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A review on the application of genetic algorithm in power systems

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ABSTRACT- This paper serves in bringing out various methods used to reduce power losses in a complex power system. A variety of methods are developed earlier in the literature for optimizing a given power system such as Fuzzy system network , genetic algorithm , neural networks , network reconfiguration , reactive power dispatch (RPD), power system stabilizers etc. In this paper a study of above mentioned techniques and their relative merits and demerits are studied with a view to give a comprehensive overview about the various techniques essential for minimizing power losses in a given transmission network.

***KEYWORDS* -** Genetic algorithm, Reactive power dispatch (RPD), power system Stabilizer (PSS), and network reconfiguration.

I. INTRODUCTION

In an attempt to deal with a wide range of operating environment and disturbance, Power System Stabilizers (PSS) can be developed by using appropriate stabilization signals. In the recent times, various stabilizing control techniques for a multimachine power system by using intelligent methods have been developed. The primary aim for the stability analysis of a complex power system is due to the importance of the power systems in the present scenario. Furthermore, industries do not encourage the design of controller if power system stability is not significant enough. In an attempt to handle the above mentioned problems, various intelligent approaches are used. The very optimal sequential design for multi-machine power systems is very important and several techniques are widely used to cater the problem with control signals in power system.

The very purpose of the reactive power dispatch (RPD) in a complex power system is to identify the control variables which can minimize a given objective function and also satisfying the unit and system constraints available to the system. A comprehensive scheduling of reactive power in an optimum manner significantly reduces circulating VAR (volt ampere reactive), and thus promoting a uniform voltage profiling which ultimately leads to appreciable power saving by reducing system losses. RPD is a very complex non-linear optimization problem and thus require the help of modern simulation techniques to accomplish it.

A very significant proportion of the power is consumed in the form of losses at distribution level. Feeder reconfiguration is a very effective and efficient way to decrease the power losses of a given complex distribution system. A usual power distribution system contains several feeders for supplying the power to the consumers' base station. These several localized feeders should be connected in a radial structure to protect and configure a distribution system. Radiality has to be maintained by using proper regulation of the switches which are installed on the distribution system at various points.

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II. REACTIVE POWER DISPATCH IN MODERN COMPUTING ENVIRONMENT

Linear programming (LP), non-linear programming and gradient based techniques are prevalent among the literature [1-4] for solving RPD problems for power loss minimization. However, because of the approximations introduced by several linearized models, the LP results do not always represent the optimal solution for several inherently non-linear objective functions similar to the one used in the reactive power dispatch problem. Thus it is very difficult to calculate accurately and precisely the gradient variables and therefore a large volume of computations I usually involved in this approach. Also, these type of conventional techniques are known to be converging to a local optimal solution rather than the global solution. Recently, expert system approach [5] is being proposed for the reactive power control computations. This particular approach is based on "If-then" based production rules commonly used in optimization problem. The construction of these type rules requires extensive help from skilled knowledge engineers and thus can't be executed directly.

Several evolutionary computational techniques such as Genetic algorithm (GA) [6], Evolutionary programming (EP) [7] and Evolutionary strategy [8] are already there in the literature to solve the optimal reactive power dispatch problems. Primary factors are generator voltages, transformer tap positions and numbers of switchable shunt capacitor banks are used as the control variables in the work [6] and typically they are represented as integer vector in the modified genetic population. In addition to the normal procedure of crossover and mutation operations, several AI-based rules were used for improving the solutions. Evolutionary programming is applied in [7] for solving the reactive power dispatch problem by minimizing active power loss used as the objective function. IEEE 30-bus system has been employed to complete the simulations and the results thus obtained using the EP-based approaches are generally found to be better as compared to the results obtained using the above discussed conventional method. Although, these type of works have successfully solved the RPD problem, none of these techniques have considered the line flow and voltage stability constraints, which is very important for any practical implementation of RPD in a complex power system. If by chance a contingency occurs in an already completely stressed system then in that cases both angular and voltage stability may be lost. Many voltage instability issues i.e. voltage collapse events have been experienced by these types of utilities in the recent years. This has been mainly of the reactive power shortage during the peak load. These events thus warrant inclusion of the voltage stability constraint usually found in the RPD for maintenance of a complex power system.

III. POWER SYSTEM STABILIZERS AND GENETIC ALGORITHM

Power system stabilizers (PSS) [8] are primarily in use for a long time for enhancing the power system damping. The methods that are nowadays very common for tuning range from pole placement, are several heuristic optimization algorithms like the genetic algorithms [9] and particle swarm optimization method [10]. The heavily complex, complete dynamic behavior and in system nonlinearity of power systems, along with their almost constant time varying nature, have always posed a great challenge for power system control engineers for several decades. The optimal sequential design for multi-machine power systems that have been available in the literature suffer from several drawbacks. These particular drawbacks can be

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reduced and overcome by better technique for stabilizing the power system. Genetic Algorithm techniques are nowadays a proven and reliable for enhancing the stabilization of the power systems [8].

Genetic Algorithms (GAs) are global optimizing techniques which utilize at a time search from multiple point unlike search from a single point at a time. GA is usually independent of the problem complexity. The primary necessity of the GA is that you have to specify the objective function and you have to place finite bounds on the parameters. GA is now a days widely used for solving robust Power System Stabilization [11] problems. Optimization using GA techniques [12] is now widely applied in several real world problems some of them are image processing, pattern recognition, independent classifiers, machine learning systems etc.

IV. NETWORK RECONFIGURATION USING GENETIC ALGORITHM

A great amount of work has been done on the study of conventional constant load scheme for feeder reconfiguration problem in the past. The problem of network reconfiguration of the distribution system to minimize loss was first introduced by Merlin and Back [13]. They used a unique branch-and-bound-type optimization technique to accurately determining the minimal loss operating configuration for a given distribution system by the use of a spanning tree structure under a specific load condition. After this particular work a plethora of research work is done in this area. Shirmohammadi and Hong [14] have proposed an efficient and robust heuristic method which was based on solution proposed in [13]. This particular method suffers a shortcoming that the solution was not always optimum. A unique branch exchange concept has been given Civanlar [15]. In this unique and distinguished method loss minimization is accomplished by switching with respect to selected pair of switches, one for opening and the another one for closing and thus the system Radially was maintained. Baran and Wu [16] proposed a very computationally attractive method for reducing loss in distribution system.

It follows the solution approach developed in [15]. Goswami and Basu developed a very computationally intense heuristic algorithm, based on the very concept of optimal flow pattern which based on KVL and KCL equations of the network. Nara [17] introduced for the first time an Artificial intelligence (AI) based effective genetic algorithm technique for solving the feeder reconfiguration problem in radial distribution system. Swarnkar and Gupta [18] developed a computationally efficient meta-heuristic based methodology that utilizes genetic algorithm for obtaining the optimal solution. This particular codification is based on the fundamentals of popular graph theory.

V. USE OF TCSC & GENETIC ALGORITHM IN POWER SYSTEM STABILITY

Thyristor-Controlled Series Compensation (TCSC) is used in power systems to dynamically control the reactance of a transmission line in order to provide sufficient load compensation. The benefits of TCSC are seen in its ability to control the amount of compensation of a transmission line, and in its ability to operate in different modes. These traits are very desirable since loads are constantly changing and cannot always be predicted. TCSC designs operate in the same way as Fixed Series Compensation, but provide variable control of the reactance absorbed by the capacitor device. The basic structure of a TCSC can be seen below:

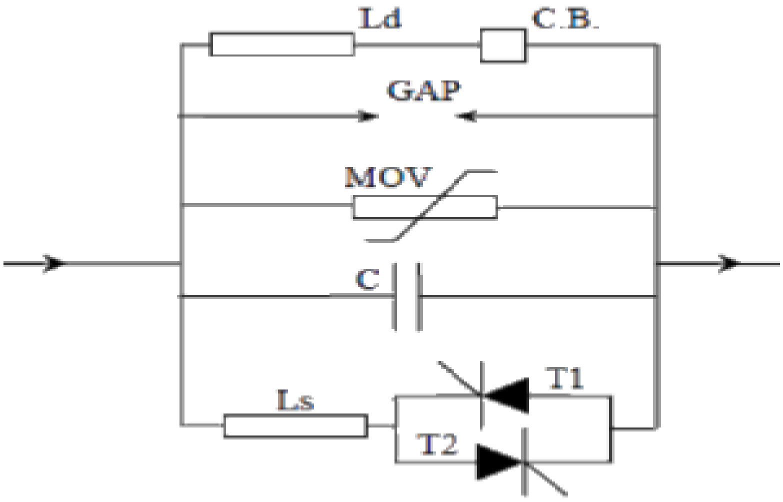

Fig.1 Basic Structure of TCSC

A thyristor-controlled series compensator is composed of a series capacitance which has a parallel branch including a thyristor-controlled reactor. TCSC operates in different modes depending on when the thyristors for the inductive branch are triggered. The modes of operation are as listed:

- Blocking mode: Thyristor valve is always off, opening inductive branch, and effectively causing the TCSC to operate as FSC
- Bypass mode: Thyristor valve is always on, causing TCSC to operate as capacitor and inductor in parallel, reducing current through TCSC
- Capacitive boost mode: Forward voltage thyristor valve is triggered slightly before capacitor voltage crosses zero to allow current to flow through inductive branch, adding to capacitive current. This effectively increases the observed capacitance of the TCSC without requiring a larger capacitor within the TCSC.

Because of TCSC allowing different operating modes depending on system requirements, TCSC is desired for several reasons. In addition to all of the benefits of FSC, TCSC allows for increased compensation simply by using a different mode of operation, as well as limitation of line current in the event of a fault. A benefit of using TCSC is the damping of sub synchronous resonance caused by torsional oscillations and inter-area oscillations. The ability to dampen these oscillations is due to the control system controlling the compensator. This results in the ability to transfer more power, and the possibility of connecting the power systems of several areas over long distances.

V. CONCLUSION

After studying all the above different methods for reactive power dispatch, power system stabilizer and network reconfiguration by using several traditional and heuristic techniques it has been made clear that the majority of the concurrent research progress in all the above mentioned fields is on the heuristic and optimization based algorithms. The algorithms based on traditional mesh and node analyses approach are not sufficient and

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also the availability of modern day simulation software has made these genetic algorithm based problem feasible for solving complex power system issues.

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