MINIMIZATION OF ACTIVE POWER LOSSES AND VOLTAGE IMPROVEMENT IN DISTRIBUTION NETWORK

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Abstract: The paper discusses about reduction of active power loss in distribution system by power system reconfiguration technique. The Reconfiguration is simple open and close operation of sectionalizing and tie switches that find the combination of switches which is optimal configuration with minimum active power losses for network. Here, the configuration can solve by Manual method, but the manual method has limitation so the genetic algorithm technique is used for determine the best configuration. The Distributed Generation (DG) unit is added for more reduction in real power loss. This method is tested for **a** part of distribution network of Madhya Gujarat Vij Company Limited (MGVCL) 30 bus system. The test results are included in paper. The result shows the reconfiguration technique for real power loss is very useful. It reduces the real power loss and improves the voltage profile of the network.

Index Terms - Load Flow Analysis, Power System Reconfiguration, Distribution Generation, Genetic Algorithm.

I. INTRODUCTION

Distribution network is one major part of electrical network system that connects consumers with substation. The distribution network has a major problem that active power loss. To overcome that problem technique used which is power system reconfiguration. The power system reconfiguration is simple open and close operation of network switches. It is called as a sectionalizing and tie switches. The open switches are called Tie switches and closed switches are called Sectionalizing switches.

The distribution system losses are higher than transmission losses, if the average transmission losses are between 1% to 2.6% while distribution losses are between 2.3% to 11.8% [1].

To find combination of tie switches to get optimal solution that minimum active power loss for network. This optimal combination of switches can minimize real power losses as well as improve voltage profile and reliability of network. For active power support on lowest voltage buses Distribution Generation (DG) unit added, that can also improve voltage profile and reduce real power losses. The major point for reconfiguration is that the network radiality must be maintained after reconfiguration of network. DG is defined as electrical power resources that are directly connected to the distribution system [2].

The reconfiguration of the network is done by manual method, but the manual method cannot work for big network. It is too difficult to find the combinations of tie switches by manual method for big distribution network, because it has lots of lines (switches) and buses. So, here the Genetic Algorithm (GA) technique is used to find combination of switches. The genetic algorithm technique has a binary operator which is in the form of ‘0’ and ‘1’. Means for closed switch it is ‘1’ and for open switch it is ‘0’.

For the power flow solution backward forward sweep method is used, because the distribution network has high R/X ratio till the distribution networks are ill-conditioned and normally used Newton-Raphson (NR) and Fast Decoupled Load Flow (FDLF) methods are not capable of solving them. In the convergence of solution there will be difficulties [3-4].

II. FORMULATION OF THE PROBLEM

With the help of reconfiguration technique to find combinations of network tie switches that network has minimum real power losses and not violating operating constraints. From the load flow there are active load, reactive load, total load, voltages are calculated.

$$\text{Minimize real power losses} = \sum_{0}^{n-1} PLOSS \qquad (1)$$

The proposed work has constraints which are following:

a. If the reconfiguration is done for any network, after reconfiguration network must be radial. Means network radiality must be maintained.
b. Each and every load which is connected to the network must be supplied by its power requirements.
c. The voltage magnitudes of each node are must be in specific limit.

- The voltage magnitude is between v_{min} and v_{max}
- The v_{min} and v_{max} are lower and upper limits respectively.

$$v_{min} < v_i < v_{max} \qquad (2)$$

III. LOAD FLOW ANALYSIS

A backward forward sweep method is used for load flow analysis. The backward forward sweep method is basically two types: Backward sweep and forward sweep.

In the backward sweep method current flow or power flow calculations with possible voltage updates are calculated. Calculation starting from last node and ends on first node. The purpose of the forward propagation is to calculate the voltages at each node starting from the feeder source node. The feeder substation voltage is set at its actual value. During the forward propagation the effective power in each branch is held constant to the value obtained in backward walk [5]. The flowchart for load flow method for MATLAB programming is below:

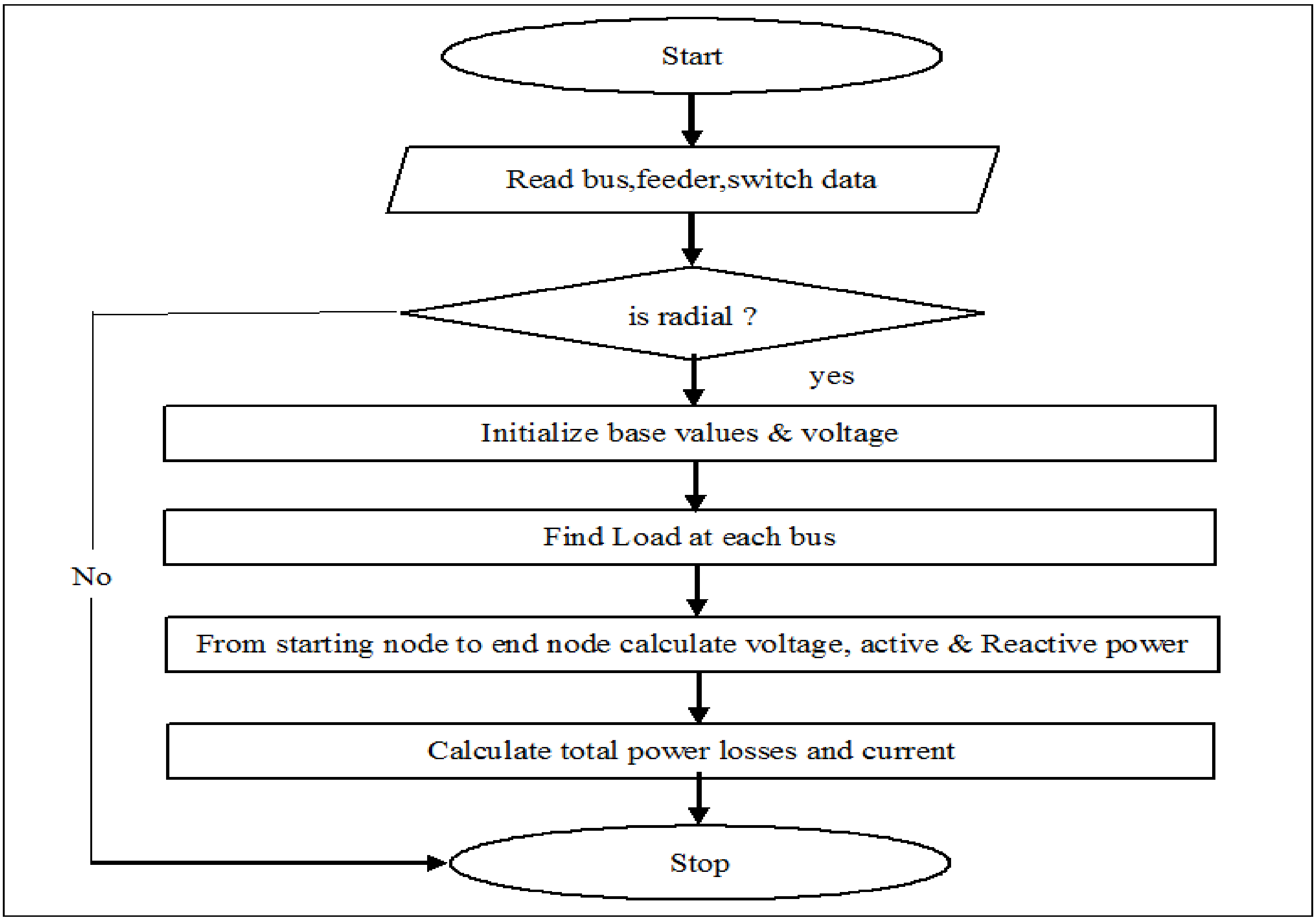

Fig.1 Flowchart for Backward Forward Sweep Method

For better understanding the load flow take an example for load flow analysis using proposed method. Consider figure 2.

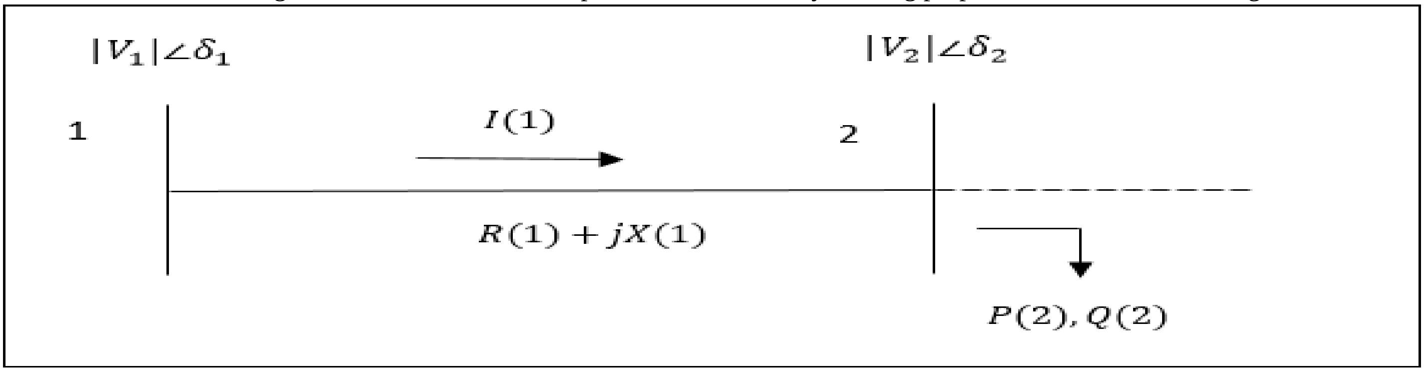

Fig.2 Example System of Load Flow [6]

From above figure 2, the equation derived:

$$I(1)=\frac{|V(1)|\angle\delta(1)-|V(2)\angle\delta(2)}{R(1)+jX(1)} \quad (3)$$

$$P(2)-jQ(2)=V(2)*I(1) \quad (4)$$

Where, $I(n)$ = current flow in branch n

$V(n)$ = voltage flow in bus n

$\delta(n)$ = load angle

$R(n)$ = Resistance of branch n

$X(n)$ = reactance of branch n

From equation (3) & (4),

$$\begin{aligned}|V(2)|=\{&[(P(2)*R(1)+Q(2)*X(1)-0.5|V(1)|^2)^2\\ &-(R^2(1)+X^2(1))(P^2(2)+Q^2(2))]^{1/2}\\ &-(P(2)*R(1)+Q(2)*X(1)-0.5|V(1)|^2)\}^{1/2}\end{aligned} \quad (5)$$

P(2) & Q(2) are active and reactive power of branch 2.
With the help of equation (5), we can calculate total active and reactive power losses [6].

$$LP(1)=\frac{R(1)*[P^2(2)+Q^2(2)]}{|V(2)|^2} \quad (6)$$

$$LQ(1)=\frac{X(1)*[P^2(2)+Q^2(2)]}{|V(2)|^2} \quad (7)$$

IV. GENETIC ALGORITHM

Genetic Algorithms (GA) are adaptive search algorithms based on the evolutionary ideas of natural selection and genetics. Genetic algorithm is used for solve difficult optimization problem [7-8]. The binary ‘0’ and ‘1’ are used here for open and close operation of switches. That is called chromosomes. That group of chromosomes is called as a population and GA use number of populations for initial process. For find the best solution genetic algorithm (GA) use fitness function. This fitness is nothing, but best combination of tie switches.

Here,

$$\text{Fitness} = \frac{1}{PLOSS} \quad (8)$$

The genetic algorithm has operators which are Reproduction, Crossover and Mutation. Reproduction is the process where selection process of parent chromosomes done. The selection process of parents is depended on fitness of parents.

The crossover is the principle operator of GAs. It aims at mixing up genetic information coming from two different parents, to make a new child. Means point of string chosen to interchange genetic information of both parents. After crossover mutation operator randomly change one bit in the string, it is depended on probability of mutation [9].

The steps of process of genetic algorithm are as below:

1. Start program read bus data, line data, and feeder data of test system.
2. Take the switch data (open/close condition) in binary ‘0/1’ form.
3. Generate population string with random chromosomes.
4. Check radiality, and choose two possible population strings for crossover process.
5. Make Crossover process between that strings and generate another two child string.
6. Change one bit of that child string for mutation process, numbers of change in bit is depended on mutation probability.
7. Respective results are displayed.
8. Stop the program.

IV. RESULTS AND DISCUSSION

The test system data is from MGVCL. The test system has 30 buses. The test system has 27 sectionalizing and 3 tie switches. Circuit breakers are used as switches.

The system Base voltage is 11kV, system total active load is 2125.935kV and system total reactive load is 1317.536kVAR. The two DGs are 50kV rating and connected to two lowest voltage buses for voltage improvement.

There are three cases take for comparison:

- Case 1: Original configuration results as shown in figure 3.
- Case 2: Best optimal solution with minimum losses after reconfiguration.
- Case 3: Add two DG units in Case 2.

Table 1 analysis of different cases

System configuration and parameter	Case 1	Case 2	Case 3
Switches open	28,29,30	5,19,25	5,19,25
Total active power losses (kW)	61.6306	52.2023	47.2337
Lowest voltage bus (pu)	0.9610	0.9635	0.9702
Lowest voltage buses	29,30	29,30	29,30

The 30 bus MGVCL real system is shown as figure 3:

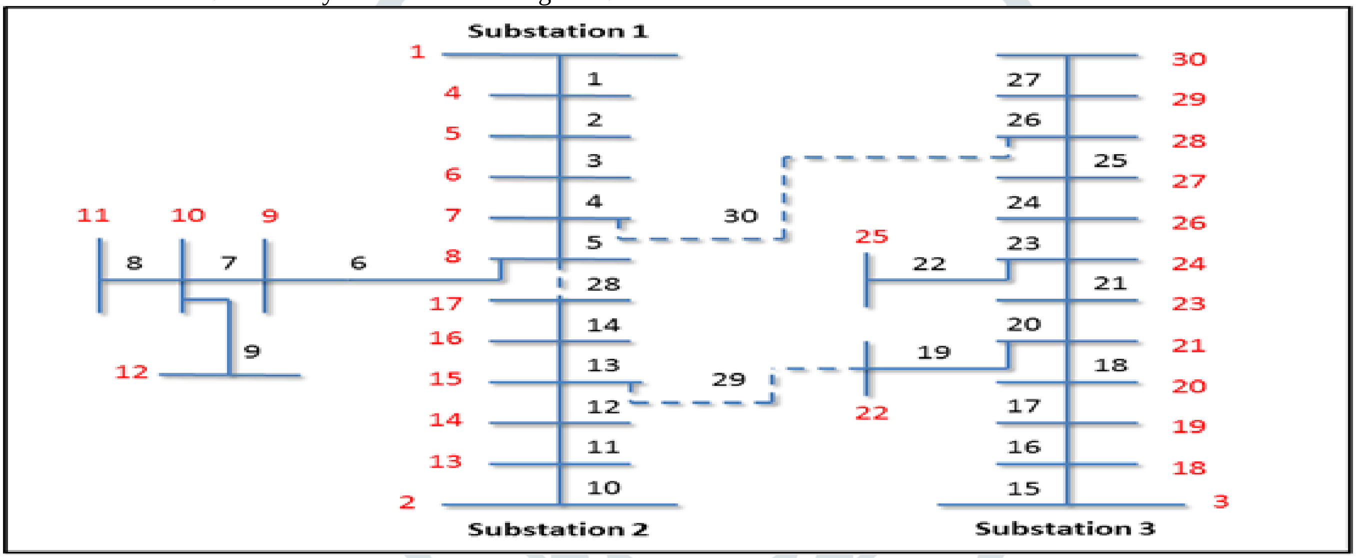

Fig.3 MGVCL Real Test System

The below figure 4 is comparison of voltage at each node between three cases for real 30 bus system:

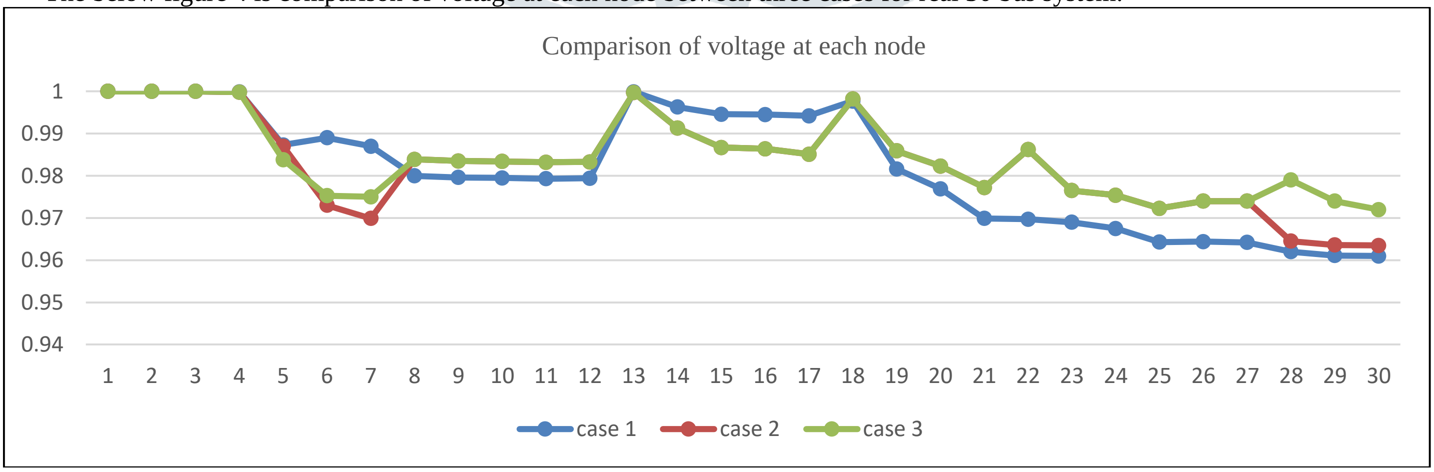

Fig.4 Comparison of Voltage at Each Node for Different Cases

The figure 5 is comparison of real power losses between three cases:

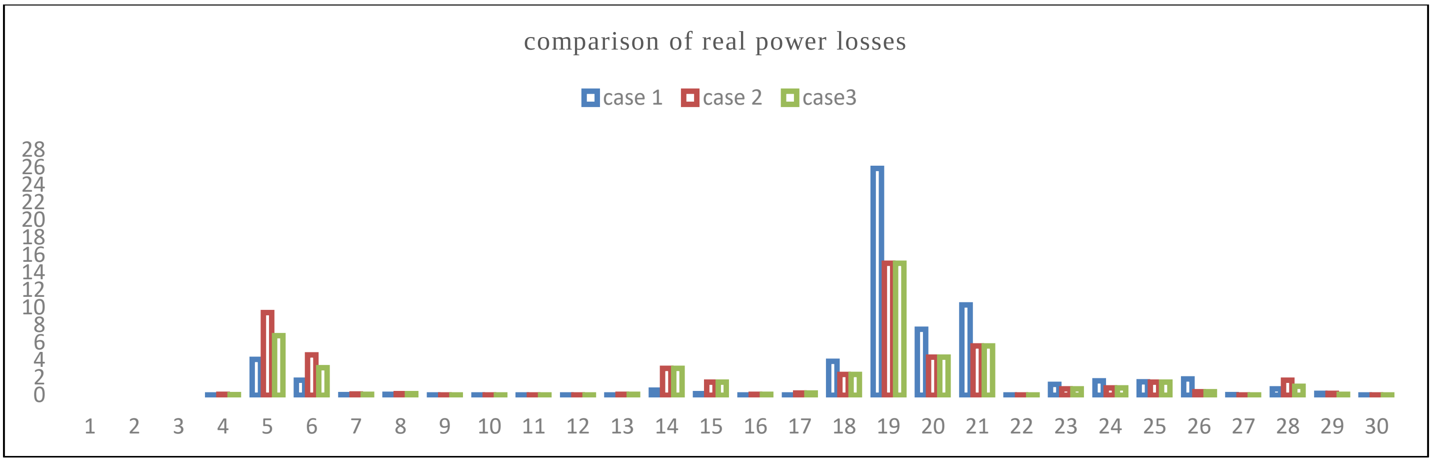

Fig.5 Comparison of Real Power Losses between Different Cases

V. CONCLUSION

As shown in Table 1 and figure 4 & 5, In MGVCL 30 bus real system, the overall system losses are decreased from 61.6306 kW to 47.2337 kW and the lowest voltage node voltage improved from 0.9610 pu to 0.9702 pu (approx. 23% losses could be reduced). The overall system losses reduced after reconfiguration. After applying GA, many solutions displayed but the case 2 is best out of them. The cost analysis can possible for this system for future scope.

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