PERFORMANCE IMPROVEMENT OF DISTRIBUTION NETWORK

[1]Srushti P Pandya, [2]Chintan R Patel

[1]PG student, Department of Electrical Engineering, G H Patel College of Engineering & Technology, Vallabh Vidyanagar
[2]Assi. Prof., Department of Electrical Engineering, G H Patel College of Engineering & Technology, Vallabh Vidyanagar

Abstract: The paper discusses the reduction of losses of the distribution network by re-planning. Re-planning of the network is done by the replacement of the line conductor that has highest losses. To further reduce the losses capacitor is placed to the system node. The optimal combination of conductor and location for capacitor placement is to be determined. First, optimal location for capacitor placement is determined manually and to overcome its limitations, Genetic algorithm (GA) technique is used. By applying the proposed method, the cost and energy losses are remarkably reduced. The proposed method is applied on a a part of distribution network of Madhya Gujarat Vij Company Limited (MGVCL). Test results are included in the paper.

***Index Terms* - Re-planning, Capacitor Placement, Genetic Algorithm, Radial Network**

I. INTRODUCTION

Distribution network is electrical network through which electrical energy is supplied to consumer. Electrical distribution system built as meshed network but operated radial. In radial feeder there are no loops and each bus is connected to source via only one path. The consumer at far end is subjected to voltage variation. One major issue in distribution system is power loss. To reduce power losses, re-planning of the network is one of the methods for overhead transmission line. In re-planning the conductor having highest loss is replaced by the conductor having lesser resistance than existing. Possible combination of conductor is to be proposed to reduce the losses after analysis.

To further reduce losses capacitor is added to the system. Capacitor placement is one of the usual techniques to reduce the energy losses of the radial distribution network. It provides reactive support at relevant node of the system which helps in reducing loss. Optimal places for the capacitor placement are to be determined such it improves the voltage profile of the system.

The distribution network due to following reasons fall in the category of ill conditions,

1) Radial or meshed structure
2) High R/X ratios
3) Multiphase or unbalanced operation

Due to above reasons the other transmission algorithm failed with distribution network. There will be difficulty in the convergence of solution. This needs the modified version of the conventional load flow methods [3].

In presented work, re-planning is done manually by replacement of conductor and also capacitor placement is done at one or more node of the system. It is very difficult re-plan or place capacitor at different node of the large system manually. To overcome this limitation Artificial Intelligence technique is used. Different AI techniques like fuzzy logic, Artificial Neural Network, Particle Swarm Optimization, Genetic Algorithm, Aunt Bee Colony method etc. are developed to solve optimization problem. Genetic algorithm is used for the presented work. Size of the capacitor bank is selected as per the total load and power losses of the system.

II. PROBLEM FORMULATION

Re-planning the distribution network and capacitor placement at one more node of the system is to find the possible combination of conductors that provides minimal energy losses and to determine optimal places of the capacitor to improve the voltage profile of the system.

The problem is formulated as,

$$\text{Minimize } P_{loss} = \sum_{b=1}^{n} R_b * I_b^2$$

Where, R_b = resistance of branch &I_b = current flowing through branch

Optimal solution has to satisfies the following constraints:

$$V_{imin} < V_i < V_{imax}$$

Where, V_{imin} &V_{imax} are lower and upper limits of the bus voltage magnitude respectively.

III. LOAD FLOW ANALYSIS

In this section, a simple and efficient Forward Backward Sweep Method is used. This method includes simple algebraic equation of voltage and power losses. These equations will not have any trigonometric functions like in traditional load flow [3].
Consider fig.1

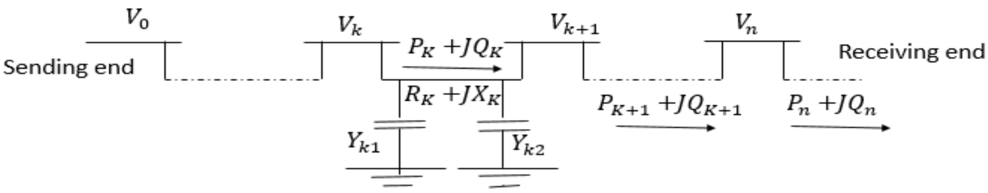

Figure 1 Single Line Diagram [3]

The power flows in distribution network are computed by following set of simplified recursive equation derived from single line diagram fig.1. A branch is connected between node 'k' and 'k+1'. The effective active (P_k) and reactive (Q_K) powers that of flowing through branch from 'k' to 'k+1' can be calculated backward from the last node is given as,

$$P_K = P'_{K+1} + r_k\left(\frac{P_{k+1}^2 + Q_{k+1}^2}{V_{k+1}^2}\right)$$

$$Q_K = Q'_{K+1} + x_k\left(\frac{P_{k+1}^2 + Q_{k+1}^2}{V_{k+1}^2}\right)$$

Where,
$P'_{K+1} = P_{k+1} + P_{lk+1} \& Q'_{K+1} = Q_{k+1} + Q_{lk+1}$
$P_{lk+1} \& Q_{lk+1}$ are loads that are connected at node 'k+1'.
$P_{k+1} \& Q_{k+1}$ are effective active and reactive power flows from node 'k+1'.

The voltage magnitude and angle at each node are calculated in forward direction. Consider a voltage $V_K \angle \delta_K$ at node 'k' and $V_{K+1} \angle \delta_{K+1}$ at node 'k+1', then the current flowing through the branch having an impedance, $z_K = r_K + jx_K$ (connected between 'k' and 'k+1') is given as,

$$I_K = \frac{V_K \angle \delta_K - V_{K+1} \angle \delta_{K+1}}{r_K + jx_K}$$

Flow chart Load flow analysis by MATLAB is shown in fig.2.

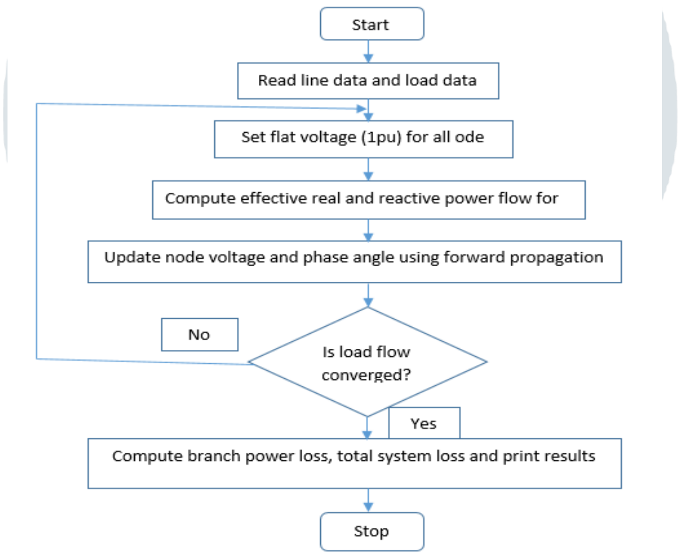

Figure 2 Flow Chart for Load Flow Analysis [3]

IV. GENETIC ALGORITHM

GA is search based optimization technique based on principle of genetics and natural selection. It is used to find optimal or near optimal solution for difficult problems. Basically, GA makes a population that evolves through time using reproduction and mutation process. Only individuals representing good solutions of the capacitor placement survive longer and their genetic information will be presented in the next generation. At the end, after several generations the interaction between these high quality individuals will produce a final population which represents the best solution set of the problem [1].

a) Genetic operator

There are three genetic operator applied to the chromosomes.

1) Selection
2) Crossover
3) Mutation

Selection operator is used to select the parent chromosome. Parent chromosome is selected as per the fitness of the population. After the selection crossover is applied to the parent chromosome. After that mutation operator is applied to the new generated off-string. In mutation one or two bits in the string is changed from '1' to '0' or '0' to '1'.

b) Initial population and fitness function

First step is to generate random population. A set of random population is generated in binary form. Then fitness is calculated using following fitness function.

$$fitness = \frac{1}{P_{loss}}$$

Where, P_{loss} are the total losses of the system.

The more fit solutions are selected for the reproduction using crossover operator. The mutation operator is used to maintain diversity of the population. The fit chromosome replaces less fit chromosome this process continues till the optimal solution is found.

c) Algorithm methodology

The overall procedure is summarized as,

1) Generate random population.
2) Evaluate fitness function and determine if it satisfies its voltage constraints.
3) Crossover operator is applied.
4) Mutate some bit of the new off-string.
5) Calculate fitness function. Go to step 2.

V. RESULTS AND DISCUSSION

Here, test system considered is real system (a part of MGVCL). The real system is shown in fig.3.

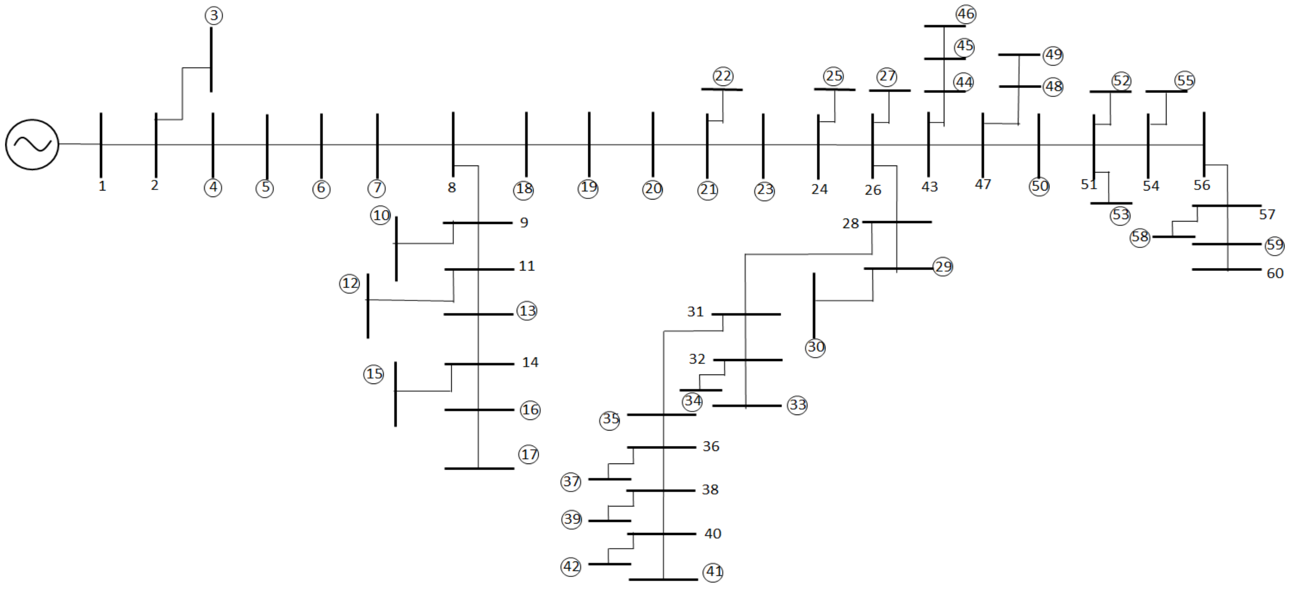

Figure 3 Simplified Diagram of Real System

The total load of the system is 1243.28 kW & 770.28 kvar. The maximum and minimum node voltage limits are 0.95 pu and 1.05 pu respectively. First the re-planning is done considering panther, zebra and moose conductor. Then capacitor bank of 50 kvar is added in the system at different locations to find optimum solution. Active power losses of each branch are shown in fig.4.and the voltage at each node of the system is shown in fig.5.

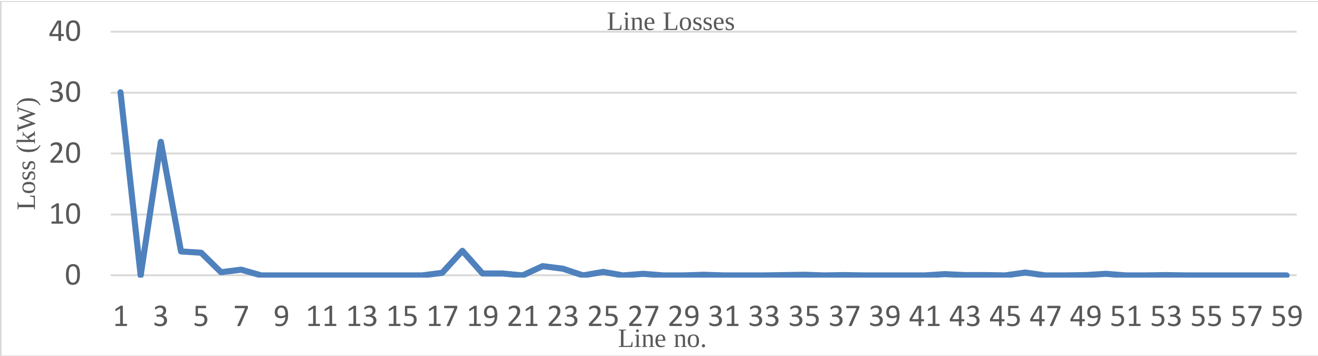

Figure 4 Active Power Losses of Each Line of the System

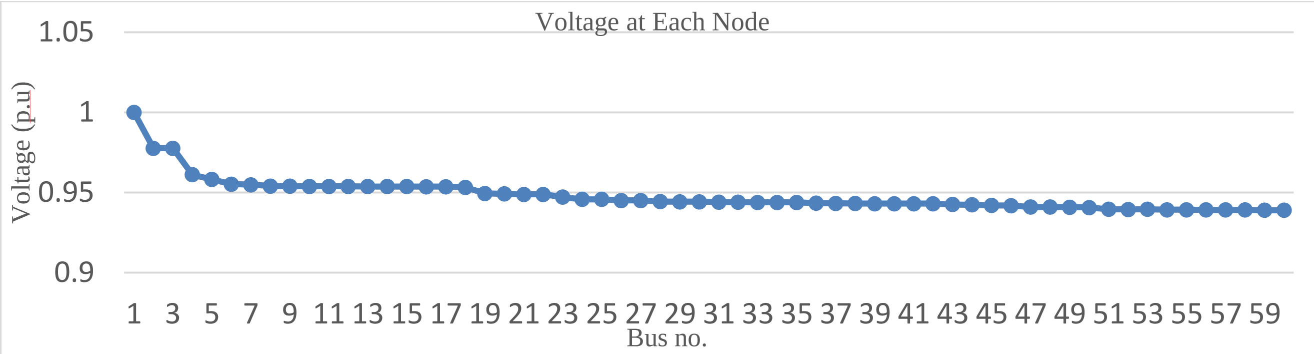

Figure 5 Voltage at Each Node of the System

Following different cases are considered. First line no 2 having highest loss is replaced. Then both the line 2 and line no 5 are replaced.

1) Re-planning by panther conductor considering only one conductor replaced.
2) Re-planning by panther conductor considering only one conductor replaced.
3) Re-planning by panther conductor considering only one conductor replaced.
4) Re-planning by panther conductor considering two conductors replaced.
5) Re-planning by panther conductor considering two conductors replaced.
6) Re-planning by panther conductor considering two conductors replaced.

Table 1 Results of Re-planning

Sr no.	Active power loss (kW)	Reactive power loss (kvar)
Test system	70.9293	40.9293
Case 1	54.9244	39.7871
Case 2	47.0263	39.6231
Case 3	45.5817	39.5556
Case 4	43.6041	39.5566
Case 5	30.3801	38.8518
Case 6	27.9810	38.7411

Now different locations for the capacitor placement are determined with the use of GA and capacitor placement is applied to above cases of re-planning. Table 2 shows the different location for the capacitor placement out of them bus no.55 & 59 are optimum locations. Table 3 shows the results after capacitor are placed at node 55 & 59 with re-planning.

Table 2 Results for Capacitor Placement using GA

Sr. No.	**Combination**	**Lowest Voltage (pu)**	**Improved Voltage (pu)**
Test system		0.9389	
1	43,50	0.9389	0.9413
2	49,57	0.9389	0.9416
3	42,52	0.9389	0.9416
4	55,59	0.9389	0.9420
5	52,60	0.9389	0.9418

Table 3 Results for Capacitor Placement using GA with Re-planning

Case	Power Loss (kW)	Lowest Voltage (p.u)	Improved Voltage (p.u)
Test system	70.9293	0.9389	0.942
1	54.9244	0.954	0.957
2	47.0263	0.9521	0.955
3	45.5817	0.9529	0.9558
4	43.6041	0.954	0.957
5	30.3801	0.9616	0.9645
6	27.9801	0.963	0.9659

Fig.6. shows the comparison of voltage profile for different cases.

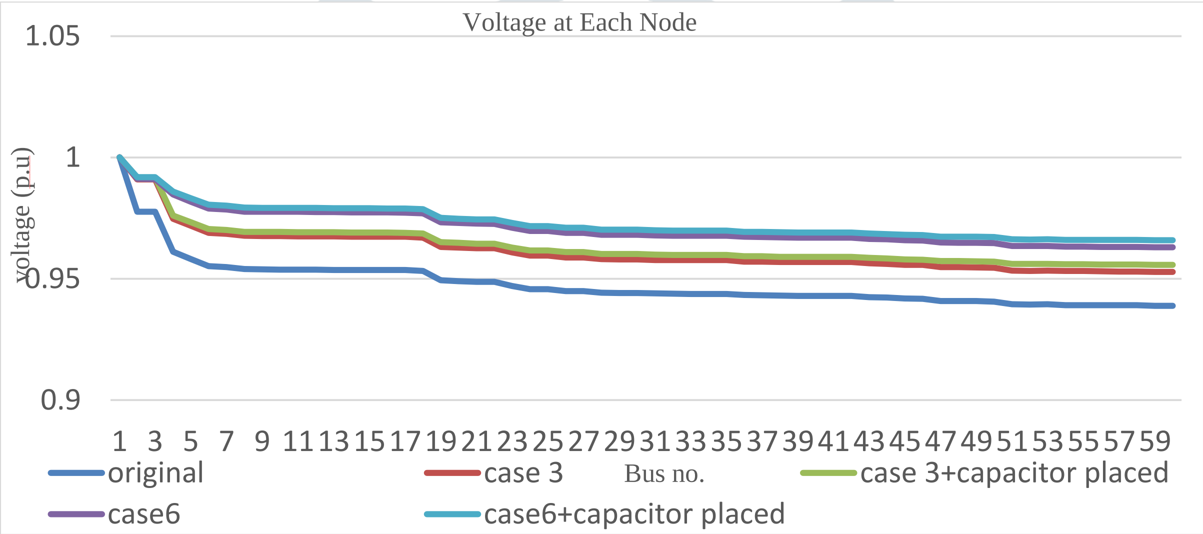

Figure 6 Voltage Profile Comparison

VI. CONCLUSION

In this work a part of Madhya Gujarat Vij Company Ltd. (MGVCL), Gujarat is considered for re-planning and capacitor placement to check the possibilities of power loss reduction and voltage profile improvement. From the above work, it can be concluded that

1. For 1st line conductor replaced by moose conductor and capacitor is placed.
   For the part of MGVCL, Gujarat system, the power loss is **reduced by 35.74%** using moose conductor **and the power loss reduced by 40.88%** for capacitor bank of 50 kvar is placed in the system. Voltage is improved from 0.9389 pu to 0.9558 pu at lowest voltage bus.
2. For 1st line conductor and 2nd line conductor both replaced by moose conductor and capacitor is placed.
   For the part of MGVCL, Gujarat system, the power loss is **reduced by 61%** using moose conductor **and the power loss reduced by 63%** for capacitor bank of 50 kvar is placed in the system. Voltage is improved from 0.9389 pu to 0.9659 pu at lowest voltage bus.

VII. ACKNOWLEDGMENT

Special thanks to Mr. Hitendra Pardasani, DE, MGVCL, Anand for providing the system data.

REFERENCES

[1] L. Rojas, R. Garcia and L. Roa, "Optimal Capacitor Location for Radial Systems using Genetic Algorithms," *2006 IEEE/PES Transmission & Distribution Conference and Exposition: Latin America*, Caracas, 2006, pp. 1-4

[2] M. E. Baran and F. F. Wu, "Optimal capacitor placement on radial distribution systems," in *IEEE Transactions on Power Delivery*, vol. 4, no. 1, pp. 725-734, Jan 1989.

[3] J. A. Michline Rupa,S. Ganesh, “Power Flow Analysis for Radial Distribution System Using Backward/Forward Sweep Method”, World Academy of Science, Engineering and Technology. International Journal of Electrical, Electronics and Communication Engineering Vol:8, No:10,2014.

[4] Jatin Singh Saini, M.P. Sharma S.N. Singh, “Voltage Profile Improvement of Rural Distribution Network by Conductor Replacement” International Electrical Engineering Journal (IEEJ) Vol. 5 (2014) No.7, pp. 1490-1494.

[5] V. Usha Reddy and T. Gowri Manohar, "A two stage approach: Capacitor placement for loss reduction in radial distribution system," *2012 11th International Conference on Environment and Electrical Engineering*, Venice, 2012, pp. 555-558.

[6] Rao, R. S. Narasimham, S. V. L, “Optimal Capacitor Placement in a Radial Distribution System using Plant Growth Simulation Algorithm”, International Journal of Electrical and Electronics Engineering (2008).

[7] Vahid Farahani, Seyed Hossein Hesamed in Sadeghi, Hossein Askarian Abyaneh, Seyed Mohammad Mousavi Agah and Kazem Mazlumi, “Energy Loss Reduction by Conductor Replacement and Capacitor Placement in Distribution Systems”, IEEE transactions on power systems, 28(3) 2077-85, August 2013

[8] V. K. Mehta, Rohit Mehta, “Principles of Power System”, S. Chand, 4threvised edition.

[9] S.N. Sivanandam, S.N. Deepa “Principle of Soft-computing” Wiley India Pvt. Ltd(publication) 2008