July 2016

REVIEW PAPER ON OPTIMAL LOCATION OF SHUNT FACTS DEVICES BY EVOLUTIONARY PROGRAMMING BASED ON OPTIMAL POWER FLOW IN POWER SYSTEM.

PRANALI H. DEKATE

Electrical Engineering Department, G.H.Raisoni College of Engineering, Nagpur , Maharashtra ,India,
pranali_dekate@yahoo.co.in

Follow this and additional works at: <https://www.interscience.in/ijcct>

Recommended Citation

DEKATE, PRANALI H. (2016) "REVIEW PAPER ON OPTIMAL LOCATION OF SHUNT FACTS DEVICES BY EVOLUTIONARY PROGRAMMING BASED ON OPTIMAL POWER FLOW IN POWER SYSTEM.," *International Journal of Computer and Communication Technology*. Vol. 7 : Iss. 3 , Article 10.

DOL: 10.47893/IJCCT.2016.1366

Available at: <https://www.interscience.in/ijcct/vol7/iss3/10>

This Article is brought to you for free and open access by the Interscience Journals at Interscience Research Network. It has been accepted for inclusion in International Journal of Computer and Communication Technology by an authorized editor of Interscience Research Network. For more information, please contact sritampatnaik@gmail.com.

REVIEW PAPER ON OPTIMAL LOCATION OF SHUNT FACTS DEVICES BY EVOLUTIONARY PROGRAMMING BASED ON OPTIMAL POWER FLOW IN POWER SYSTEM.

PRANALI H. DEKATE

Electrical Engineering Department, G.H.Raisoni College of Engineering, Nagpur , Maharashtra ,India
Email: pranali_dekate@yahoo.co.in

Abstract— The modern power system is operating closed to its voltage and thermal instability limits. The present transmission network was not originally planned for heavy power trading in the market. The time is to maximize the utilization of existing transmission lines and to manage the congestion. FACTS (Flexible AC transmission system) devices are having capability of improving power transmission, improving voltage profile, minimizing power losses, etc. This paper presents a review on how FACTS devices are used to provide the maximum relief to the congested line by computation techniques. The proposed paper uses sensitivity index to locate FACTS devices optimally. These computation techniques are used solve the OPF (Optimal Power Flow) problems on various IEEE buses.

Key words — Congestion, Evolutionary programming, FACTS, OPF.

I. INTRODUCTION

The restructuring of the electricity industry has made the problem of transmission congestion increasingly significant. It disturbs the smooth functioning of power competitive system and typically high costs are associated with it, which have to be ultimately borne by the consumers. With the increasing number of market participants, the number of desired transactions between the various companies is growing. Each transaction necessitates energy to be transferred from a sending point to a point of receipt. The sellers and buyers of energy rely on the transmission network for the transportation of their goods as sellers and buyers in other markets rely on transmission line networks. In the days before restructuring, the power grid used to be operated by vertically integrated utilities, who had control over both generation and transmission facilities. Since the unbundling of generation and transmission and the advent of more decentralized management, it has happened to be a challenge to coordinate and operate the system. The current transmission lines were not originally planned for trading in a competitive market. In addition, one of the key characteristics of the electricity market is that the energy, will not necessarily take the direct route from the sender to the receiver, but will travel across the transmission system according to the laws of physics. If market participants intend to undertake a high number of transactions to transport energy between various points in the network, the realization of all schedules might lead to violations of one or more limits of transmission system. This situation is called transmission congestion. Whenever this is the case, not all of the desired transactions can be realized. The market players value the transmission of energy differently and the fact of not being able to realize

certain transactions can have severe impacts and cause high additional costs.

In deregulated power systems, GENCO's, TRANSCO's and DISCOM's are different organizations and ISO (Independent System Operator) maintains the coordination between them. Figure 1 shows the structure of Deregulated power system.

Figure 1. Deregulated Power System Structure

ISO has a responsibility to relieve congestion to maintain system security and reliability.

The objective of using FACTS devices, introduced by N.G.Higorani [9] in the transmission system may be reduction of real/reactive power loss and provide maximum relief of congestion in system. Here, in this paper, where the objective is to provide maximum relief to the congested line, the optimal location of FACTS device is found out using computational techniques and OPF so that the power flows through

the designated path, the FACTS devices being costly affair.

II. COMPUTATIONAL TECHNIQUES

There are mainly three computational techniques such as-

- i. Genetic Algorithm (GA)
- ii. Particle Swarm Optimization (PSO)
- iii. Evolutionary Programming (EP)

Genetic Algorithm is generally based on mechanics of natural selection and genetics. They operate on string structure called as chromosome which is composed of genes. Genes are nothing but control parameters and chromosomes are digital strings of these control parameters. GA uses a population of points rather than a single point GA doesn't require any previous information. Particle Swarm Optimization is population based algorithm. It explores a population of individuals of promising regions. The population is called Swarm and individuals are called particles. As swarm iterates, the fitness of the global best solution improves. It is anticipated that all particles approaches global's best.

Evolutionary programming searches the optimal solution by evolving a population over number of generations or iterations. Evolution is carried out through mutation and competitive selection. The key steps are as follows:

- a. An initial parent's population is selected randomly.
- b. Each parent generates offspring by addition Gaussian random variable which results in increase in invitations in competing pool.
- c. Each individual in competing pool is evaluated for its fitness. All the individuals compete with each other. The individuals with minimum fitness are retained as parents for next generation. This process is iterated till there is appreciable improvement in the minimum fitness.

III. OPTIMAL LOCATION OF FACTS DEVICES

One pertinent solution issue of FACTS application was the selection of appropriate location. The benefits of the expensive FACTS controllers due to Proper location. Paper deals with the location of the series FACTS controllers. Especially to manage congestion in the deregulated electricity.

Static or dynamic performance of the system decides the location of FACTS controllers. The best placement of FACTS controllers is to improve the dynamic performance which requires the time domain and Eigen value analysis simulation with dynamic

modeling of FACTS Controllers. For improving static performance, sensitivity factor method is used.

IV. OPERATING PRINCIPAL OF STATCOM

A STATCOM consists of a coupling transformer, an inverter and a DC capacitor is shown in Figure 2.

Figure 2. Structure of STATCOM

Figure 3. Equivalent circuit of STATCOM

For such an arrangement, in ideal steady state analysis, it can be understood that the active power exchange between the AC system and the STATCOM can be neglected, and only the reactive power can be exchanged between them. STATCOM is generally used to control transmission voltage by reactive power shunt compensation. It is assumed that (a) Harmonics generated by STATCOM are neglected and (b) the system as well as the STATCOM is three phase balanced. Then the STATCOM can be equivalently represented by a controllable fundamental frequency positive sequence voltage source V_{sh} . The STATCOM output voltage is regulated in such way that the reactive power of the STATCOM is changed as per requirement.

V. METHODS FOR FINDING OPTIMAL LOCATION FOR STATCOM

STATCOM is placed in a transmission line which is over loaded. It is located optimally in a line such that the overall fuel cost of the system is least. The optimal location of STATCOM is done in two ways:

- a. Reduction of System's Real Power loss
- b. Performance Sensitivity indices
 - i) Voltage Performance index
 - ii) Reactive power loss performance sensitivity index

VI. EVOLUTIONARY PROGRAMMING BASED ALGORITHM OF OPF FOR CONGESTION MANAGEMENT

The solution shall be done using Evolutionary Programming using following steps:

1. The objective function to execute Optimal Power Flow (OPF) to minimize the total production cost subject to real and reactive power flow constraints are run without STATCOM.
2. The congestion in the lines is checked from step 1.
3. The congestion shall be relieved by locating STATCOM according parameter index calculations .i.e. Most positive reactive power loss sensitivity index and Voltage sensitivity index
4. Run OPF with STATCOM using Evolutionary programming.
5. Check whether the congestion is relieved.
6. If the congestion is relieved stop the iteration and print result. Else go to step 1.

VII. METHODOLOGY

1. First step is to design IEEE 14 bus system in MATLAB.
2. Run OPF with Evolutionary based Algorithm.
3. To design STATCOM in MATLAB as STATCOM is not readily available MATLAB.
4. Two performance indices shall be chosen. The first is the reactive power loss sensitivity index and voltage sensitivity index. Both these indices shall be run by using Optimal Power Flow (OPF) in MATLAB.

VIII. LITERATURE REVIEW

Various methods have been used to establish the optimal location and control of FACTS devices to enhance loadability in transmission system. M.Karthikeyan,et al [1] have employed STATCOM for control of voltage and the power flow in long distant transmission lines. PWM fire pulse control technique is used to find location of FACTS devices. P. Ramasubramanian ,et al[2] have proposed approach introduces performance index parameter to locate TCSC optimally for relieving the congestion. The proposed approach introduces performance sensitivity index parameter to locate TCSC optimally for relieving the congestion. In congestion management, the objective function is nonlinear. Hence an EP based approach is used to solve the Optimal Power Flow (OPF) problem. IEEE 14 bus system is considered to reveal the suitability of this algorithm and the results are appreciably good.

IEEE 14 BUS SYSTEM

Suppakarn Chansareewittaya ,et al[3] have proposed Particle Swarm Optimization (PSO) technique to determine the optimal allocation of multi type FACTS controllers to enhance power transfer capability of power transactions between source and sink areas in power systems. Three FACTS controllers including unified power flow controller (UPFC), thyristor-controlled series capacitor (TCSC), and static var compensator (SVC) are used in this study. The objective function is formulated like maximizing the benefit to cost ratio. The benefits denote increasing total transfer capability (TTC) with deducting system losses while the cost are the investment of FACTS controllers installation. Power transfer capacity determinations are calculated based on optimal power flow (OPF) technique. Test outcomes on the modified IEEE 30-bus system from PSO are compared with those from evolutionary programming (EP). In this study, it is seen that, FACTS devices improve the load ability in transmission network for pool model using DE with less computational time and faster convergence characteristics than PSO. On conclusion, Differential Evolution (DE) is more effective, easy to use, robust algorithm having less computational time and faster convergence characteristics for enhancement of load ability using FACTS devices in transmission system for pool model in deregulated electricity market. In paper by Sarika Varshney,et al[4] most severe single line outage contingencies are considered for finding optimal location and sizing of STATCOM in a power system. As a initial step, contingency ranking is executed to determine the most severe line outages by evaluating voltage performance index (VPI). Afterward Particle Swarm Optimization-Time Varying Acceleration Coefficients (PSO- TVAC) algorithm is used to find the location and size of STATCOM. The proposed methodology is demonstrated on standard IEEE 30-bus system.

IEEE 30 BUS SYSTEM

Chandrakar, V.K. [5] was examined the optimal location of shunt FACTS devices in transmission line for highest possible benefit under normal condition. They considered three different line models 1) line impedance model 2) reactance model and 3) π -model. Shankaralingappa, C.B. [6] had achieved the optimum required rating of shunt and series flexible ac transmission systems controllers for EHVAC long transmission lines using computing 'optimum compensation requirement' (OCR) for different loading conditions. Shakib, D. [7] is used to determine the area on which the FACTS device has significant influence, for the detection of sensor nodes. Then only this limited area was included in the Optimal Power Flow control. K. R. Padiyar [8] had been considered a shunt active compensation and series passive compensation provided by STATCOM connected at the electrical center of the transmission line to minimize the effects of SSR.

IX. CONCLUSION

Reviewing the references, optimal location and control of FACTS devices using various methods, studies are done for enhancing the transmission system loadability, minimizing the cost of installation or both and there are fewer studies regarding the computational effort and convergence characteristics of system loadability enhancement using above methods. Computational effort increases when there is increase in the size of the optimization problem. Hence a method producing good quality solution with less computational effort and stable convergence is

required. In this work, loadability enhancement with optimal location and control of FACTS devices using DE and PSO algorithms are performed for pool model in deregulated electricity market. In [3] PSO are compared with those from evolutionary programming (EP). In this study, it is found that, FACTS devices enhance the loadability in transmission system for pool model using Differential Evolution (DE) with less computational time and faster convergence characteristics than PSO. On conclusion, DE is more easy to use, effective, robust algorithm having less computational time and faster convergence characteristics for enhancement of loadability using FACTS devices in transmission system for pool model in deregulated electricity market.

REFERENCE

- [1]. M.Karthikeyan, Dr.P.Ajay-D-Vimalraj, "Optimal Location of Shunt Facts Devices for Power Flow Control", 2011 International Conference on ICETECT, pp.154-159, March 2011.
- [2]. P. Ramasubramanian, G. Uma Prasanaand K. Sumathi, "Optimal Location of FACTS Devices by Evolutionary Programming Based OPF in Deregulated Power Systems," British Journal of Mathematics & Computer Science, 2012, Vol.2 (1), pp.21-30.
- [3]. Suppakarn Chansareewittaya & Peerapol Jirapong, "Power transfer capability enhancement with optimal maximum number of FACTS controllers using Evolution Programming," IEEE Transactions 2011, pp.4733-4738.
- [4]. Sarika Varshney & Laxmi Shrivastva, "Optimal location & sizing of STATCOM for voltage security enhancement using Particle Swarm Optimization," 2011 Power System (ICPS), International Conference, 2011, pp.1-6.
- [5]. Chandrakar, V.K. Kothari, A.G., "Optimal location for line compensation by Shunt connected FACTS controller", The 5th International IEEE Conference on Power electronics and Drive system, vol.1, pp.151-156, November 2003.
- [6]. Shankaralingappa, C.B. Jangamashetti, S.H., "FACTS Controller to improve voltage profile and enhancement of line loadability in EHV long transmission lines", International IEEE conference on Powercon, pp.1-5, October 2008
- [7]. Shakib, A.D.Balzer, G. "Optimal location and control of shunt FACTS for transmission of renewable energy in large power systems", 15th IEEE Mediterranean Electrotechnical Conference, MELECON 2010, pp.890-895, Apr 2010.
- [8]. K.R. Padiyar N. Prabhu "Design and performance evaluation of subsynchronous damping controller with STATCOM", IEEE Transactions on Power Delivery, Vol.21 (3), pp 1398-1405, July 2006.
- [9]. Narain G. Hingorani & Laszlo Gyugyi, "Understanding FACTS".