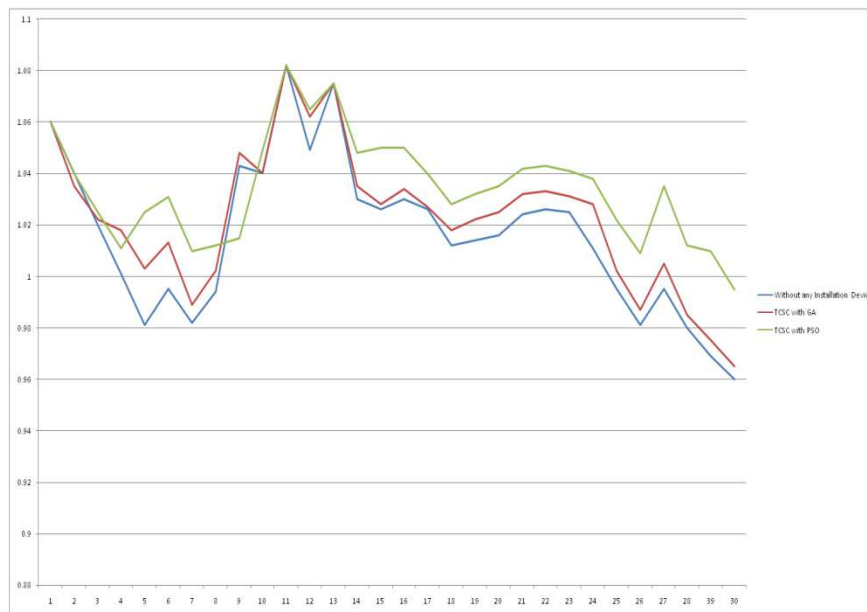
Figure 6: Voltage Profile with and without Placement UPFC

CONCLUSIONS

In this paper, performance of transmission system with TCSC device is studied using Particle Swarm Optimization (PSO) and Genetic Algorithm (GA). It is concluded that with PSO the performance studies in terms of voltage profile and power loss are more accurate compared with GA. Using PSO accurate results can be obtained. Case Study was conducted on IEEE-30 bus system.

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