

An Overview: Optimal Location of TCSC for Enhancing Line Loadability Using Heuristic Techniques



Engineering

KEYWORDS : FACTS devices, TCSC, Optimal Sizing (OS), Optimal Location (OL), Heuristic Techniques, Transmission Loss Minimization

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ABSTRACT

Today's power systems are increase in size and complexity due to increase in demand. So the modern power systems are prone to failures and system will become less secure. Failures can result in widespread blackouts with potentially serve social and economic problems. Power system security is the most concerned aspect, which is given at most importance in present days. A new technology based on power electronics devices known as Flexible Alternating Current Transmission System (FACTS) devices are introduced to control the active and reactive power flow and also regulates the bus voltage resulting in an increased transfer capability, low system losses, improved stability and security.

Introduction

The number of unplanned power exchanges increases, due to the competition among utilities and due to contracts concluded directly between producers and consumers. If these exchanges are not controlled, problems may appear with the power flows. The control of power flows was mostly realized by reallocating productions. This kind of control is subject to an ancillary services market. Therefore, it is in the interest of the transmission system operator (TSO) to have another way of controlling power flows in order to permit a more efficient and secure use of transmission lines. With ever-increasing demand for electricity, the power transfer grows, consequently the power system becomes increasingly more difficult to operate, and more insecure with unscheduled power flows and higher losses. With the rapid development of self-commutated semiconductor devices, it is possible to design power electronics equipments known as the Flexible AC Transmission System (FACTS) devices which are introduced by Hingorani in 1988[1]. 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. FACTS devices are used for increasing transmission capacity to its maximum thermal limit in the power system and bring the system under control and also possible to control the phase angle, the voltage magnitude at chosen buses and / or line impedances of a transmission system. These devices have the capacity to control several parameters in transmission network and have the capability to increase the reliability of power system network. It also enhance the power flow control of the system. There are various methods to connect the FACTS devices such as series, shunt, series-series and series-shunt[3]. FACTS devices also provides strategic profit for improved transmission system reliability and availability, increased dynamic and transient grid and enabling environmental benefits.

Thyristor Controlled Series Compensation: 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 figure1 shows model of a transmission line with series impedance and a TCSC connected between two buses [4]. TCSC acts as the inductive or capacitive compensation by modifying the reactance of the transmission line and the reactance of transmission line is adjusted by TCSC directly. The rating of TCSC depends on the reactance of the transmission

line where the TCSC is loaded.

TCSC may have one of the two possible characteristics: capacitive or inductive, respectively to decrease or increase the impedance of the branch. It is modeled with variable series reactance. Its value is function of the reactance of the line X_L where the device is located. It is in the range:

$$-0.8X_L \leq X_{TCSC} \leq 0.2X_L \quad (1)$$

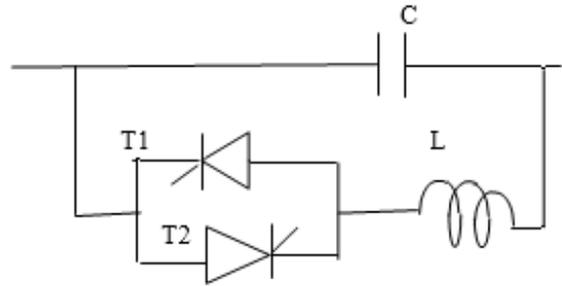


Fig.1 Basic Block Diagram of TCSC

HEURISTIC TECHNIQUES FOR OPTIMIZATION:

Heuristic methods may be used to solve combinational optimization problems. Because of the move from one solution to another is done using rules close to the human reasoning, these methods are called 'Intelligent'. The heuristic algorithms search for a solution inside a subspace of the total search space. Thus they are able to give a good solution of a certain problem in a reasonable computation time, but they do not assure to reach the global optimum. The most important advantage of heuristic methods lies in the fact that they are not limited by restrictive assumptions about the search space like continuity, existence of derivative of cost function [4]. In a general manner, the principle of a heuristic method may be represented with figure2. The specificity of each method lies mainly in the way of moving from the current solution(s) to the new solution(s).

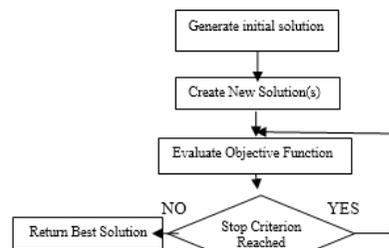


Fig.2 General Principle of a Heuristic method

To obtain most suitable location and sizing of TCSC installation several heuristic techniques are used. These techniques are help in optimal placement of TCSC for improving many factors such as voltage profile, system stability etc., can also help in reducing power loss, voltage deviation, installation cost, and has been implemented at any of the standard IEEE bus system. Some of these techniques which are used for optimal placing are Genetic Algorithm Particles Swarm Optimization, Differential Evolution, Evolutionary Programming, Non-dominated Sorting Genetic Algorithm etc.

1]. Evolutionary Programming (EP): One of the artificial intelligent method is the EP method. this method is introduced in 1960 inspired from natural selection process to find the global optimum of complex problem. It is an evolutionary processes like initialization, mutation, selection and reproduction. When EP is used to optimize the size of TCSC, it gives better result as compared with artificial immune system (AIS). To define the optimal placement of FACTS device for maximization the total transfer capability (TTC) of power system. Fogal proposed EP [5]. 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 figure3.

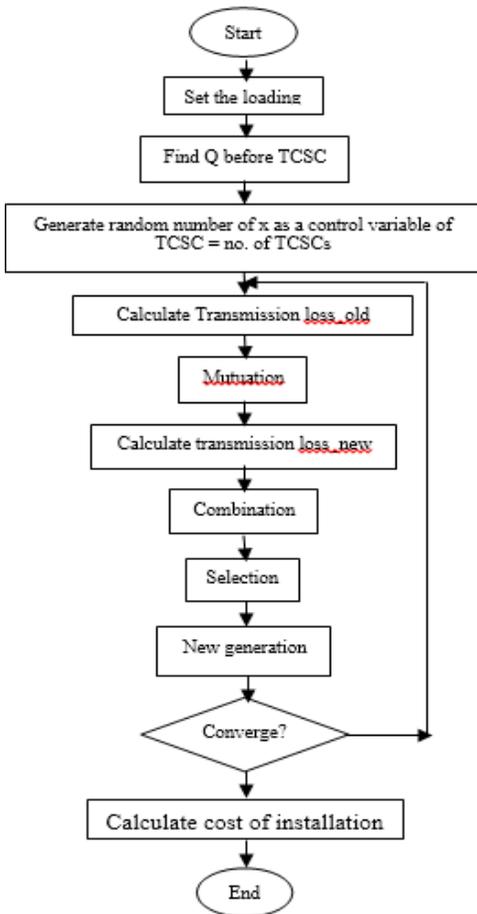


Fig.3 Flowchart of EP

2]. Particle Swarm Optimization (PSO): PSO is a stochastic optimization and population based self adaptive technique, for optimizing the parameters of control system which are complex and difficult to solve by other conventional optimization methods. PSO is an artificial intelligent search approaches which have the potential in solving these type of problem. This technique is faster than GA.

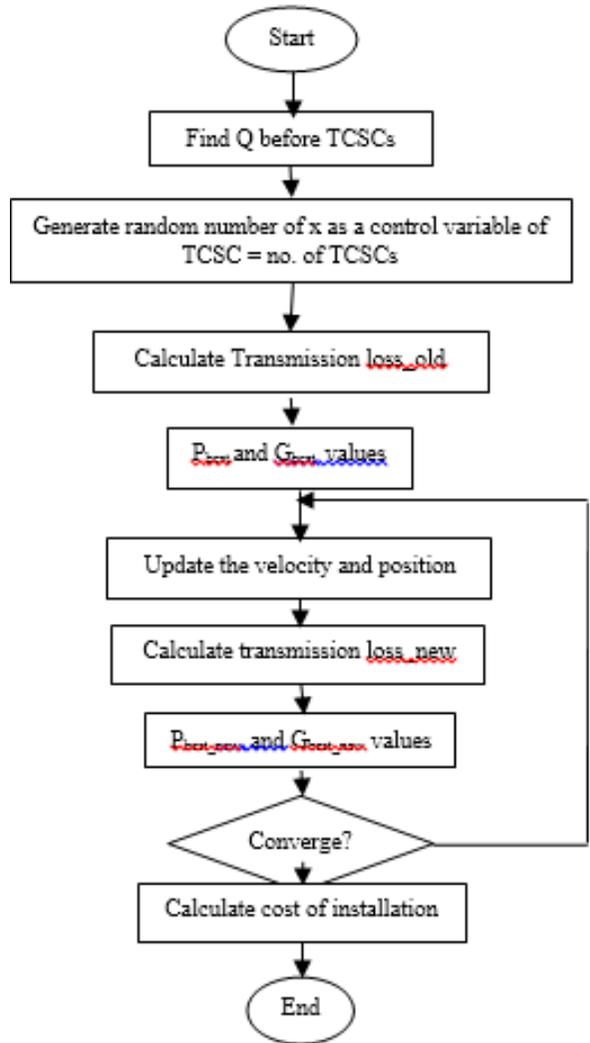


Fig.4 Flowchart of PSO

There is a drawback in PSO therefore the different variants of PSO were proposed by researchers to improve the performance of PSO. The PSO algorithm is totally based on social behaviors of animal swarm. Kennedy and Eberhart developed the Particle Swarm Intelligence. PSO is biologically inspired optimization method. This techniques provide a population-based search procedure in which individuals are called particles and they change 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 P_{best} . G_{best} is overall best value obtained so far by any particle in population. The PSO consists of velocity changes of each particle towards its P_{best} and G_{best} by time to time [6]. All particles tries to modify its current position and velocity according to the distance between its current position and P_{best} , and the current position and G_{best} . The particle updates its velocity and its position after finding the best value. The general flowchart of PSO for placement of TCSC is shown in figure4. Fig.7 shows that the percentage of PSO techniques is 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 application.

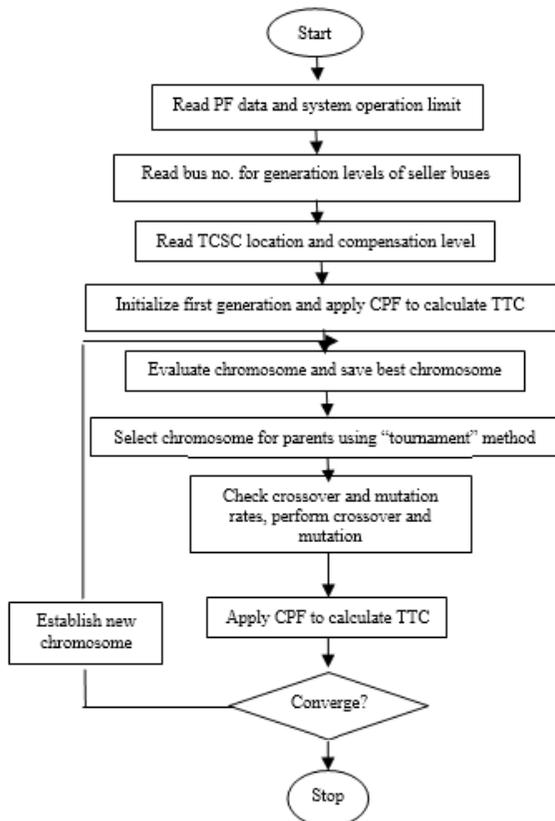


Fig.5 Flowchart of GA

Fig.5 Flowchart of GA

3]. Genetic Algorithm (GA): GA 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. Genetic helps us to reach to near a global optimum solution. In 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 [7]. The general flowchart of GA is shown in fig.5.

4]. Differential Evolutionary (DE): DE is a typical Evolutionary Algorithm (EA). This method is novel parallel direct search method and it utilized NP parameter vectors as a population for each generation. This method proposed in 1955. 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 a few 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 function [8]. The general flowchart of DE for placement of TCSC is shown in fig.6.

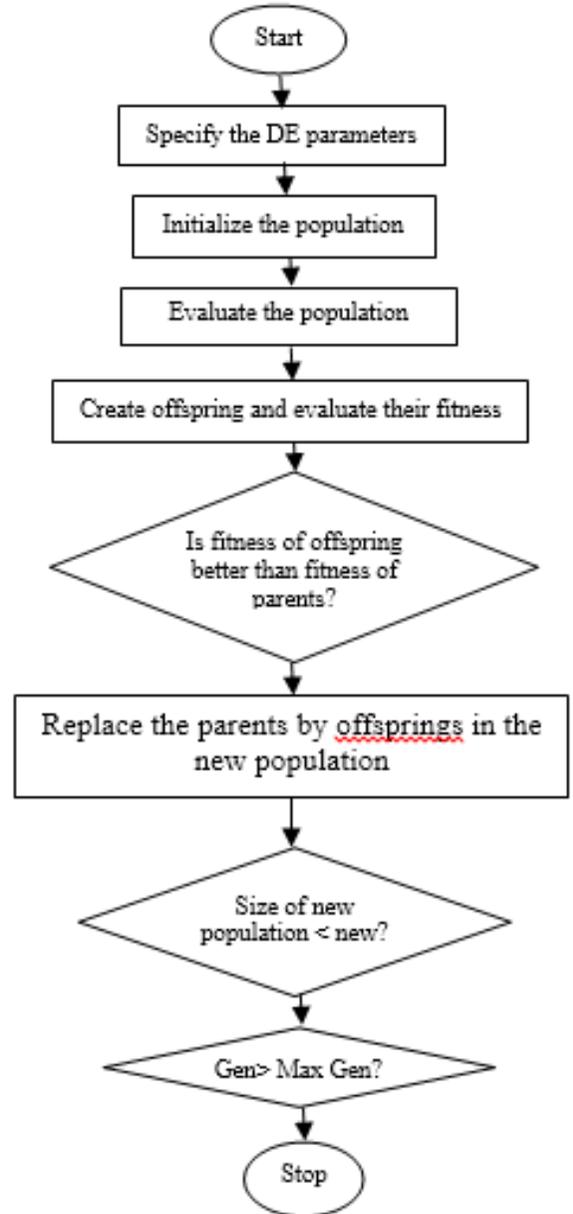


Fig.6 Flowchart of DE

CONCLUSION

A review on optimal placement of TCSC for enhancement of power system stability by using heuristic techniques has been presented in this paper. This paper investigate the capability of the optimal installation of TCSC for reducing the active power loss in power system and shows that the execution of heuristic method helps in transmission-loss reduction. PSO can be implemented on other types of FACTS controllers. DE has been applied successfully as it is one of the newest computational intelligence technique. DE and GA techniques can easily find out the optimal location and the best parameters of TCSC but DE technique has superior features. 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. With system loss minimization, it is possible to place TCSC in the transmission line and proper power planning can be achieved

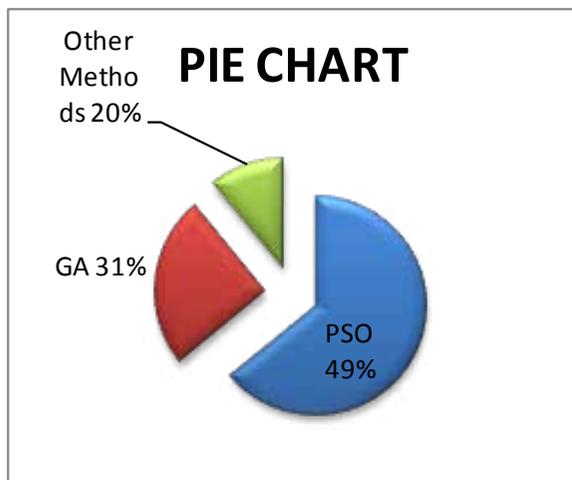


Fig.7 Pie Chart for heuristic methods

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