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OPTIMAL SVC PLACEMENT FOR LOSS MINIMIZATION IN ELECTRIC POWER NETWORKS USING ARTIFICIAL INTELLIGENCE TECHNIQUES

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Abstract - The problem of reducing power losses in electrical networks is a task that must be solved in an optimal manner. At present, this optimality can be achieved by efficient usage of existing facilities along with installing FACTS devices. The Static VAr Compensator (SVC) is chosen for study because of its maturity as well as acceptable costs. In the study, genetic algorithm (GA) is trying to identify the optimal location and size of the Static VAr Compensator (SVC). The computer program is run on IEEE 30- bus test system, assessing reducing power losses, and also checking Voltage profile and voltage deviation of the system under consideration. The purpose of this study is to validate the solution method and Check GA for it to be adapted for systems of higher dimensionality.

Keywords- FACTS, SVC optimal placement, SVC optimal sizing, genetic algorithm, Power loss, Voltage deviation.

I. INTRODUCTION

Generally generators are located far away from the load center. Due to this, a large network of conductors between the power station and consumer is there. Network can be divided in two major components first is transmission network and distribution network. For efficient flow in the network minimization of transmission losses is necessary. Power loss results in lower availability of power at the consumer end. To eliminate this problem, proper steps have to be taken by the network operator. For Minimization of power loss in the network, network operator has to improve voltage profile of the network. In simple words network operator has to minimize network voltage deviation.

To do so FACTs devices are useful. Facts devices can control active power and reactive power flow at the point of connection of device. FACTs devices are used for increased transmission capacity, Loss minimization, Voltage support, Increasing network stability, Oscillations damping and Power flow control. Among all the FACTs devices Static Var compensator (SVC) is most widely used device because of low cost as compared to other FACTs devices like STATCOM, UPFC, and TCSC etc. But for minimization of power loss in the network Operator has to install SVC Of proper size at proper location. This optimal location and size of SVC can be found by using any optimization method. In the paper Genetic algorithm (GA) is used for selection the optimal location and size of SVC. Genetic algorithm (GA) is a nature inspired computerize search and optimization algorithm. By using GA optimal location and size of SVC can be found for the objective of loss minimization in the network. GA is working on Darwin’s theory of survival of fittest. Professor John Holland predicts the concept of this algorithm. Reproduction, Crossover and Mutation are the basic elements of the natural genetics.

Here for simplicity, this paper only address the placement and sizing of SVC devices for the objective power loss minimization in the network. Paper is also considering the SVC installed at only nodes of the network.

II. SVC MODEL

A brief view of the static Var compensator (SVC) model and how it will affect the network is given in this section. Modeling of SVC is done by using by shunt variable admittance model. SVC can be placed on the load bus of the network (or) on the middle transmission line. In this paper Loss less SVC is considered. Because of no losses in SVC admittance of SVC has only imaginary component. In practice up to 300MVAr ratings of SVC is available.

$$y_{SVC} = j\, b_{SVC} \qquad (1)$$

After implementing the SVC modification in admittance matrix is occurred like bellow in diagonal elements only.

$$Y_{ii(new)} = Y_{ii(old)} + y_{SVC} \qquad (2)$$

In the paper only the case of installing SVC on load busses is considered.

In the case in which SVC is installed at the load buses, so that only one term of the nodal admittance matrix is changed. The change of admittance matrix is depends on the selection of the location of SVC device. But here in this paper only size and location is of SVC is directly calculated in MVAr by using genetic algorithm.

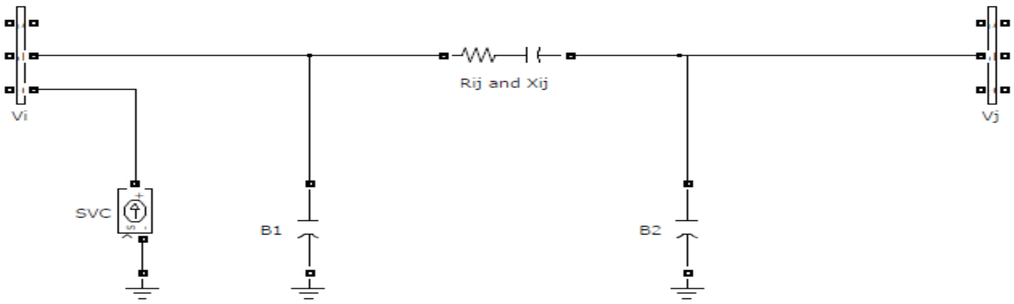


Figure 1 SVC placement

III. PROBLEM FORMULATION

For optimal placement and sizing of SVC in power system power loss of the system is considered as an objective function. In this paper only one single objective (system power loss) is considered. Objective function is as shown as bellow,

$$\text{Power loss} = \sum_{i=1}^{n} [Vi^2 + Vj^2 - 2ViVj\cos(\delta i - \delta j)]\, Yij \cos(\varphi ij) \quad (3)$$

Where,

V i and = voltage magnitude and angle from node i
V j and = voltage magnitude and angle from node j
Y ij and = magnitude and angle of the “i-j” line admittance.
n= number of transmission line in network

In this paper above equation is used for loss calculation. Two test case systems are considered in the paper, one is 13-BUS test system and second is IEEE 30-BUS test system.

IV. THEORY OF GENETIC ALGORITHM

Genetic algorithm is a probabilistic search and optimization algorithm.GA works on Darwinian principal of mechanics of natural genetics and natural selection. In genetic algorithm, individuals (in population) were represented as string of binary numbers. By using proper encoding technique one can use GA for many real-world applications. There are three Genetic operators,

A. Reproduction operator:
Reproduction process is used to select individuals which have high fitness values. Fitness values are evaluated by using objective function. The individual with high fitness values will have high probability of selection in next generation. There are three methods for selection process

- Roulette-wheel selection
- Tournament selection
- Stochastic universal selection

In this paper roulette-wheel selection and tournament selection are considered for study. But for the particular application roulette-wheel selection is suppose to be better than tournament selection.

B. Crossover operator:
The purpose of crossover is to produce new individual which is different from their parents. Two types of crossover operation are there,

- One point crossover
- Two point crossover
- N-point crossover

In this paper one point crossover is considered. In crossover operation right portion of the individuals are interchanged from randomly selected crossover point. The process of one point crossover operation is shown in bellow figure:

1	1	0	1	0	0	1	0	1	1
0	1	1	0	1	1	0	0	0	1

FIGURE-2: Parents

1	1	0	1	0	1	0	0	0	1
0	1	1	0	1	0	1	0	1	1

FIGURE-3: Children

C. Mutation operator:

Mutation operator is very important operator in GA. Because reproduction and crossover operator cannot change left most gene of the individual is very important to have global optimum solution. By using mutation one can change any gene individually. Mutation operation can be understood by bellow figure:

1	1	0	1	0	1	0	0	0	1
1	1	1	0	1	0	1	0	0	1
1	0	0	1	0	1	1	1	0	0
1	0	0	0	1	1	1	0	1	1
1	1	1	0	1	0	0	1	0	0

FIGURE 4: Population

An example consider the following population of size “n=5” with a string length 10. Here in all strings there is 1 at the left most position, and if true optimal solution require 0 at the left most position. In this case mutation operator is necessary.

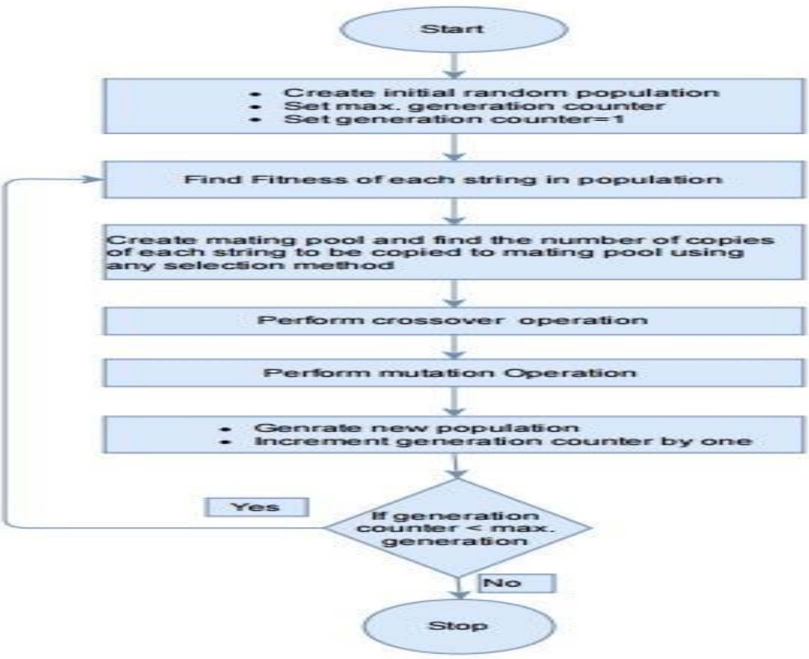


Figure- 5: Flow chart

V. Problem implementation

Implementation of problem "optimal svc placement for loss minimization in electric power networks using artificial intelligence techniques" is as followed. Here selection of location of SVC and size is done for the objective to minimize the power loss of the network. Here in randomly generated individual first string is for location of SVC and second string is for size of SVC.

Location of SVC	Size of SVC

Here size of SVC is considered as 100 MVAr maximum. Optimal size and location for IEEE-30 bus test system is as followed.

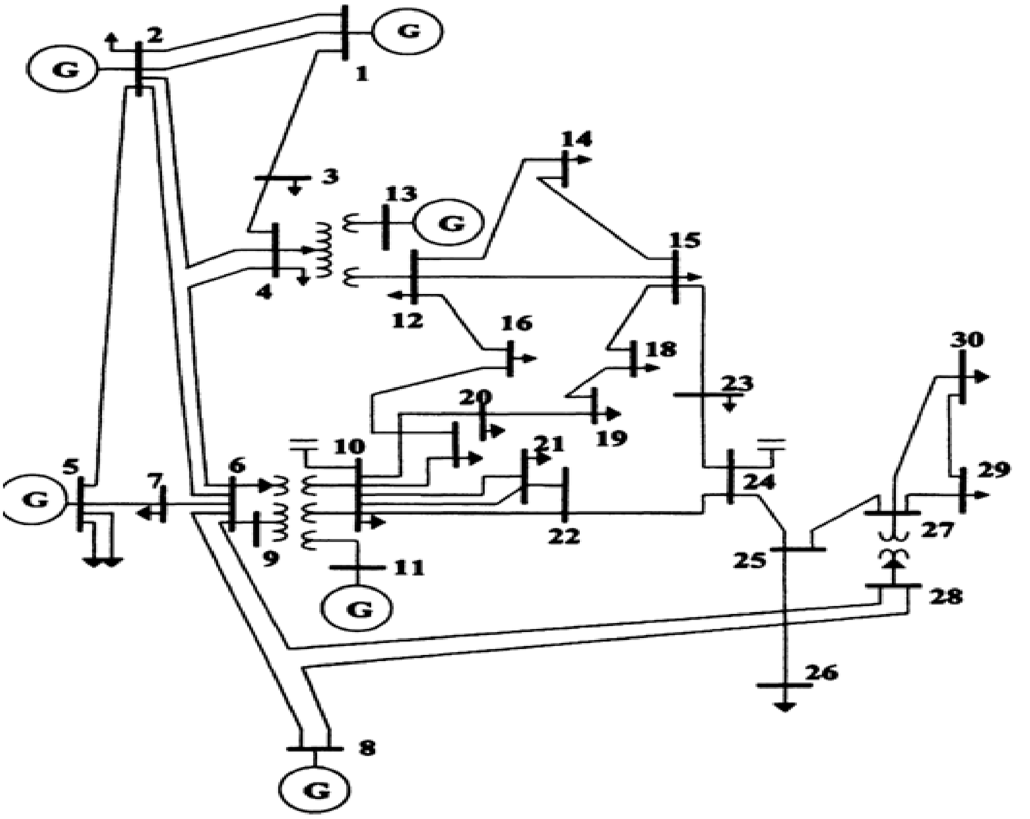
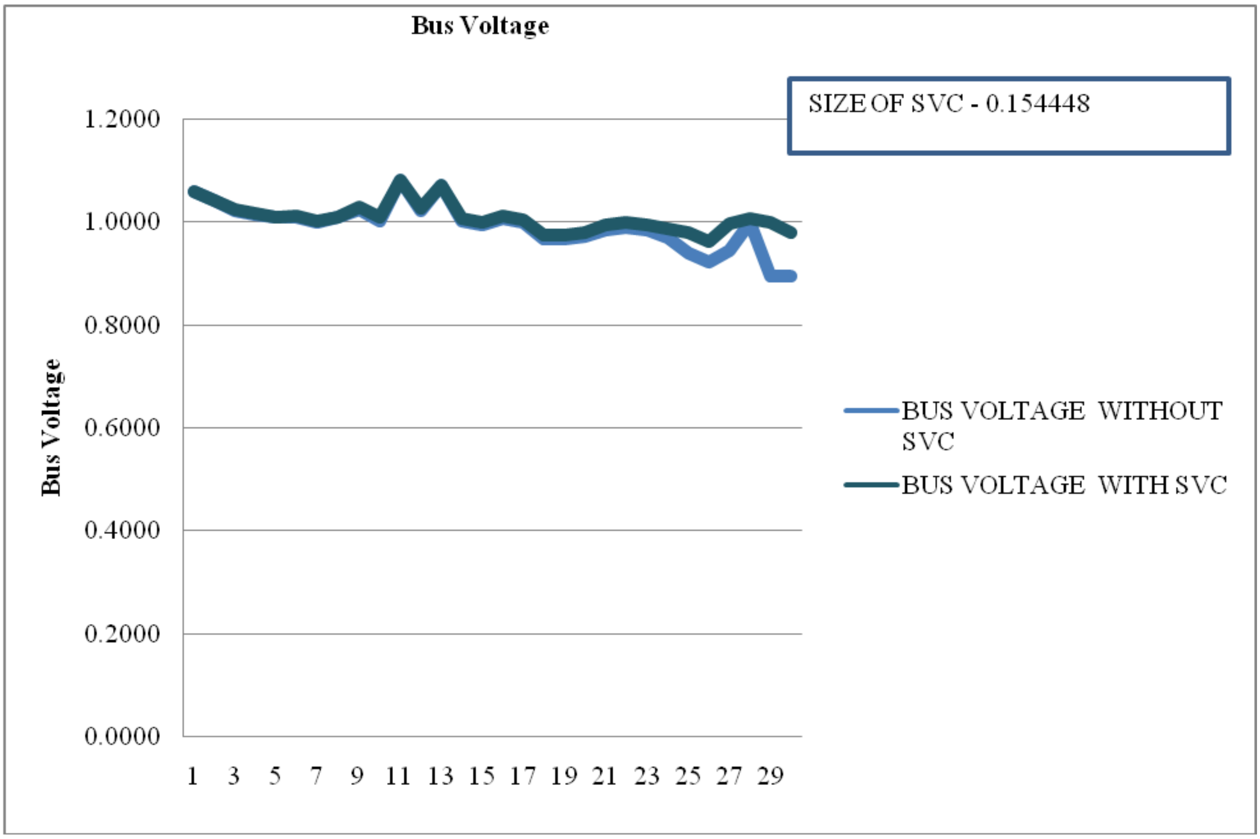


Figure- 6: IEEE 30 Bus test

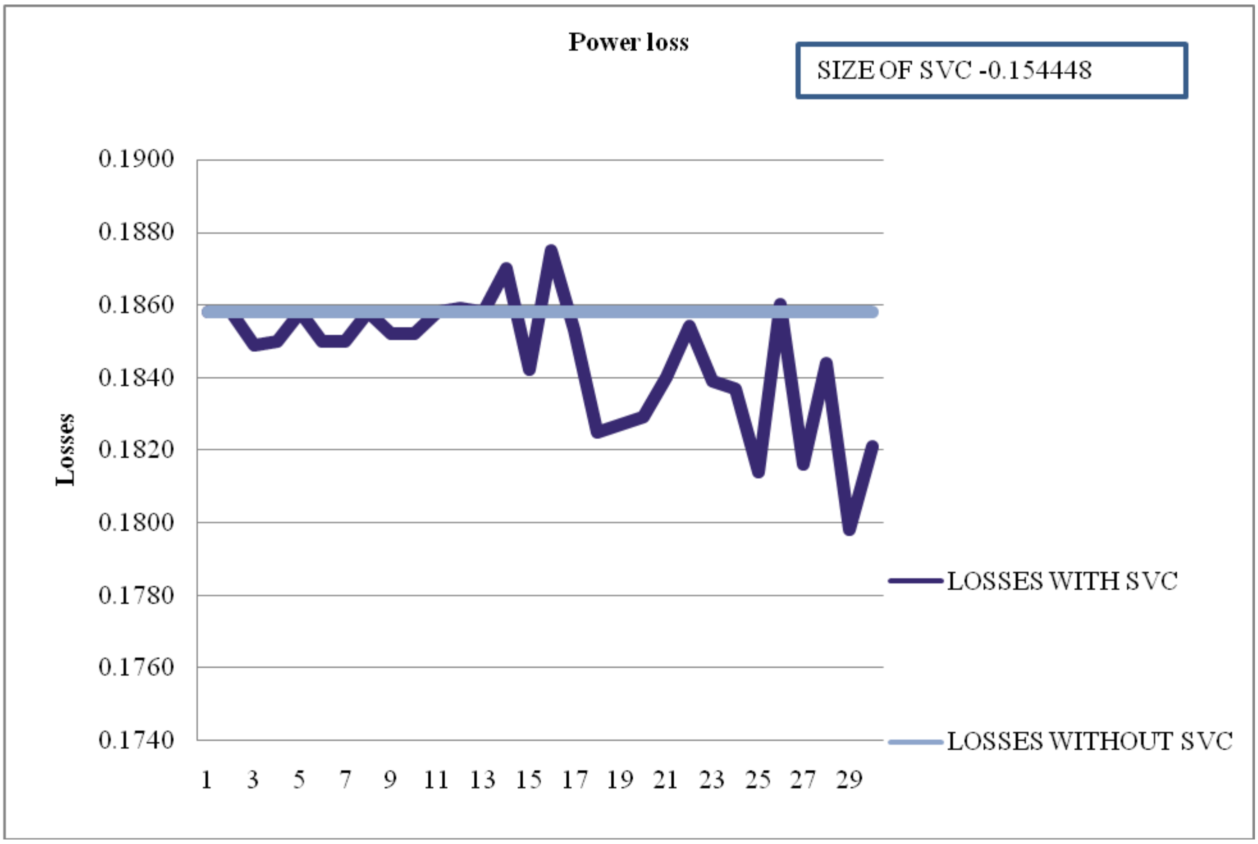
Now results for optimal location and size is obtained as bellow for two selection methods

Roulette wheel selection	Tournament selection
Trial Runs =25	Trial Runs =25
Elapsed time=133.636322 seconds	Elapsed time=117.279117 seconds
Base case losses=0.252998 pu	Base case losses=0.252998 pu
Losses after placing SVC=0.250256 pu	Losses after placing SVC=0.250309 pu
Get optimal Bus 16 times out of 25 trials	Get optimal Bus 3 times out of 25 trials

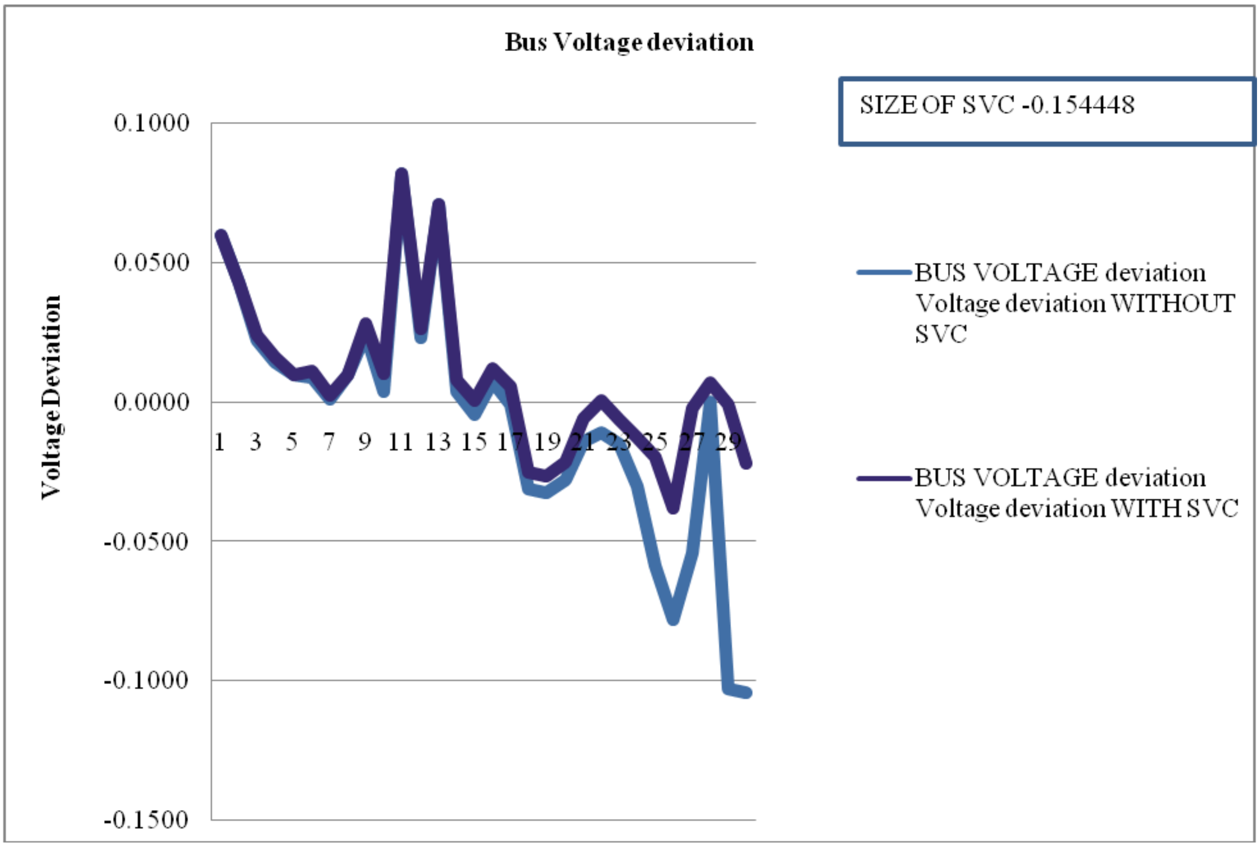
A. Results of Bus voltages:



B. Results of Power loss:



C. Results of Bus voltage deviation:



VI. CONCLUSION

Objective of minimum line loss is used to formulate optimal placement and sizing of static VAR compensator (SVC). Genetic algorithm has shown promising results for standard test case functions as well as for optimal size and SVC placement. Due to improvement in voltage profile, power loss is reduced. The results obtained for IEEE 30 bus test case are found to be satisfactory. Optimal location for IEEE-30 Bus test system is 29 bus and size of SVC obtained is 0.154448 pu. Voltage deviation will be in its limits after implementation of SVC at 29th bus of the size 0.154448 pu.

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