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The Survey on FACTS Devices Optimization Techniques for Enhancement in Voltage Stability Margin

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ABSTRACT— Nowadays, with the increase in demand for electricity, the production of electricity increases, which leads to an increase in the transmission of energy. This gives rise to various problems such as voltage stability problems and redundancy problems. This leads to an energy management problem. This can be effectively controlled using the FACTS controller. Due to their cost, in (EPS) FACTS device allocation is a combinatorial optimization where the location and size of equipment must be determined to achieve maximum savings in the power system. This article attempts to provide a literature review of optimization techniques used to find the optimal allocation of FACTS devices using load traffic and analysis as well as redundancy problems. . Review published data to date for various FACTS devices such as Static VAR Compensator (SVC), Thyristor Controlled Phase Shifter (TCPST), Thyristor Controlled Series Compensator (TCSC), Unified Current Controller (UPFC) functions in detail. The purpose of this review is to provide an overview of the various optimization techniques that are relevant to each FACTS device and the performance improvements that have been developed over the past two years. Various optimization techniques, hybrid metadata and optimal power factor (OPF) optimization will be discussed in detail. This article aims to discuss the general method of optimization technique for the assignment of FACTS devices to improve the voltage stability margin.

Keywords— FACTS devices; TCSC; STATCOM; UPFC;Optimal FACTS Placement

I. INTRODUCTION

The increase in demand for electricity as well as the decrease in power transmission capacity in the grid can be explained by destability in the deregulated system by explaining several factors. Electrical safety is a fundamental factor to consider in electrical design and processes. There are more than one reasons for voltage instability which may include voltage collapse, power contingency and although natural disasters are the reasons, most of the times manmade mistakes truly lead to the system failure. For monitoring the power management and overcome the crisis at the time of need it is necessary to prevent the catastrophe from happening. The need for additional electricity in all power systems is very important as electricity consumption is increasing year by year and power production has to regulate fuel consumption. The maximum value that the busbar can transmit depends on the reactive power it receives from the system. When the system reaches full load, the operation and response losses become very high. In this case, the system can be stabilized by reducing the reactive power load or by introducing a reactive power source (such as a capacitor or FACTS device) into the correct situation before the system voltage collapse point is reached.

Electricity production now rises in response to the rising demand for electricity, which also increases energy transmission. This leads to a number of issues, including redundancy and voltage stability issues. An issue with energy management results from this. The FACTS controller can be used to properly control this. The placement and size of equipment must be chosen carefully in order to maximize power system savings in (EPS) FACTS device allocation because of their cost. This article seeks to provide a review of the literature on optimization strategies for locating FACTS devices using load traffic, analysis, and redundancy issues. Review published information for several FACTS devices.

The use of FACTS devices has the lead of reducing reactive power from the mains to the load, reducing current harmonics, reducing busbar voltage drops and swelling, and reducing all active energy losses. There is always a problem with a faulty FACTS device. Due to the high price of this equipment, precise placement is crucial for proper operation. The advantage of including a FACTS device is that it will increase the actual power delivered without the need to add to the generator. FACTS devices not included in other expansions can improve safety by adding electrical controls and reduce accidents through power management. The important thing about the FACTS device is that it does not force the electrical and electronic control system in any way. This article focuses on the best placement of the FACTS device in transmission. Objectives for optimal placement of the FACTS device:

1. Reduce cost and power loss in special line.
2. Better use of existing network
3. Delay or eliminate congestion problems
4. Current control
5. Increase the load capacity of the system but with a limit
6. Increase the margin of safety within the stress limit.
7. Reduce reactive power loss.
8. Congestion management in the system
9. It is necessary to strengthen the power transmission capacity.

II. LITERATURE REVIEW ON FACTS DEVICES

FACTS controller are one of the important part of EPS in regards to maintain voltage stabily, reducing total losses, increase in loadability margin and maintain power system transfer capability. Although FACTS devices are expensive, decrease in even 0.5% stability margin can be detrimental to the system. Thus for continuous power flow along with financial contraints these are the different parameters for optimal allocation of FACTS devices:

1. Location of device
2. We can use types, different type of FACTS or only one type in the body.
3. Financial issues, regulations, etc.

In general, electrical power can be measured by the frame load capacity and/or the body loss if the node voltage magnitudes remain within the applied limits and the thermal constraints of the system components are not violated. According to [3], such problems can be solved using heuristics algorithms such as genetic algorithm (GA) [4, 5].

A. Modeling of FACTS Devices

1. A TCSC can have one of two types of products, capacitive or inductive depending on the decrease or increase in total reactance. of the transmission line. It is modeled with three ideal switching elements connected in parallel:
a capacitor, an inductor and a simple short switch when not needed in the circuit. Capacitors and inductors are different and their value depends on the reactance and power transmission capacity of the lines connected to the device. To avoid noise, only one of the three items can be changed at a time. In addition, the maximum capacity value is set to -0.8XL to avoid overcompensation of the line. For inductors, the maximum is 0.2XL.
2. TCPST works by adding a quarter current to the busbar to increase or decrease its angle. Model series used for this
This device is an ideal zero impedance phase shifter. The needle is inserted into it and can make an angle from -5 degrees to +5 degrees. Zero is also useful for TCPST.
3. TCVR works by adding a non-inverting voltage to the vehicle's mains voltage to change its amplitude.
As a model for this controller, the authors of [3] used an ideal stepping-shift transformer with no series impedance. The value of this ratio is given by the ratio v1/v2. It determines the variability beyond the nominal variability and its value varies from 0.9 to 1.1.

4. SVC can have two functions:
It can take the injection value or absorb 1 p.u energy. power. These values range from -100 MVAr to 100 MVAr. Depending on inductive or capacitive claim. In the first case it absorbs reactive power and in the second case it transmits reactive power. The SVC model is represented by two well-connected transformers:

A capacitor and an inductor. Only one FACTS controller is allowed per line. TCSC, TCPST and TCVR tools are used directly in the design process. They are placed in series with the resistance and reactance of the line. With SVC, the line is divided into two equal parts and the equipment is placed in the middle. In TCSC [6], the difference along the compensated line is modeled as reactance, while the SVC is modeled as an additional field on the line. UPSC is modeled as a combination of SVC on a bus and TCSC on lines connected to the same bus. In [7], TCSC can have one of two performance:
capacitance or inductance instead of decreasing or increasing the total reactance of the transmission line respectively. The TCSC's capacitance or inductance value is expressed in X. TCPST adjusts its angle by adding an orthogonal device to the existing bus. This device is modeled as an ideal transformer with zero series impedance. It is placed on the transmission line and can take the value of angle θP. TCVR works by increasing the voltage level. The controller is modeled using an ideal tapping transformer with no series impedance. The price report is displayed on the TV. SVC is also available in two types:

Inductance or capacitance. In the first case, it absorbs energy passively and in the second case it

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transfers energy passively. The amount of reaction energy introduced or absorbed is expressed in Qs.

The problem is to increase the load capacity of the system. The choice is therefore between a "series" device [46] such as the TCSC and a "parallel series" device [46] such as the UPFC. The best home tool to solve this problem is TCSC [3]. However, UPFC achieves lower capacity than TCSC at the price [6] so TCSC is an economically sound choice and will be used in this paper. The TCSC consist of inductor in series with TRIAC shunted by capacitve reactance as well as series reactance. The TCSC model is shown Fig. 1.

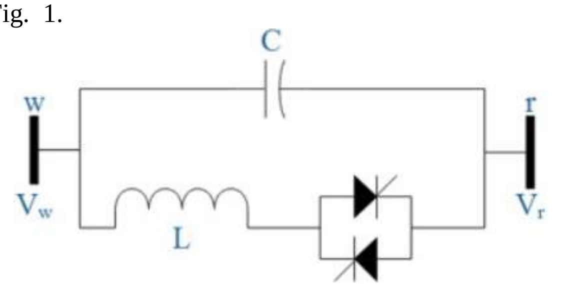

Fig. 1 TCSC schematic diagram.

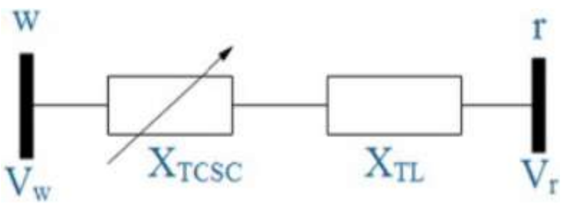

Fig. 2 TCSC equivalent circuit

III. BRIEF SURVEY OF OPTIMIZATION TECHNIQUES

Optimization methods can be divided into classical methods and cognitive methods. The traditional method has the following disadvantages:

1. In general, mathematical design must be easy to solve, because its ability to solve large force problems on earth is limited.
2. They do not tolerate negative constraints. 3. A wrong combination will fall in the right place.
4. They can only find one correct solution in a simulation.
5. If the number of changes is large, they happen very slowly and involve spending a lot of money to solve big problems. The main advantage of

The peculiarity of AI methods is that they are capable of resolving various quality constraints such as thermal and stability limitations. By running a single simulation, AI methods always yield rather better solutions than their counterpart, i.e. classical methods. Therefore, they are very suitable for solving multi-objective optimization problems. Often they can find the best solution in relatively less time and more efficiently. The following sections give a brief overview and explanation of the optimization techniques used in the EPS applications presented in [13].

A. Linear programming method

It requires linearization of the objective function and limits to non-zero values.[14] provide a method to restore operation to reduce line losses and have a good view of the electrical equipment in the generator. Find the number of conversion levels, network settings, and settings that maximize system performance.

B. Quadratic Planning (QP) Methodology

[21] proposed the Ultimate Security Optimization Framework (SCOPF) to determine the optimal placement and performance of UPFCs and TCPARs.

Karmarkar in 1984 proposed a new method that can very well solve large-scale linear programming problems. This is called the inside method because it sees the progression of a search as close as possible.

Sergio Granville [27] reported the application of an inward approach to detecting reactive power failures. Lin Hui et al. [28] proposed to use the predictive corrected internal point nonlinear programming algorithm (PCIPNLP) to solve the problem of welfare maximization by the FACTS device in a parity economic model.

E. Artificial Intelligence (AI) Method

AI methods are better than traditional optimization methods:

1. Artificial intelligence, continuity, presence of objects, etc. It is not limited to other traditional methods such as

b. Smart tools use changing rules rather than decisions.

1. The Artificial Neural Network (ANN) method is a collection of artificial neurons that are connected together using a number or a computational pattern as a combination of calculations for processing. Chowdhury [25] proposed the concept of Optimal Scheduling with Integrated Safety Constraints (ISCOD), which can solve the OPF problem when subjected to both static and non-safety related conditions. . ISCOD harnesses the diagnostic and decision-making capabilities of Knowledge Base Systems (KBS) as well as the learning capabilities of ANNs and traditional energy engineering techniques to provide healthcare and management capabilities. health in real time. KBS and ANN are used in many setups to add command or control programming. Santoso et al. [31] proposed a two-level electronic neural network for real-time control of multistage capacitors installed in power transmission system to achieve continuous power reduction when the system is off.

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2. Fuzzy logic (FL) method derives from fuzzy set theory, which involves more predictable thinking facts in classical predicate logic.V.C. Ramesh et al. [32] proposed a fuzzy logic approach to the OPF probability problem, formulated in a factored form that allows rearrangement of subsequent Probability. P. Padhy [33] proposes a well-matched model to analyze active and reactive energy exchange congestion control in the ambiguous environment of power system deregulation.
3. There have been many speculation regarding which algorithm should be used and hence to further reduce the complexity for simple genetic algorithm has proved to be cost effective and very easy to develop. Although there are many advantages such as the algorithm is simple and easy to use as well as cost efficient but the disadvantages has prove to be more dangerous and contains high risk factors for large power system as well as complex and meticulous branch network in the transmission line. There has to be constraints and limits on the stress limits of the sypower syste [37] proposed the use of genetic algorithms to improve the selection and classification of FACTS devices in highly dynamic systems. The aim is to provide financing and distribution of electricity in the illicit electricity market.
4. The method is based on the idea that ants find their way by transmitting pheromones while feeding. [38] proposed a new collaborative approach based on to solve the problem of short-term thermal energy systems. \ based on a combination of ant colony optimization and randomization mechanism, and this algorithm is designed to solve the observed combination by determining the spin. To solve the problem of choosing the right power and redundancy distribution to ensure the reliability of parallel systems in terms of performance and cost constraints.
5. Particle Swarm Optimization (PSO) method is based on the idea of behavior of living organisms such as herds of animals and fish. [41 method for dynamic financial transfers.
To solve the problem of driving traffic. JG Frachogiannis et al. [44] formulated the generator contribution to the current in the transmission line as a problem and calculated it using the). M. Saravanan et al.[6] recommend using PSO to find the best location, configuration, type and number of FACTS devices to reduce installation costs and increase physical capacity.

It can be seen that, in most of the previous studies, the number of FACTS devices was used instead of the number of FACTS devices in the optimization problem. When using equipment, different types of FACTS can be used to increase efficiency. It was decided that another strategy should be considered for material incorporation in order to further optimize the process.
Line thermal limits and busbar voltage limits are used as limits to find the best position. A summary of the above discussions is presented in the table below

Objective function to be optimized	Suitable method(s)	Reason to use that method
Economic dispatch	LP, NR	Fast methods
Economic dispatch with non-smooth cost function	AI	Non-linear problem
Economic – Emission dispatch	Fuzzy	Suitable for conflicting objectives
Reactive power optimization	NLP, QP,IP,AI	Accurate methods
Optimal location of FACTS device	AI	Multiobjective nonlinear problem
Social welfare	QP, AI	....
Congestion management	AI	....
Security constrained	NLP, IP	Stable convergence

Table 1 Different optimization techniques

The problem is to find the correct number, location and reactance of TCSCs used in the power system. The problem is a nonlinear multi-objective problem. So artificial intelligence (AI) will be used. Produce efficient solutions with short computation time and stable convergence power. Both genetic algorithm and particle swarm optimization are suitable and effective for the optimization of the current problem.

The main differences are mentioned below:

1. PSO and GA have many similarities. Both algorithms start with a set of generators from humans.
2. Both are trying to measure the population.
Both change the population and use stochastic methods to search for the best. It cannot guarantee success.
3. PSO shares information very differently from GA: By sharing the information using communication genetic algorithm is donen and PSO only gbest (or Pbest) provides information to others. This is a data sharing mechanism.
4. Evolution only finds the best solution. Unlike the genetic algorithm, most of the time, even in the local version, all particles converge to the optimal solution quickly.
5. In terms of connectivity, PSO is faster than GA at the initial stage of optimization. However, it was found that the performance of GA was better than PSO as the number of generations increased. The recommended approach has been displayed in the flowchart shown in Figure 3.1, the selection process uses two genetic algorithms, power limit zero and no other value in MATLAB. The first is to find the location and number of TCSC devices by calculating the smallest possible loss after implanting the TCSCs into the system. Once the position and number of TCSCs were obtained, they were inserted into another genetic algorithm to calculate all the losses and get good results.

1. The process starts with the random population of the binary position and multiplies the random population by a TCSC value at a distance, which changes the reactance of the system.
2. The system was then electrically tested, TCSC passed the entire range.
3. Then calculate the total loss and calculate the activation energy.
4. Constraints are not finally evaluated, if not met, the next generation begins with reproduction, competition and change.

A. First method

From first method, as mentioned[51] above that the without considering the limitation of the material, objective function is to minimize the total loss that is, it should minimize the objective function:

Total system loss = Sum of Actual loss of all equipment System Line = Sum of Actual Lines (S_f + S_t) (3rd method). Where S_f and S_t are the complex powers of the "from" and "target" terminals, respectively.

B. The Second Method

It is the same as the first method, but should reduce the target function considering the equipment: (whole system is turned off after TCSC is used) / (total system failure before TCSC is requested) + (Number of TCSC devices / connection to TCSC)
= [Sum of real numbers with TCSC (S_f + S_t)/Sum of real numbers without TCSC (S_f + S_t)] + [No. current equipment/location]

Total losses are calculated using MATLAB m-file MATPOWER [47] for calculating the load flow of the system and calculate the number of actual losses.

As mentioned earlier, the goal is to make the right choice of location, number and measurement of TCSCs to increase their ability to not violate voltage and current limits. It is done in two ways:
1) First is to use minimum loss as objective function
2) Second is to use minimum loss from equipment as intended work.

C. Steps for Flowchart

Step 1: Initially start with the modelling of the bus system
Step 2: After properly modelling make the data noted down of various buses and branches
Step 3: Perform the load flow analysis using FDLF or NR method analytically as well as perform simulation in MATLAB SIMULINK.
Step 4: Obtain the data after performing contingency analysis
Step 5: Find the weakest bus using bus data obtained after load flow analysis
Step 6: Now for performing optimization technique using genetic algorithm, increase the number of location of FACTS devices to be used.
Step 7: Obtain random values of TCSC for a specific range and make sure to note it down
Step 8: Now add the extra reactance into the old reactance without using TCSC
Step 9: Now solve the fitness function which the objective function
Step 10: If the criteria is reached then continue otherwise go back to step 8 again
Step 11: After reaching the criteria print the most suitable location for placement of TCSC
Step 12: Now intialitize the population in GA
Step 13: againg perform the fitness function using various parameters for the result

Step 14: If the result is satisfied then move forward otherwise perdform the step 12 again
Step 15: If the criteria is reached then make the way forward
And print the weakest bus and most optimal location for TCSC to be used after different equality constraints.
.After following these ,there has to be some limits to how much the fitness function cambe optimized and hence after repeating the process many times the result may not satisfactorily improve within the expectations.

D. AC formulation of the sytem

Real power P in MW (expended) and Reactive power Q in MVAr (injected) at nominal voltage of 1 p.u. at angle zero and the static loads are modelled as real power P and reactive power Q injection, i.e. P_r and Q_r respectively. The shunt admittance of any constant shunt elements at bus is specified[51].

$$Y_{sh} = \frac{G_{sh} + B_{sh}}{base\ MVA}$$

Having series resistance R including inductive reactance X_l and total shunt capacitance X_c in series with an ideal transformer, the branch whether transmission line or transformer or phase shifter are to be modelled as π-model XL line at the from end, with transformer tap ratio Tau and alternator phase shift angle $\theta_{shift.}$ and also the differernt branch voltages and currents of 'from' and 'to' ends of the branch are inter-linked by the branch admittance matrix Y_{branch} as follows:

$$\begin{bmatrix} I_f \\ I_t \end{bmatrix} = Y_{br} \begin{bmatrix} V_f \\ V_t \end{bmatrix} \quad (2)$$

$$Y_{br} = \begin{bmatrix} (Y_s + j\frac{B_c}{2})\tau^2 & -Y_s \frac{1}{\tau e^{j\theta} shift} \\ -Y_s \frac{1}{\tau e^{-j\theta} shift} & (Y_s + j\frac{B_c}{2}) \end{bmatrix} \quad (3)$$

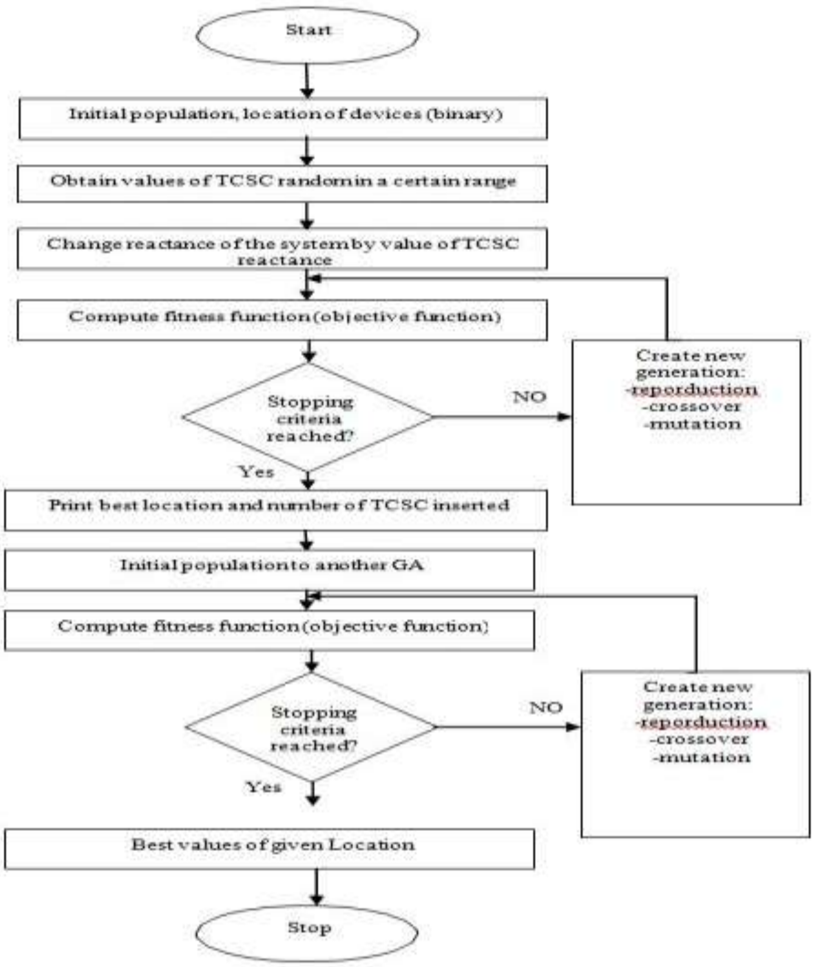

Fig 3 The Proposed Optimization Algorithm (1)

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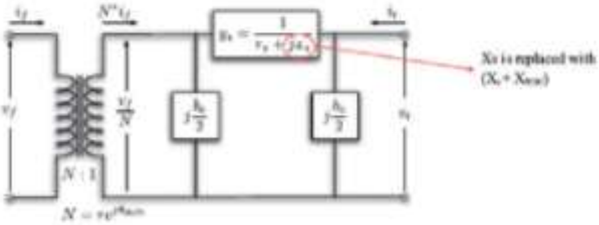

Fig 3 Branch model

Having formed the branch network of n x 1 matrices and after performing the AC system modelling .n_b x n_b matrice that relates the complexity of nodal ccurrentl injections I_{bus} to complexity of nodal voltages V_{bus}.

$I_{bus} = Y_{bus}V_{bus}$ (4)

Associated to bus voltages of n_1 x 1 vectors I_f and I_t of branch currents at the 'from' and 'to' ends respectively.Correspondingly for network with n_1 branches, the n_1 x n_b system branch admittance matrices Y_f and Y.

$I_f = Y_fV_{bus}$ (5)

$I_t = Y_tV_{bus}$ (6)

$S_{bus} = diag(V_{bus})I_{bus}^*$ (7)

$S_f = diag(V_f)I_f^*$ (8)

$S_t = diag(V_t)I_t^*$ (9)

Total active loss = sum of real of ($S_f + S_t$)

Where the total vectors representing currents and voltages can be expressed as shown in equation

IV. CONCLUSIONS

In this research, an optimization technique is presented to obtain the number, location and reactance of TCSC in power system by GA for increasing the system loadability. The first technique use minimization of total loss as objective function. The second technique use minimization of total loss with taking into consideration the minimization of number of devices. In the future,

1. Taking into consideration directly cost of FACTS and generation cost.
2. Using the FACTS with system in transient state.
3. Using PSO instead of GA.
4. Using UPFC instead of TCSC.
5. Using the proposed technique with larger systems.

Finally, proper selection of FACTS devices and their locations can effectively improve the overall system performance.

REFERENCES

[1] Xiao-Ping Zhang, Christian Rehtanz, Bikash Pal, "Flexible AC Transmission Systems: Modeling and Control", Springer, 2006, pp 1, 2, 15-18, 22.

[2] S. Meikandasivam, Rajesh Kumar Nema, Shailendra Kumar Jain , "Behavioral Study of TCSC Device – A Matlab/Simulink Implementation", World Academy of Science, Engineering and Technology 45, 2008.

[3] Stéphane Gerbex, Rachid Cherkaoui, and Alain J. Germond, "Optimal Location of Multi-Type FACTS Devices in a Power System by Means of Genetic Algorithms", IEEE Transactions on Power Systems, Vol. 16, No. 3, Aug. 2001.

[4] S. M. Sait and H. Youssef, "Iterative Computer Algorithms with Application in Engineering: Solving Combinatorial Optimization Problems", IEEE Computer Society, 1999.

[5] D. E. Goldberg, "Genetic Algorithms in Search Optimization and Machine Learning, Addison-Wesley Publishing Company", Inc., 1989.

[6] M. Saravanan, S.M.R Slochanal, P. Venkatesh, J. P. S. Abraham, "Application of Particle Swarm Optimization Technique for Optimal Location of FACTS Devices Considering Cost of Installation and System Loadability", Electric Power Systems Research, Vol. 77, No. 3/4, 2007 , pp. 276-283.

[7] Z. Lu., M. S. Li, L. Jiang, Q.H. Wu, "Optimal Allocation of FACTS Devices with Multiple Objectives Achieved by Bacterial Swarming Algorithm" , IEEE Power and Energy Society 2008 General Meeting: Conversion and Delivery of Electrical Energy in The 21st Century, PES , Art. No. 4596320, 2008.

[8] R. Narmatha Banu and D. Devaraj, "Genetic Algorithm Approach for Optimal Power Flow with FACTS Devices", 4th International IEEE Conference "Intelligent Systems", 2008.

[9] W. Feng, G. B. Shrestha, "Allocation of TCSC Devices to Optimize Total Transmission Capacity in a Competitive Power Market", Proceedings of The IEEE Power Engineering Society Transmission and Distribution

Conference (Winter Meeting), 2001, pp. 587-593.

[10] G. I. Rashed, H.I. Shaheen, S. J. Cheng, "Optimal Location and Parameter Setting of TCSC by Both Genetic Algorithm and Particle Swarm Optimization" , Iciea 2007, Second IEEE Conference on Industrial Electronics and Applications , Art. No. 4318586, 2007, pp. 1141-1147.

[11] S. A. Taher, H. Besharat, "Transmission Congestion Management by Determining Optimal Location of FACTS Devices in Deregulated Power Systems" ,American Journal of Applied Sciences, Vol. 5, No. 3, 2008, pp. 242-247.

[12] G. Y. Yang, G. Hovland, R. Majumder, Z. Y. Dong, "TCSC Allocation Based on Line Flow Based Equations Via Mixed-Integer Programming" , IEEE Transactions on Power Systems ,Vol. 22, No.4, 2007 , pp. 2262-2269.

[13] K. S. Pandya, S. K. Joshi, "A Survey of Optimal Power Flow Methods", Journal of

[14] Theoretical and Applied Information Technology, Vol. 1, No. 4, 2008, pp 450-458.

[15] T. S. Chung, And Ge Shaoyun, "A Recursive LP-Based Approach for Optimal Capacitor Allocation with Cost-Benefit Consideration", Electric Power System Research, Vol. 39, 1997, pp. 129-136.

[16] E. Lobato, L. Rouco, M. I. Navarrete, R. Casanova And G. Lopez, "An LP-Based Optimal Power Flow For Transmission Losses And Generator Reactive Margins Minimization", in Proc. of IEEE Porto Power Technology Conference, Portugal, Sept. 2001.

[17] F. G. M. Lima, F. D. Galiana, I. Kockar, And J. Munoz, "Phase Shifter Placement in Largescale Systems Via Mixed Integer Linear Programming", IEEE Transaction Power System, Vol. 18, No. 3, Aug. 2003 , pp. 1029-1034.

[18] J. A. Momoh, "A_Generalized_Quadratic-Based Model for Optimal Power Flow",

[19] IEEE Conference on Systems, Man and Cybernetics, 1989, pp. 261-267.

[20] N. Grudinin, "Reactive Power Optimization Using Successive Quadratic Programming Method", IEEE Transaction Power System, Vol. 13, No. 4, Nov. 1998, pp. 1219-1225.

[21] G. P. Granelli, And M., Montagna, "Security Constrained Economic Dispatch Using Dual Quadratic Programming", Electric Power System Research, Vol 56, 2000, pp. 71-80.

[22] X. Lin, A. K. David, and C. W. Yu, "Reactive Power Optimization with Voltage Stability Consideration in Power Market Systems", IEE Proc.-General Transmission Distribution., Vol. 150, No. 3, May 2003 , pp. 305-310.

[23] A. Berizzi, M. Delfanti, P. Marannino, M. S. Pasquadibisceglie, and A. Silvestri, "Enhanced Security-Constrained OPF with FACTS Devices", IEEE Transaction Power System, Vol. 20, No. 3, Aug. 2005, pp. 1597-1605.

[24] J. A. Momoh, and J. Zhu, "Multi-Area Power Systems Economic Dispatch Using Nonlinear Convex Network Flow Programming", Electric Power System Research, Vol. 59, 2001, pp. 13-20.

[25] D. Pudjianto, S. Ahmed And G. Strbac, "Allocation Of Var Support Using LP And NLP Based Optimal Power Flows", IEE Proc.-General Transmission Distribution, Vol. 149, No. 4, July 2002 , pp.377-383.

[26] G. L. Torres and V. H. Quintana, "A Jacobian Smoothing Nonlinear Complementarity Method for Solving Nonlinear Optimal Power Flows", in Proc. of 14th PSCC, Sevilla, Session 41, Paper 1, June 2002, pp.1-7.

[27] H. Badrul, Chowdhury, "Towards The Concept of Integrated Security: Optimal Dispatch Under Static and Dynamic Security Constraints", Electric Power System Research, Vol.25, 1992, pp. 213-225.

[28] A. K. Sharma, "Optimal Number and Location of TCSC and Loadability Enhancement in Deregulated Electricity Markets Using MINLP", International Journal Of Emerging Electric Power System, Vol. 5, Issue. 1, 2006, pp. 1-13.

[29] S. Granville, "Optimal Reactive Dispatch through Interior Point Methods", IEEE Transaction Power System, Vol. 9, No. 1, Feb. 1994, pp. 136-146.

[30] Whei-Min Lin, S-J. Chen And Y. Su, "An Application of Interior Point Based OPF for System Expansion with FACTS Devices in a Deregulated Environment", The Fourth IEEE -PES/CSEE International Conference on Power System Technology (PowerCon 2000), Dec. 2000, pp. 1407-1412.

[31] D. Xiaoying, W. Xifan, S. Yonghua and G. Jian, "The Interior Point Branch and Cut Method for Optimal Power Flow", IEEE International Conference on Power System Technology (PowerCon 2002), Vol. 1, 2002, pp. 651-655.

[32] Narayana Prasad Padhy, "Congestion Management under Deregulated Fuzzy Environment", IEEE International Conference on Electric Utility Deregulation, Restructuring and Power Technologies (Drpt2004), Hong Kong, April 2004, pp.133- 139.

[33] C. Walters David and B. Sheble Gerald, "Genetic Algorithm Solution of Economic Dispatch With Valve Point Loading", IEEE/PES 1992 Summer Meeting.

[34] P. H. Chen and H. C. Chang, "Large Scale Economic Dispatch by Genetic Algorithm", IEEE Transactions on Power System, Vol. 10, No. 4, Nov. 1995, pp. 1919-1926.

[35] T. S. Chung and Y. Z. Li, "A Hybrid GA Approach for OPF with Consideration of FACTS Devices", IEEE Power Engineering Review, Feb. 2001, pp. 47-50,

[36] L. J. Cai, I. Erlich And G. Stamtsis, "Optimal Choice and Allocation of FACTS Devices in Deregulated Electricity Market Using Genetic Algorithms", in Proceeding IEEE PES General Meeting, 2004, pp. 201-207.

[37] I. K. Yu and Y. H. Song, "A Novel Short-Term Generation Scheduling Technique of Thermal Units Using Ant Colony Search Algorithms", Electrical Power and Energy System, Vol. 23, pp. 471-479, 2001.

[38] Libao Shi, Jin Hao, Jiaqi Zhou and Guoyu Xu, "Ant Colony Optimization Algorithm with Random Perturbation Behavior to the Problem of Optimal Unit Commitment with Probabilistic Spinning Reserve Determination", Electric Power Syst. Research, Vol. 69, 2004, pp. 295-303.

[39] R. Meziane, Y. Massim, A. Zeblah, A. Ghoraf and R. Rahli, "Reliability Optimization Using Ant Colony Algorithm Under Performance and Cost Constraints", Electric Power System Research, Vol. 76, 2005 , pp. 1-8.

[40] H. Yoshida, K. Kawata, Y. Fukuyama Et Al. "A Particle Swarm Optimization for Reactive Power and Voltage Control Considering Voltage Security Assessment", IEEE Transactions on Power Systems, Vol. 15, No. 4, Nov. 2000, pp. 1232-1239.

[41] J. B. Park, Ki. S. Lee, J. R. Shi and K. Y. Lee, "A Particle Swarm Optimization for Economic Dispatch with Nonsmooth Cost Functions", IEEE Transactions on Power Systems, Vol. 20, No. 1, Feb. 2005, pp. 34-42.

[42] Cui-Ru Wang, He-Jin Yuan, Zhi-Qiang Huang, Jiang-Wei Zhang and Chen-Jun Sun, "A Modified Particle Swarm Optimization Algorithm and Its Application in Optimal Power Flow Problem", in 4th International Conference on Machine Learning and Cybernetics, Guangzhou, Aug. 2005, pp.2885-2889.

[43] J. G. Vlachogiannis and K. Y. Lee, "Determining Generator Contributions to Transmission System Using Parallel Vector Evaluated Particle Swarm Optimization", IEEE Transaction Power System, Vol. 20, No. 4, Nov. 2005, pp.1765-1774.\

[44] G.I. Rashed, H.I. Shaheen, X.Z. Duan, S.J. Cheng, "Evolutionary Optimization Techniques for Optimal Location And Parameter Setting of TCSC Under Single Line Contingency" , Applied Mathematics and Computation ,Vol. 205, No. 1, 2008 , pp. 133- 147.

[45] J. Gotham Douglas, G. T. Heydt, "Power Flow Control and Power Flow Studies for Systems with FACTS Devices", IEEE Transactions on Power Systems, Vol. 13, No. 1, Feb.1998.

[46] Ray D. Zimmerman, E. Carlos Murillo-Sánchez, "MATPOWER A MATLAB™ Power System Simulation Package Version 3.2", User's Manual, September 21, 2007. Http://WWW.Pserc.Cornell.Edu/Matpower/

[47] Ray D. Zimmerman, E. Carlos Murillo-Sánchez, "MATPOWER A MATLAB™ Power System Simulation Package Version 4.0b4", User's Manual, May 21, 2010.

[48] Http://WWW.Pserc.Cornell.Edu/Matpower/

[49] W. F. Tinney and C. E. Hart, "Power Flow Solution by Newton's Method", IEEE Transactions on Power Apparatus and Systems, Vol. Pas-86, No. 11, Nov. 1967, pp. 1449- 1460.

[50] V. P. Rajderkar, V. K. Chandrakar "Optimal Location of Thyristor Controlled Series Compensator (TCSC) for Congestion Management ", IE(I) Journal–EL, Volume 90, December 2009.

[51] G.I. Rashed, H.I. Shaheen, X.Z. Duan, S.J. Cheng,Evolutionary optimization techniques for optimal location and parameter setting of TCSC under single line contingency,Applied Mathematics and Computation,Volume 205, Issue 1,2008,Pages 133-147,ISSN 0096-3003,https://doi.org/10.1016/j.amc.2008.05.022.