OPTIMAL LOCATION AND OPTIMAL SIZING OF FACTS DEVICE USING BACTERIAL FORAGING ALGORITHM FOR IMPROVING VOLTAGE PROFILE AND LOSS MINIMIZATION

J.KALYAN KUMAR, I.PRABHAKAR REDDY

1PG Student, Dept of Electrical and Electronics Engineering, Narayana Engineering College, Nellore, A.P, India
2H.O.D. Dept of Electrical and Electronics Engineering, Narayana Engineering College, Nellore, A.P, India
E-mail: kalyankumar214@gmail.com, isanaka2008@gmail.com

Abstract- This project bestows optimal sizing and placement of FACTS device, which is achieved by the searching method of bacteria foraging algorithm (BFA) with optimal sizing of FACTS device. Static Var Compensator (SVC) is one of the FACTS devices, utilized for progress of voltage profile and loss minimization. The precise strategy of SVC offers the real power loss minimization with increase of voltage profile. The proposed algorithm is made estimated in IEEE 30 bus system. The results illustrate that progress of voltage profile with loss minimization in the transmission line.

Keywords – Bacteria Foraging Algorithm, Loss Minimization, Static Var Compensator, Voltage profile

I. INTRODUCTION

The relevance of flexible ac transmission systems (FACTS) controllers, such as static var compensator (SVC), static compensator (STATCOM) and static synchronous series compensator (SSSC), is rising in power systems. This is owing to their capability to become stable the transmission systems and to enhance power quality (PQ) in distribution systems. There are numerous benefits in power system process and planning. Such benefits consist of the minimization of system losses, exclusion of line overloads and low voltage profiles. Newly, the Evolutionary Computation (EC) in the solution of difficult problems such as Differential Evolution (DE), Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), and Genetic Algorithms (GAs) are some of the heuristic methods having enormous convergence uniqueness and potential of determining global optima.

This project, proposes a method for finding the optimal location and strategy of Static Var Compensator (SVC) using Bacterial Foraging algorithm so as to achieve the objective function of minimization of real power loss, voltage profile progress. The proposed algorithm has been checked on IEEE 30-bus reliability test systems. A load flow program written in MATLAB using bacterial foraging method is handled to calculate power flow. The efficacy and efficiency of the proposed methods is found giving special results of IEEE standard systems.

II. MODELING OF SATIC VAR COMPENSATOR (SVC)

Static Var Compensator is a shunt connected FACTS device, which play a major role to regulate voltage profile at the give bus and to reduce the real power loss by adjusting the reactance value of it. SVC composed of fixed capacitor (FC) and thyristor controlled reactor (TCR).

In the equivalent circuit of SVC, it is noticed that it has parallel connection of capacitor and reactance. Herein it has the potential to proceed in capacitor mode or inductor mode to make certain the objective function. The reactance Xsvc is supposed as a event of tuning the firing angle of TCR, as it is made parallel connection to fixed capacitor. Estimation of SVC parameter becomes key task for progress of Voltage profile and real power loss minimization in transmission line. The value of capacitor and the TCR inductive value are made as,

\[
X_{c} = \frac{V_{base}^{2}}{Q_{ SVC}}, X_{L} = \frac{X_{c}}{2}, X_{SVC} = \frac{X_{c} + X_{TCR}}{X_{c} + X_{TCR}}
\]

III. PROBLEM FORMULATION

The objective function of this work is to find the optimal location and size of SVC which lessens the real power loss and voltage deviation.

\[
F = [f_1, f_2]
\]

\[
f_1 = \sum_{k=1}^{n} f_k \left( \sqrt{P_{j}^2 + Q_{j}^2} - \sqrt{P_{ref}^2 + Q_{ref}^2} \right) = \gamma_{loss}^{j}
\]
The first term \( f_1 \) represents real power loss. The second term \( f_2 \) represents the total voltage deviation (VD) of all load buses from desired value of 1p.u.

The minimization problem is subject to the following equality and inequality Constraints:

1. Load flow constraints
   \[ P_{gi}^{min} \leq P_{gi} \leq P_{gi}^{max}, \ i = 1,2,\ldots,G \]
   \[ Q_{gi}^{min} \leq Q_{gi} \leq Q_{gi}^{max}, \ i = 1,2,\ldots,G \]

2. Voltage constraints
   \[ V_{i}^{min} \leq V_{i} \leq V_{i}^{max}, \ i = 1,2,\ldots,N \]

3. Reactive power generation limit
   \[ Q_{ci}^{min} \leq Q_{ci} \leq Q_{ci}^{max}, \ i = 1,2,\ldots,C \]

4. Transmission line flow limit
   \[ S_{i}^{min} \leq S_{i} \leq S_{i}^{max}, \ i = 1,2,\ldots,L \]

\[ \text{ALGORITHM} \]

### IV. BACTERIA FORAGING ALGORITHM

Foraging theory is based on the natural behavior of animal searching for their nutrient which maximize their energy for foraging. This algorithm is based on the searching behavior of E.Coli bacteria. E.coli is a microorganism which has the nature of searching of food more quicker than other. Chemotaxis is the natural foraging behavior of bacteria, which helps to catch the required nutrient. Implementation of chemotaxis steps, the searching process are followed. Let \( j \) be the stepping rate of chemotaxis, \( k \) be there production step and \( l \) be the index of elimination dispersal event. The length of life time of bacteria \( Nc \) is measured by the number of chemotaxis steps. Bacteria swims in the free space to reduce loss, along with maximum number of steps \( Ns \). Next to the chemotaxis reproduction is adopted. \( Nre \) is the number of reproduction steps to be taken by bacteria for population sorting. So as to make increase of population of bacteria reproduction is carried out. This method provides bacteria with a lot of nutrients and also keeps the population size constant.

For initialization, you must choose \( p, S, Nc, Ns, Nre, Ned, \) and the \( C(\ i), \ i = 1,2,K, S \). If you use swarming, you will also have to pick the parameters of the cell-to-cell attractant functions; here we will use the parameters given above. Also, initial values for the \( \theta_i \), \( i = 1,2,3, K, S \) must be chosen. Choosing these to be in areas where an optimum value is likely to exist is a good choice. Alternatively, you may want to simply randomly distribute them across the domain of the optimization problem. The algorithm that models bacterial population chemotaxis, swarming, reproduction, elimination, and dispersal is given here (initially, \( j = k = I = 0 \)). For the algorithm, note that updates to the \( \theta_i \) automatically result in updates to \( P \). Clearly, we could have added a more sophisticated termination test than simply specifying a maximum number of iterations.

Algorithm were as follows,

**STEP 1:** Elimination-dispersal loop: \( I = I + 1 \)

**STEP 2:** Reproduction loop: \( k = k + 1 \)

**STEP 3:** Chemotaxis loop: \( j = j + 1 \)

For \( i = 1,2,K, S \) take a chemotactic step for bacterium \( I \) as follows.

Compute \( J(i,j,k,l) \). Let \( J(i,j,k,l) = J(i,j,k,l)+Jcc(\theta_i(j,k,l), p(j,k,l)) \) (i.e., add on the cell-to-cell attractant effect to the nutrient concentration). Let \( Jlast = J(i,j,k,l) \) to save this value since we may find a better cost via a run.

Swim: Generate a random vector \( \Delta(i) \in _p \) with each element \( m(i); m = 1,2,K,p, \) a random number on \([-1,1] \).

Move: Let

\[ e^j(j+1,k,l) = e^j(j,k,l) + C(i) \frac{\Delta(i)}{\sqrt{\sum_{j=0}^{n} \Delta(j)^2}} \]

This results in a step of size \( C(i) \) in the direction of the tumble for bacterium \( i \).

Compute \( J(i,j+1,k,l) \) and then let \( J(i,j+1,k,l) = J(i,j+1,k,l)+Jcc(\theta_i(j+1,k,l), p(j+1,k,l)) \). Swim (note that we use an approximation since we decide swimming behavior of each cell as if the bacteria numbered \( 1,2,K,i \) have moved and \( i+1,i+2,K,S \) have not; this is much simpler to simulate than simultaneous decisions about swimming and tumbling by all bacteria at the same time.

Let \( m=0 \) (counter for swim length) while \( m<Ns \) (if have not climbed down too long) let \( m=m+1 \).

If \( J(i,j+1,k,l) < Jlast \) (if doing better), let \( Jlast = J(i,j+1,k,l) \) and let

\[ e^j(j+1,k,l) = e^j(j+1,k,l) + C(i) \frac{\Delta(i)}{\sqrt{\sum_{j=0}^{n} \Delta(j)^2}} \]

Else, let \( m= Ns \). This is the end of the while statement.

Go to next bacterium (i + 1) if i \( \neq S \) (i.e., go to b) to process the next Bacterium.

If \( j < Nc \), go to step 3. In this case, continue chemotaxis, since the life of the bacteria is not over.

Reproduction:

a) For the given \( k \) and \( l \), and for each \( i = 1,2,K, S \), let the be the health of bacterium \( i \) (a measure of how many nutrients it got over its lifetime and how successful it was at avoiding noxious substances). Sort bacteria and chemotaxis parameters \( \theta_i \) in order of ascending cost \( Jhealth \) (higher cost means lower health).

\[ J_{search}^i = \sum_{j=1}^{Nc} J(i,j,k,l) \]

\[ J_{search} = \sum_{i=1}^{Nc} J(i,j,k,l) \]
STEP 4: If k < Nre, go to step 2. In this case, we have not reached the number of specified reproduction steps, so we start the next generation in the chemotaxis loop.

STEP 5: Elimination-dispersal: For i = 1,2,K, S with probability ped, eliminate and disperse each bacterium(this keeps the number of bacteria in the population constant). To do this, if you eliminate a bacterium, simply disperse one to a random location on the optimization domain.

STEP 6: If l<Ned, then go to step 1; otherwise end.

V. RESULT AND DISCUSSION

BFA has been coded as M-file in MATLAB platform. Base MVA of the system is 100MVA and the reference bus is taken as bus node 1. So as to prove the algorithm the networks are made with critical loading state. The results are given that, losses minimization and voltage profile enhancement has made. Here the optimal location of SVC is at bus no 17 and 27 by using foraging algorithm in IEEE30 bus system. IEEE 30 bus system consists of 6 generator buses, 4 transformer tap positions, 2 shunt var generators. The voltage profile and loss minimization when both controllers are placed are as follows:

Here red color bars represents voltage before SVC and green bars represents voltage after SVC placement. Real Power Loss before Compensation=1.61761 MW Real Power Loss after Compensation = 0.668608 MW Here in this project after optimal placement, when one of the SVC placed at buses are in off condition then the results observed as follows:

CASE: 1 After optimal placement if the SVC at node 17 is in Off state then voltage profile and power losses are as follows:

Real Power Loss before Compensation = 1.61761 MW Real Power Loss after Compensation = 1.10983 MW

CASE: 2 After optimal placement if the SVC at node 27 is Off state then
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Real Power Loss before Compensation = 1.61761 MW
Real Power Loss after Compensation = 1.30276 MW

CONCLUSION

In this project an effort is made for the optimal location and optimal sizing of SVC has been prepared to progress voltage profile and to lessen the real power losses in the power system. The test systems are given away the justification of results for voltage profile enhancement and real power loss minimization. In this voltage profile and loss minimization are much better when both the SVC’s are placed instead of single SVC placement. These results also prove that, BFA has efficient performance for voltage profile enhancement and real power loss minimization in power system. From the results, it is accomplished that SVC develops the system performance of the electrical network.

REFERENCES


