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Distribution System Power Loss Reduction by Optical Location and Size of Capacitor

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Abstract: - This paper presents an ant colony optimization (ACO) and genetic algorithm (GA) mythology with integer programming to effectively and efficient solving capacitor placement problems in distribution systems. Distribution system is a very important link between the transmission system and the end power uses, so it's very important to keep the system healthy with minimum loss. In this study, concept of ant colony search with limits and improvement technique is use along with GA to search the proper mutation operator to accelerate searching out the global solution. Capacitor which is optimally placed in distributed system, is able to reduce the power losses and also helpful in voltage improvement. IEEE 33-bus distributed system is used as the testing model to get the result.

Key-Words: - - Power System, optimization techniques bus voltage control, Capacitor Placement.

1. INTRODUCTION

Demand of Electricity is increasing day by day; presently power industry has a high demand. Generated electricity power is not completely consume by the end user and a large amount of power losses occurs during transmission and distribution. To achieve power and energy no reduction, voltage regulation and for reactive power compensation, capacitors are widely installed in distribution systems. Large amount of power system losses occurs in distributed system. The Loss in power at distributed system end is due to lower voltage and high current. The location of capacitor and its size play an important role in accomplish the benefits of capacitor in the power system [1],[2]. Depending on the pattern of loads, capacitor not only minimizes the losses but also reduces annual power cost. Different view and suggestion has been proposed about the size and capacity of capacitor bank [3]-[5]. One of the method to solve the capacitor location problem is by sensitivity base approach which is proposed in Ref. [6]. Genetic Algorithm (GA) is an effective tool in solving the optimization problem specially in case of capacitor location in radial distribution system [7].In the above mentioned methods, the capacitors are often specified as continuous variables. However, commercially available capacitors are of discrete type. Result may largely effect by selecting integer capacitor size [8].One other paper suggested a new mythology of ant colony for optimal location of capacitor [9].Work regarding calculating annual power losses for a distributed system is also done with taking variation in load annually [10].The paper here discussed about discrete capacitors for optimal placement with variation in load annually. The Transmission System basically use shunt compensation to improve the voltage regulation and quality of power and its stability [11]. Shunt Capacitor maintains the voltage level in power line by reactive power compensation, while shunt reactors reduce the overvoltage by reactive power consumption. Whereas Series compensation are used to control the impedance of power line.

The basic concept behind the application of evolutionary computation to any problem in power systems is Optimization [12]. The Optimization Technique has been applied successfully in several problems of power

Systems for reactive sources allocation, optimal power flow, economic dispatch and future expansion planning are among the most important applications. Optimization technique such as ACO and GA can also be applicable for large distribution problem. Methodology used by such a technique is nearly similar in terms of minimization of a problem. The challenge incorporated with these techniques is to gain their working mythology and to adapt them in the required problem. Continuous up gradation is proceeding in these technology time to time.

1.1 Ant Colony Optimization

Ant Colony Optimization (ACO) is a metaheuristic algorithm for paradigm and designing combinatorial of optimization base problems. In order to escape from local metaheuristic algorithm it impel some basic heuristic Optima. In [13]1991 its framework was classified as algorithm since then many literatures are published on it. ACO basically works on the theory of a priori information about the structure of a promising solution along with information for obtained better solution with in the structure. ACO is a significant pattern for crafting valuable combinatorial optimization solution algorithms and can be applied to the quadratic assignment problem [14]. ACO can be explained as a set of asynchronous as well as concurrent practical or agents that run across the problem corresponding to a factional solution of the problem to be solved. To initiate the solution these practical or agent also called as ants, have been put on randomly selected vertices on the construction graph or map, where initial vertices are major part of their path [12]. Within each building step, all the agents or ants build their feasible paths or method by moving to the subsequently vertex based on their probabilistic choice. ACO run on the formula given below The probability with which the k^{th} ant at the vertex *i* chooses to move to the vertex *j* can be determined by the random-proportional state transition rule[15]. where *t(i,j)* represents the pheromone trail associated with *li,j,* which is the connection between vertices *i* and *j, h(i,j)* a heuristic value, called the desirability of adding connection *li,j* to the solution under construction and can be determined according to the optimization problem under consideration.

$$p_k(i,j) = \begin{cases} \frac{[\tau(i,j)]^{\alpha}.[\eta(i,j)]^{\beta}}{\sum_1^t [\tau(i,u)]^{\alpha}.[\eta(i,u)]^{\beta}} & j,u \in N_{k,i} \\ o & \text{otherwise} \end{cases} \quad (1)$$

$$\tau(i,j) = (1-\alpha).\tau(i,j) + \sum_{k=1}^{m} \Delta\,\tau_k(i,j) \quad (2)$$

1.2 Genetic Algorithm

Optimization is the basic concept behind the application of GAs, or any other evolutionary Algorithm [16]. A genetic algorithm (GA) is a search algorithm technique release on the conjecture of natural selection and genetics. GA mechanism deals with a coding of parameters in place of the parameters themselves. It only needs to check and correct objective function (fitness) to guide its search. Also it is a multipath function that finds many peaks in parallel, hence decreased the possibility of local minimum trapping. Research on genetic algorithms (GAs) has proven that it is capable of solving hard problems in a robust and efficient way.

Genetic Algorithm (GA) was first introduced by John Holland of Michigan University in 1970's. The GA is a stochastic global search method that mimics the metaphor of natural biological evolution such as selection, crossover, and mutation. The GA's combines an artificial principal with genetic operation. The artificial principal is the Darwinians survival of fittest principal and the genetic operation is abstracted from nature to form a robust mechanism that is very effective at finding optimal solutions to complex real world problems.GA is effectively working on power system problems. GA in combination with conventional optimization techniques, is uses for solving large scale problems. The main advantage of genetic algorithms is their robustness and flexibility as a global search technique. It can deal with non differentiable functions and highly nonlinear problems as well as functions with multiple local optima. The crucial drawback of GA results is its flexibility.

2 PROBLEM FORMULATION

Loss of electrical power is an important issue basically when large part of electrical power is generated from non renewable energy sources. Various ideas have been proposed for reduction of such losses which also include concept of distributed generation [17]. Such concepts are developing slowly and need capital cost involvement. The paper suggest the concept to control reactive power at the distribution end by introducing capacitor in bus system. The Location and size of capacitor in power system or distribution system is to be determined, then after Load flow analysis is done, majorly by using Newton Rapson to compute the power losses. The processes is done
considering the current and voltage capacity of bus. Location and size is obtained by applying optimization techniques. Two optimization techniques have been discussed here. ACO which basically work on principal of ants search for shortest part for travelling. The major problem of such techniques is to consider the starting point of the agents or ants. The paper suggests taking origin of coordinate to be

considered as the starting point. Other optimization technique is used to verify the result obtain by different approach.GA is majorly used method for problem related to power system.

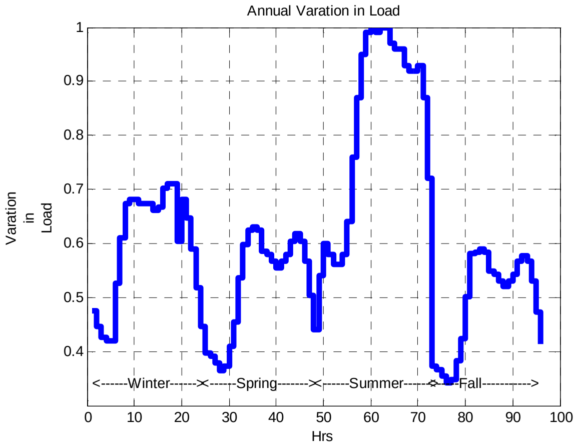

Fig 1 .Graf representation of Voltage Mag. in all cases [10]

Fig 1 describe annual change in load [10].The complete year is bifurcated into four major season winter, spring, summer and fall and data per hour is produced. Twenty four hrs variation of load in a season is taken. The fig 1 suggests large demand during the summer season and low during the fall.

3 PROBLEM SOLUTION

Power flow equation of distributed system are computed as [18-19].

Objective function

Minimization= $\sum_{k}^{N} P_{Loss,k}$

P_k = Real power flowing out of bus k.

Q_k = Reactive power flowing out of bus k.

P'_k =Real power flowing out of bus k after reconfiguration.

Q'_k = Reactive power flowing out of bus k after reconfiguration.

P_{Lk+1} = Real power flowing out of bus k+1.

Q_{Lk+1} = Reactive power flowing out of bus k+1.

V_k = Voltage at bus k.

1) Power Flow Equations:

$$P_{k+1} = P_k - P_{Loss,k} - P_{Lk+1} \quad (1)$$

$$= P_k - \frac{R_k}{|V_k|^2}\{{P_k}^2 + (Q_k + Y_k|V_k|^2)^2\} - P_{Lk+1}$$

$$Q_{k+1} = Q_k - Q_{Loss,k} - Q_{Lk+1} \quad (2)$$

$$= Q_k - \frac{X_k}{|V_k|^2}\{{P_k}^2 + (Q_k + Y_{k1}|V_k|^2)^2\} - Y_{k1}|V_k|^2 - Y_{k2}|V_{k+1}|^2 - Q_{Lk+1}$$

$$|V_{k+1}|^2 = |V_k|^2 + \frac{R_k^2 + X_k^2}{|V_k|^2}(P_k^2 + Q_k^2) - 2(R_k P_k + X_k Q_k)$$

$$= |V_k|^2 + \frac{R_k^2+X_k^2}{|V_k|^2}(P_k^2+(Q_k + Y_k|V_k|^2)^2) - 2(R_k P_k + X_k(Q_k Y_k|V_k|^2)) \quad (3)$$

2) The power loss in the line section connecting k and k+1 may be computed as

$$P_{Loss(k,k+1)} = R_k.\frac{(P_k^2+Q_k^2)}{|V_k|^2} \quad (4)$$

3) Power Loss Equations:

$$P_{Loss,k} = 0.5 * \sum_{i=1}^{n}\sum_{j=1}^{n} G_{ij} * \left[(V_{k,i})^2 + Vk,j2-2*Vk,1*cos\delta k,j-\delta k,i\right. \quad (5)$$

3) Branch Current Equations:

$$I_{k,i,j} = |Y_{ij}| * [(V_{k,i})^2 + (V_{k,j})^2 - 2 * V_{k,i} * V_{k,j} * \cos(\delta_{k,j} + \delta_{k,i})^{1/2}] \quad (6)$$

Where $I_{k,ij}$the current in the feeder connecting is busses i and j during state k.

4) Slack Bus Voltage and Angle (Assumed to be Bus 1):

$$V_{k,1} = 1.0 \quad (7a)$$

$$\delta_{k,1} = 1.0 \quad (7b)$$

5) Voltage Limits at the Other Buses:

$$V_{min} \leq V_{k,i} \leq V_{max}; \forall i \quad (8)$$

6) Feeder Capacity Limits:

$$0 \leq I_{g,ij} \leq I_{ijmax}; \forall i, j, g \quad (9)$$

3.1 Results

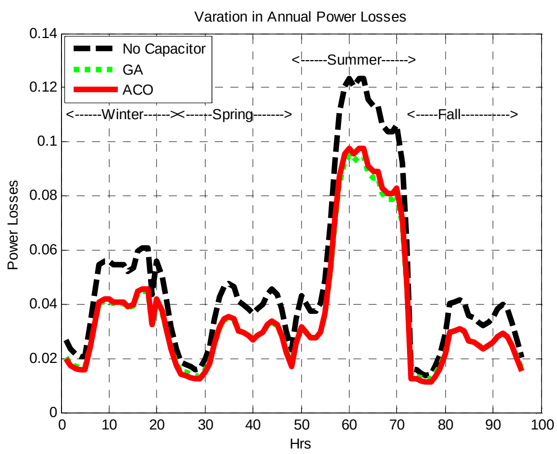

Fig 2 .Graf representation of load in all cases

Fig 2 represents graphical view of power losses with respect to hours, annually during the four seasons for all three cases. Result obtains from GA and ACO are nearly same particularly in spring and fall season. Small variation is observed during the summer season where at peak level GA obtain better result compare to ACO, while ACO provide best result during change in season. Location and size of capacitor to be placed is an important aspect to reduce the power losses of system. However Placement of capacitor in distributed system bus has reduces the power losses of the system.

S.NO.	Method Adopted	Bus Location	Capacity (Mvar)	Annual Loss(MW)	% Decrease
01	No Method	-------	-------	4.6506	--------
02	ACO	30	0.7744	3.5352	24.00%
03	GA	30	0.9130	3.5094	24.60%

Table 1 Method adopted, bus location and losses

Table 1 represents method wise bus location, Capacity (Mvar), annual Loss along with percentage of loss decreased. Here also result obtained from both the technique is nearly same.

Bus Location	Voltage Magnitude	Angle Degree	Injected Mvar
30	0.983	0.018	0.000
30	0.992	-0.695	0.913
30	0.990	-0.588	0.774

Table 2 variation in Voltage and angle

Table 2 presents voltage magnitude as well as angle degree due to Injected Mvar in the system.

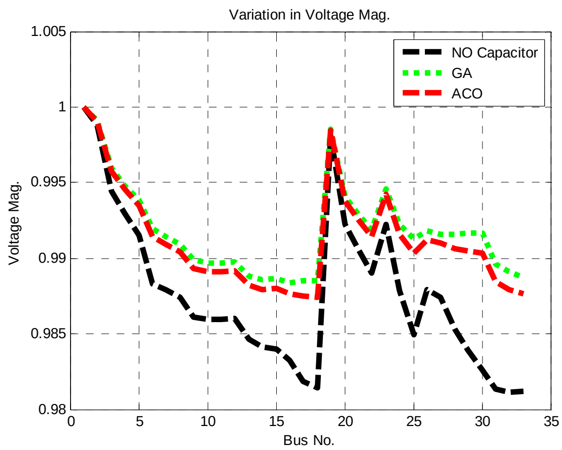

Fig 3 .Graf representation of Voltage Mag. in all cases

Fig 3 represents voltage rise by help of capacitor placement, here result obtain by GA is better than that of ACO. Results are obtained for radial 33 bus distribution system, considering the optimal tie lining for the system.

4 CONCLUSION

Location and size of Capacitor in distribution system is an important aspect. Optimal location and size of capacitor reduce the power loss. Capacitor controls the reactive power flow in the system. FACTS technique can also be applied to inject capacitor in the system. Optimal Location and capacity is obtain by applying optimization technique such as ACO and GA. GA is less time consuming compare to ACO, result obtain from both the technique are nearly same. Solution is been obtain in IEEE 33 bus distribution system to reduce the power losses. Injection of reactive power improves the voltage level as well as also changes the angle degree. The motive of the study is to enhance the efficiency of transmission and distribution system and minimize the fuel consumption, reduce operation cost as well as generating capacity.

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