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Optimal Placement of SVC Using Fuzzy and Firefly Algorithm

P. Suresh Babu, P.B. Chennaiah, M. Sreehari
Department of Electrical and Computer Engineering, AITS Rajampet

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ABSTRACT

Voltage stability is major phenomena in any power system network for reliability and continuity operation. But the tight operation of power system due to overloading or fault on the system which is evitable and major threat to the power system. So it is necessary to maintain the voltages within the constraints at the overloading conditions also by placing of Static VAR Compensator (SVC) at optimal locations. New approaches are used to find the placement and size of the SVC at different locations. Fuzzy is used to find the location and the size of the SVC is fined by the Firefly algorithm. This paper considers different loading conditions of the power system network (125,150,175over loading conditions). From the results we can conclude that the power losses are reduced and the voltages can be maintained within the limits .IEEE 14 bus, IEEE 30 bus system is taken for the implementing the above techniques.

Corresponding Author:

P. Suresh Babu,
Department of Electrical and Computer Engineering,
AITS Rajampet.
Email: sureshram48@gmail.com

1. INTRODUCTION

The unpredictable demand has been changed the individual living in the recent years with the development of technologies. These considerations throw cautions on transmission system against congestion, line loss and voltage instability [1]-[6].Over loading, faults and the shortage of reactive power are the main reasons for voltage collapse. There is one old method for to overcome these problems that is providing the additional transmission line. There is one more alternative advanced technical solution that is FACTS control which is used for better control purpose of reactive power. Additionally FACTS can control the line parameters such as voltage, voltage angle and line reactance. It is necessary to select the most favorable device for compensation and placing it optimally in literature. For placement of SVC many approaches are used, such as loss sensitivity index in [2]-[3], where it is placed in the most negative index. An approach is used in [4] named as Voltage stability index (VSI) is defined for placement of SVC. In [5]-[6] for providing placement genetic algorithm (GA) is used. In this paper SVC is used for shunt compensation. It is a static VAR Generator or absorber connected in shunt whose output is adjusted to exchange inductive or capacitive current so as to provide voltage support only and it can also reduce power losses when installed in a proper location. Best optimal locations can be given by the Fuzzy approach depending on the objectives considered, and Firefly techniques iteratively optimize the sizes of the devices for the concerned locations. A MATLAB code is developed for the proposed approach and applied to IEEE 14, 30 bus system and the results are tabulated.

2. MODELING OF SVC

In the basic form of SVC it is a thyristor controlled reactor which is combination of capacitor connected parallel. SVC resembles in the working point of view as a variable reactor which generates or absorbs the reactive power. It is mainly used for voltage regulation. It is an important component to voltage control placed at the end of the transmission the SVC has been considered as a shunt branch with a compensated reactive power QSVC shown in Figure 1 set by available inductive and capacitive susceptance [6].

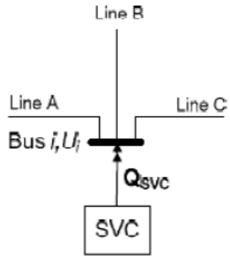

Figure 1. Injection Model of SVC

3. FINDING OPTIMAL LOCATION USING FUZZY APPROACH

In this paper fuzzy approach is used for optimal location of SVC on load buses [7], two objectives are considered for the development of fuzzy i.e. (i) reducing real power losses (ii) maintaining voltage profile within the allowable limits (0.9p.u–1.1p.u). For writing fuzzy rules two inputs nodal voltage (p.u) and Power loss index (PLI) are taken.

$$LR_i = P_i^1 - P_i^2 \quad (1)$$

for i = 1 to number of load buses.
Where,
LR – Loss Reduction.
P_i^1- Real power before compensation.
P_i^2 - Real power after compensation at i^{th} node.

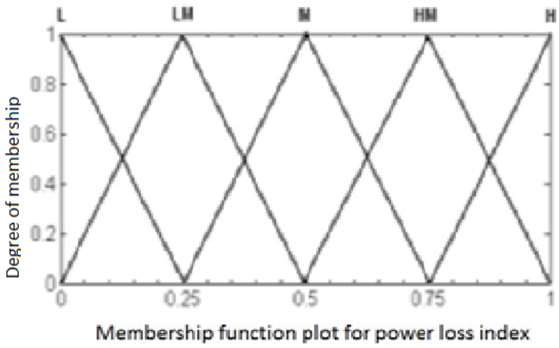

Figure 2. Membership Function Plot for Power Loss Index (PLI)

The LR input can be normalized by equation (2), so that the values will be between 0 to 1, where the smallest as 0 and the largest number having a value of 1.

$$PL_i = \frac{LR(i) - LR(min)}{LR(max) - LR(min)} \quad (2)$$

For i = 1 to number of load buses.

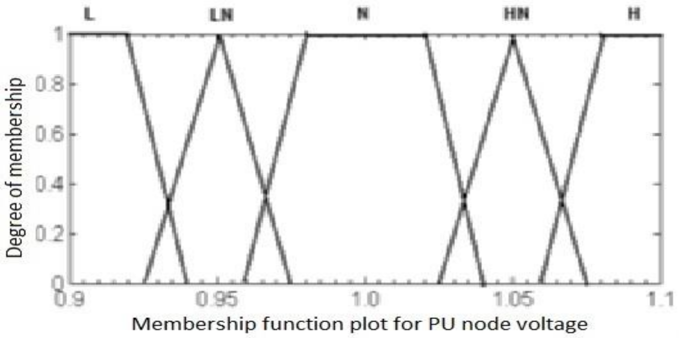

Figure 3. Membership Function Plot for Nodal Voltages p.u.

The fuzzy rules are taken from [8]. The output of fuzzy gives the suitability index for SVC placement. Maximum values will be promising locations for SVC placement.

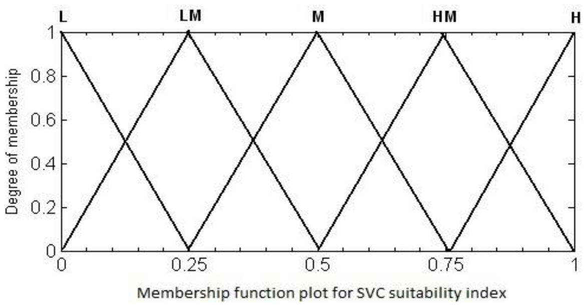

Figure 4. Membership Function Plot for SVC Suitability Index

4. FIREFLY ALGORITHM

Firefly Algorithm (FA) was developed based on natural phenomenal behavior of the firefly by which is used for solving the multimodal optimization problem. There are about thousands of fireflies where the flashes often unique on a particular firefly.

There are three ideal rules are introduced in Firefly development those are 1) All the fireflies are gender-free that is every firefly will attract the other firefly substantive of their sex, 2) Attractiveness depend on their brightness. The less bright one will move towards the brighter one, 3) the landscape of the objective function affects the firefly brightness. Let us consider the continuous constrained optimization problem where the task is to minimize cost function f(x). Firefly algorithm is a speedily converging algorithm. The algorithm gives solution that depends on the selection of swarm size, maximum attractiveness value, the absorption coefficient value and the iteration limit. The basic steps of the Firefly can be summarized as the pseudo code [10, 11].

Pseudo code of Firefly Algorithm
Objective function
f(x), x = (x1,…,xd)T
Generate initial population of fireflies x_{ii}
(i=1, 2…, n)
Light intensity I_{ii} at x_{ii} is determined by f (xii)
Define light absorption coefficient γ
while (t < MaxGeneration)
for ii = 1: n all n fireflies
for jj = 1: ii all n fireflies
if ($I_{jj} > I_{ii}$), More firefly ii towards jj in d-dimension; end if
Attractiveness varies with distance r
Evaluate new solutions and modify the light intensity
end for jj

end for ii
Rank all the fireflies and find the current best firefly
end while
Post process results and visualization

5. RESULTS

The analyzed approach is used for SVC placement by the objectives considered, and is placed on the node having maximum loss reduction and poor voltage profile which is discussed.

5.1. Results of 14 bus system

IEEE 14 bus system [12-13] contains 5 generator buses (bus numbers: 1,2,3,6 and 8, 9 load buses (bus numbers: 4, 5, 7,9,10,11,12,13 and 14) and 20 transmission lines. The load is increased by125, 150 and 175%. Optimal location on load buses, rating of SVC and real power losses after SVC placement for different load scenario using Firefly potimization are shown in Table 1. Voltages of 14 bus system for 175% loading shown in table 2.

Table 1. Result for 14 Bus System.

Loading condition	Losses without SVC	SVC Loc	Firefly algorithm	
			Rating of SVC	Losses with SVC
Normal loading	13.393	5,14	5.556 6.952	13.333
125% loading	22.636	5,14	36.93 10.08	22.101
150% loading	35.011	5,14	66.97 13.09	33.769
175% loading	51.295	9,14	58.58 15.94	49.495

Table 2. Voltages of 14 Bus System for 175% Loading

Bus no:	Voltages (p.u)	
	Before SVC	After SVC
1	1.0600	1.0600
2	0.9950	1.0050
3	0.9600	0.9600
4	0.9448	0.9729
5	0.9514	0.9756
6	1.0200	1.0600
7	0.9851	1.0565
8	1.0400	1.0900
9	0.9651	1.0720
10	0.9606	1.0568
11	0.9833	1.0523
12	0.9898	1.0393
13	0.9785	1.0351
14	0.9358	1.0477

5.2. Results of 30 bus system

IEEE 30 bus system[12] contains 6 generator buses (bus numbers: 1, 2, 5 ,8, 11, and 13), 24 load buses (bus numbers: 3, 4, 6, 7, 9, 10, 12, 14 ,15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30) and 41transmission lines. The load is increased by125, 150 and 175%. Optimal location on load buses, rating of SVC and real power losses after SVC placement for different load scenario using FA are shown in Table 3.

Table 3. Result for 30 Bus System

Loading condition	Losses without SVC	SVC Loc.	Firefly algorithm	
			Rating of SVC	Losses with SVC
Normal loading		26.	3.1427	
	17.528	30.	3.3826	17.4057
		7	12.7310	
125% loading		30.	5.8710	
	29.850	7.	32.7977	29..912
		26	4.9527	
150% loading		24.	17.0266	
	46.942	30.	6.9730	45.4175
		26	4.5245	
175% loading		24.	22.3177	
	68.962	21.	63.7552	65.8756
		30	14.4736	

6. CONCLUSION

A two-fold approach is used in this paper for finding sizes of SVC devices and optimal locations is presented. Fuzzy approach is used for optimal locations and sizes are obtained through FA method for their optimal rating values are calculated. From results it is observed that for all overloads i.e., 125%, 150% and 175% of normal loading, the voltage profile of the system is increased and maintained within the specified limits, and the real power losses are also reduced.

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[14] Optimal Placement of SVC Using Fuzzy and PSO Algorithm. K dhanunjaya babu, M Damodar reddy 1PG Student, Department of E.E.E., S.V. University, Tirupati, Andhra Pradesh, India. 2 Associate Professor, Department of E.E.E., S.V. University, Tirupati, Andhra Pradesh, India