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Optimal Placement of TCSC For Enhancement of Power System Stability Using Heuristic Methods: An Overview

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Abstract

Flexible Alternating Current Transmission Systems (FACTS) represents a vast development in the area of power system operation and control. As we know that under heavily loaded conditions our power system is at high risks of consequent voltage instability problem. This paper gives an overview about application of series connected Flexible alternating current transmission system (FACTS) for improvement of power system performance like transfer stability, secure voltage profile and reduce the system losses etc. FACTS devices require huge capital investment. Therefore, heuristic techniques are used for optimal location and sizing of series FACTS controllers like Genetic Algorithm (GA), Particle Swarm Optimization (PSO) etc. These techniques are used to solve the optimization problem. This paper gives details of optimal placement and sizing of FACTS devices based on different evolutionary techniques which is used for minimization of transmission loss, enhancement of stability of power system. In this study one of the FACTS devices is used as a scheme for enhancement of power system stability.Proper installation of FACTS devices also results in significant reduction of transmission loss. In this review,TCSC is selected as the compensation device.

***Key Words** - FACTS devices, Optimal Sizing, Particle Swarm Optimization, TCSC, Transmission Loss Minimization*

1. Introduction

FACTS (Flexible Alternating Current Transmission System) devices are generally based on power electronics which is used for increasing transmission capacity in the power system. They also have the capacity to control several parameters in transmission network. These types of devices can increase the stability of power system network and support voltage with better controllability of their parameters like impedance, current, phase angle and voltage. FACTS have the capability to increase the reliability of power system networks. It also enhance the power flow control of the system. There are various methods to connect the FACTS devices such as in series, shunt, series-series and series-shunt[1]. FACTS devices also provide strategic profit for improved transmission system management by better utilization of existing transmission assets, increased transmission system reliability and availability, increased dynamic and transient grid and enabling environmental benefits. In this paper, some evolutionary techniques are reviewed to optimize the placement and sizing of FACTS devices in order to minimize the transmission loss and increase the voltage profile in the System for enhancement of power system stability. The TCSC is chosen as the device for compensation and modeled as a reactive source added at the line.

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2. Thyristor Controlled Series Compensator

Thyristor Controlled Series Compensator (TCSC) provides controlling and increasing power transfer level of a system by varying the apparent impedance of a specific transmission line. A TCSC can be utilized during contingencies to enhance the power system stability. It is possible to operate stably using TCSC at power levels well beyond those for which the system was originally intended without endangering system stability. It consists of series controlled capacitor which is shunted by a Thyristor controlled Reactor. The figure shows model of a transmission line with series impedance and a TCSC connected between two buses[2].

TCSC acts as the inductive or capacitive compensation by modifying the reactance of the transmission line and the reactance of the transmission line is adjusted by TCSC directly. The rating of TCSC depends on the reactance of the transmission line where the TCSC is located.

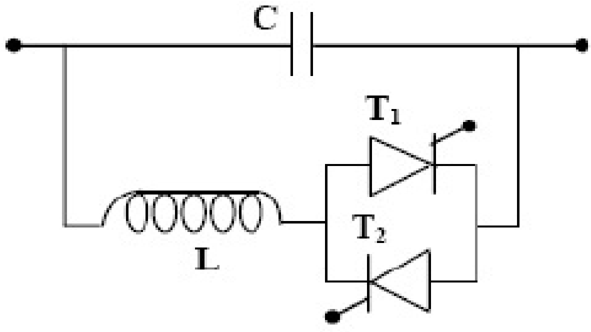

Figure 1. Basic structure of TCSC

3. Modern Optimization Techniques

To obtain the most suitable location and sizing of TCSC installation several optimization techniques are used. These techniques are help in optimal placement of TCSC for improving many factors such as voltage profile, system stability etc. These techniques can also help in reducing power loss, voltage deviation, installation cost. These techniques has been implemented at any of the standard IEEE bus system. Mainly IEEE 30 and IEEE 57 bus systems are used with these methods. Some of these techniques which are used for optimal placing are Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Differential Evolution (DE), Evolutionary Programming (EP), Non-dominated Sorting Genetic Algorithm(NSGA) etc. Some modern Heuristic Optimization and Meta heuristic Optimization techniques are used for this purpose. PSO has the capability to achieve optimal solution and it is faster than Genetic Algorithm. It gives better results than other optimization techniques.

A. Particle Swarm Optimization (PSO)-

Particle Swarm Optimization is a stochastic optimization and population based self adaptive technique. It was inspired by the social behavior of bird flocking and fish schooling. PSO is used for optimizing the parameters of conrol system which are complex and difficult to solve by other conventional optimization methods.Particle Swarm Optimization (PSO) is a artificial intelligent search approaches which have the potential in solving these type of problem. This technique is faster than Genetic Algorithm GA. There is a drawback in PSO therefore the different variants of PSO were proposed by the researchers to improve the performance of PSO. The Particle Swarm Optimization (PSO) algorithm is totally based on the social behaviors of animal swarms (e.g. bird blocks and fish schools). Kennedy and Eberhart developed the Particle Swarm

Intelligence. PSO is biologically inspired optimization method. This technique provides a population-based search procedure in which individuals are called particles and they changes their positions. XY plane presented the position of each particle. All the particle moves to the new position using velocity according to its own experience called as Pbest. Gbest is the overall best value obtained so far by any particle in the population. The PSO consists of velocity changes of each particle towards its Pbest and Gbest by time to time[3]. All particles tries to modify its current position and velocity according to the distance between its current position and Pbest, and the current position and Gbest. The particle updates its velocity and position after finding the best value.The general flowchart of PSO for placement of TCSC is shown in Fig.3. It can be seen from Fig.2 that percentage of PSO techniques used is greater which shows the effectiveness of this algorithm. PSO is prevalent because of large number of benefits such as easy implementation, robustness, low computational burden and rapid convergence. PSO shows superior performance in large manner of applications.

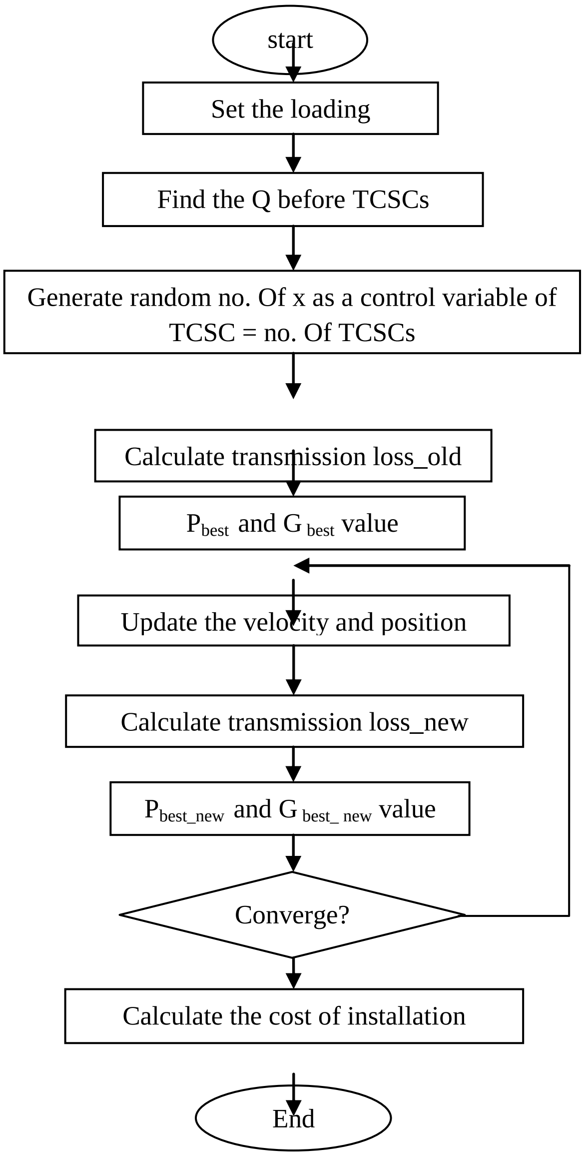

Figure 3. Flowchart of PSO

B. Evolutionary Programming (EP)-

One of the artificial intelligent method is the Evolutionary Programming method. David B.Fogel introduced this method in 1960 inspired from natural selection process to find the global optimums of complex problem. It is an evolutionary algorithm which based on computational models of fundamental evolutionary processes like initialization, mutation, selection and reproduction. EP gives better result as compared with artificial immune system (AIS), when it is used to optimize the size of TCSC. To define the optimal placement of FACTS device for maximization the total transfer capability (TTC) of power system, Fogel proposed Evolutionary Programming[4]. EP also works for FACTS parameters, FACTS locations, and the real power generations except the slack bus in power system, the real power loads in sink area and generation bus voltages. The general flowchart of EP for placement of TCSC is shown in Figure 4.

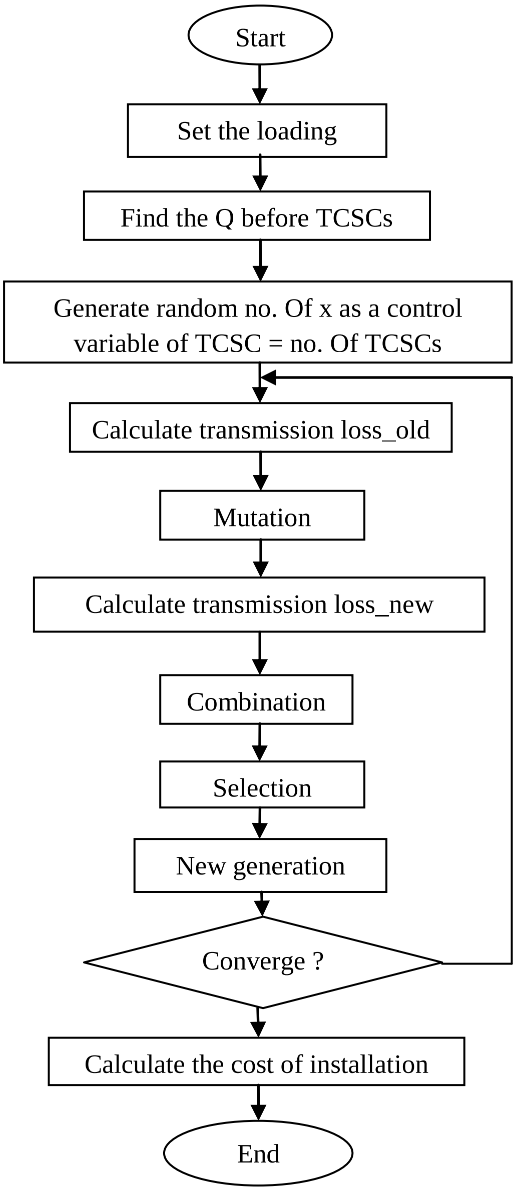

Figure 4. Flowchart of EP

C. Differential Evolutionary (DE)-

Differential Evolutionary is a typical Evolutionary Algorithm(EA).This method is a novel parallel direct search method and it utilized NP parameter vectors as a population for each generation G. Storn and Price proposed this method in1995.By adding the weighted difference between two population vectors it generates new vectors of parameters.This is an effective, fast, simple, robust, inherently parallel and has few control parameters need little tuning. This can be used for many functions like to minimize non-continuous, non-linear, non differentiable space functions.It can also work with noisy, flat,multi-dimensional, and time dependent objective functions and constraint optimization in conjunction with penalty functions[7].The general flowchart of DE for placement of TCSC is shown in Figure 5.

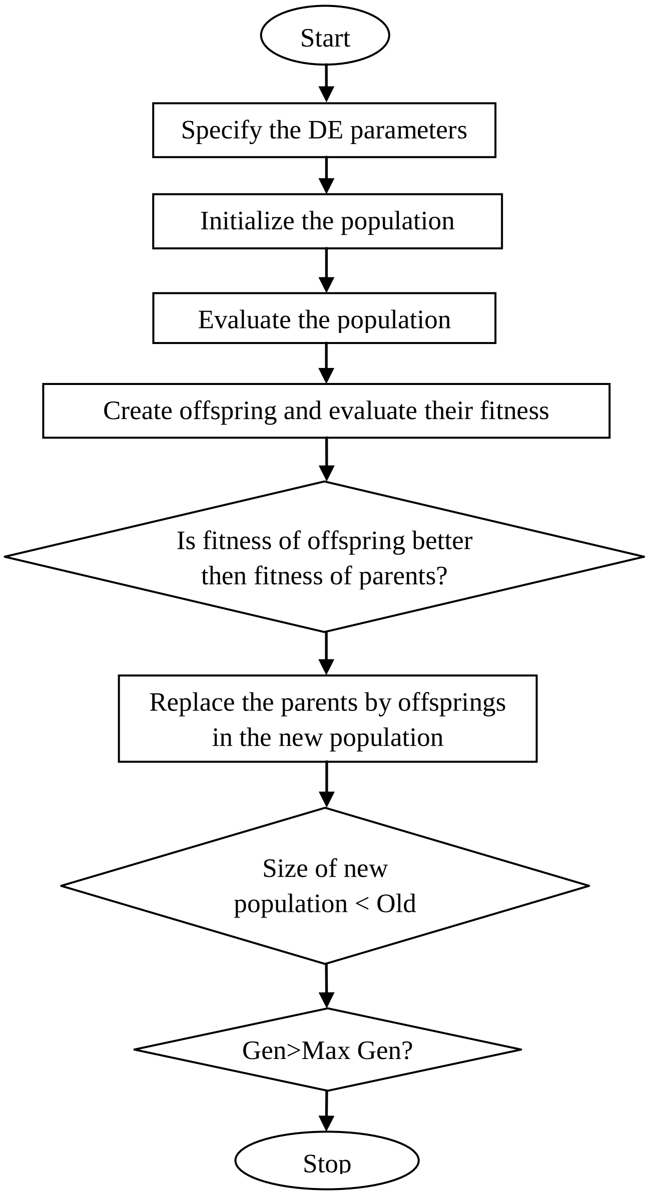

Figure 5. Flowchart of DE

D. Genetic Algorithm (GA)-

Genetic Algorithm is an evolutionary computing method.It can give a global optimal solution. Holland proposed this algorithm in the 60's and 70's.It is a global search algorithm that is based on concepts from natural genetics and the Darwinian survival-of-the-fittest code. Meta-heuristic algorithm-based engineering optimization methods, including GA, have occasionally overcome several deficiencies of conventional numerical methods. Genetics helps us to reach to a near global optimum solution. In each iteration of GA (referred as generation), a new set of string (i.e. chromosomes) with improved fitness is produced using genetic operators they are selection, crossover and mutation[8]. The general flowchart of GA for placement of TCSC is shown in Figure 6.

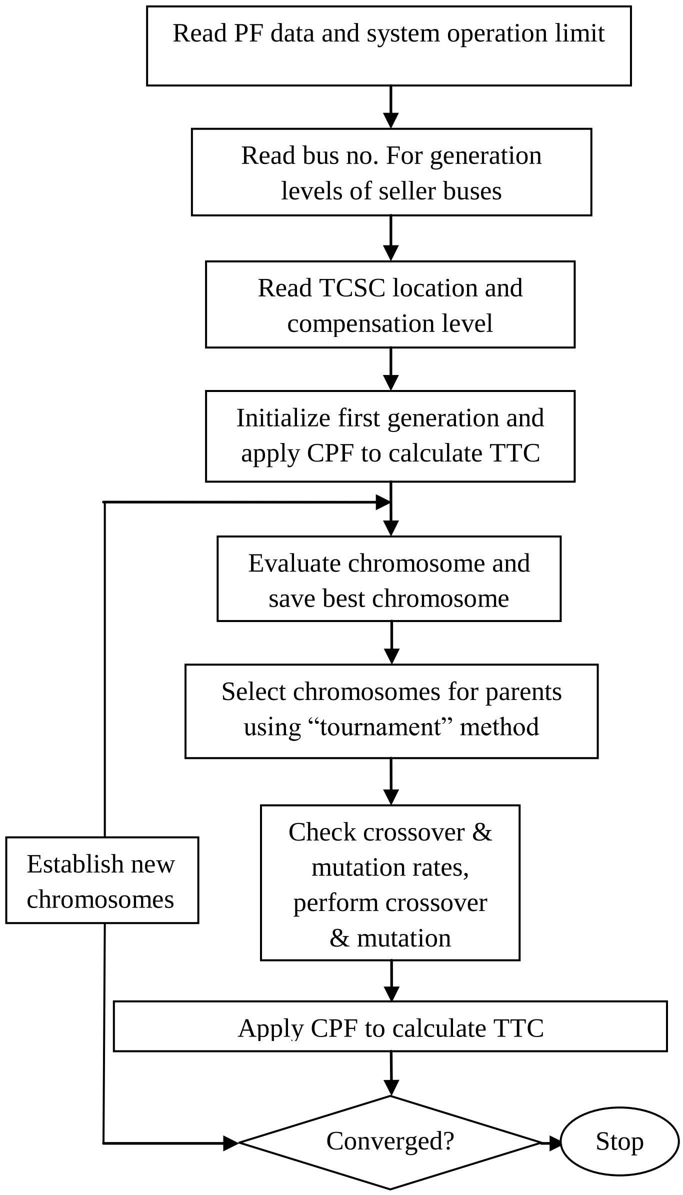

Figure 6. Flowchart of GA

4. Conclusion

In this paper a review on optimal placement of TCSC for enhancement of power system stability by using optimization techniques such as PSO, GA, DE and EP has been presented. This paper shows that the execution of PSO, GA, DE and EP helps in transmission loss reduction.PSO can be implemented on others types of FACT controllers.This paper investigate the capability of the optimal installation of TCSC for reducing the active power loss in power system. DE has been applied successfuly as it is one of the newest computational intelligence technique.It is possible to place TCSC in the transmission line and proper power planning can be achieved with system loss minimization. DE and GA techniques can easily find out the optimal location and the best parameters of TCSC but DE technique has superior features like high-quality solution, stable convergence characteristics, and good computation efficiency.The correct location of TCSCs identified by using new selection factors, leading to quick reduction of severity of overloading of the system under contingencies, with minimum number of TCSCs, in addition to eliminating or alleviating the line overloads.

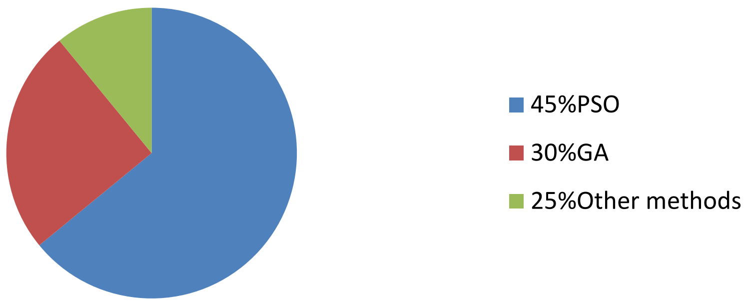

Figure 2. Pie chart for PSO,GA and other techniques

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