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A New Approach for Restructuring Vijayanagar Feeder [MUSS Hassan] to reduce the distribution loss

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Abstract: Electricity distribution is the final stage in the delivery of electricity to end users. A distribution system's network carries electricity from the transmission system and delivers it to consumers. The performance of distribution system becomes inefficient due to the reduction in voltage magnitude and increase in distribution losses. Distribution system reconfiguration is one of the techniques to minimize the losses. The standard switching indices are used for the network reconfiguration. An algorithm has been developed to arrive at an efficient network configuration using MATLAB software. The algorithm has been tested on standard 32 bus system and 11kV distribution system of Master Unit Sub Station, Hassan.

Keywords: Distribution losses, Switching Indices, Voltage Magnitude, Weighing factor.

I. INTRODUCTION

Feeder reconfiguration for loss reduction is a very important function of distribution system to reduce distribution feeder losses and improve system security. There are a number of normally closed and normally opened switches in a distribution system, and hence the number of possible switching operations is challenging. The initially designed and implemented distribution network later sometime requires reconfiguration of feeders which allows the transfer of loads from heavily loaded feeder to less heavily loaded feeder. By changing the normally open (NO)/normally close (NC) status of the switches as and when required based on the load demand helps in transferring load currents from one feeder to another feeder. Feeder reconfiguration allows the transfer of loads from heavily loaded feeders (or transformers) to relatively less heavily loaded feeders (or transformers). Such transfers are effective not only in terms of altering the level of loads on the feeders being switched, but also in improving the voltage profile along the feeders and effecting reductions in the overall system power losses. The installation of reconfiguration network is much simpler and cost efficient compared to other techniques.

II. METHODOLOGY

The problem of network reconfiguration is formulated as below.
The power loss in the branch between the buses i and j is given by

$$P_{loss(i,j)} = R_{i,j}(|V_i - V_j|\,|Y_{ij}|)^2 \quad (1)$$

Where
R_{ij} : branch resistance between bus i and bus j
V_i : bus i voltage
V_j : bus j voltage
Y_{ij}: branch admittance between bus i and bus j
In general, network reconfiguration for loss minimization can be formulated as

$$\text{Min} \sum P_{loss(i,j)} = \sum R_{i,j}(|V_i - V_j|\,|Y_{ij}|)^2 \quad (2)$$

The operational constraints have to be satisfied. The constraints may be listed as the

- final network must remain radial with all the nodes energized
- The voltage and current magnitudes must remain within the permissible limit.

The most appropriate switching combinations are determined using the switching indices. To obtain the switching indices close all the tie switches in the network to form as many loops as the number of tie switches. For the minimum loss in

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every loop has one opening switch. By opening that switch radiality in that loop is regained. The procedure is repeated for all other loops. The switching indices for all the branches are calculated in the looped state.

Switching Index= (Voltage index) * (Ohmic index)

The Voltage index

$$\mu_v (n) = \exp^{-(\omega(\Delta vn)^2/(\Delta vav)^2)} \quad (3)$$

Where,

ΔVn : The voltage drop between two terminals of branch N

ΔV^2: The mean square voltage drop of all branches for chosen loop

ω : Weighing Factor

The Ohmic index

$$\mu_l(n) = \exp^{-\omega(R|Y|^2)(Rav * Yav)} \quad (4)$$

Where,

R_{av}: The average branch resistance for a chosen loop

Y_{av}: The average branch admittance for a chosen loop.

ω: Weighing Factor

Under normal operational state, the optimal decision can be obtained by:

$$\text{Max } \mu_D(n) = \text{Max } \{\mu_v(n) * \mu_L(n)\} \quad (5)$$

The weighing factor ω is assigned to every branch in looped state and the weightage to open a branch progressively decreases as we move away from the tie branch in either direction of the loop starting from the tie branch. The switching indices are arranged in the descending order and those branches having largest index values are the candidate branches for reconfiguration. Since the problem of reconfiguration is a complicated combination the best solution may not be obtained from opening the braches with highest index values. The best option could be further down in the order of switching indices. Therefore for selected number of options in the descending order of switching indices, the losses are determined. The combination which gives the minimum loss is the best option.Load flow analysis is done using Newton-Raphson method. Based on the solution methodology an algorithm is developed and the flow chart is as shown in fig 1.

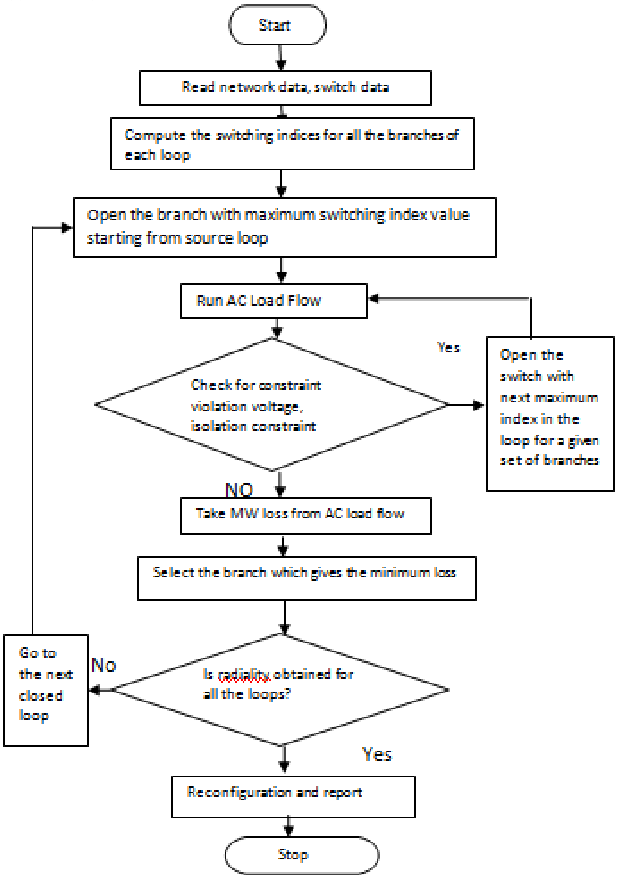

Fig 1. Flow Chart

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The developed algorithm for reconfiguration of distribution network is given below.

1. Read the network data
2. Form a network and tabulate the bus data and line data.
3. Close all the switches to form looped network and run AC load flow.
4. 4. From the load flow data, for all the loops identify the highest priority branches and assign weighing factors to all the branches.
5. Compute the switching indices for all the branches of each loop; arrange them in the descending order.
6. Starting from the loop near the source, open the branch with highest switching index and run the AC load flow.
7. Check for constraint violation.
8. If any constraint is violated, ignore that branch for opening and go to step 6.
9. Retain the radial topology of the loop and repeat steps 6, 7 and 8 for all the loops in the network.
10. Obtain the final reconfiguration report.

IV. CASE STUDIES AND RESULT

A) STANDARD 32 BUS SYSTEM

The proposed algorithm has been applied to a standard 32 bus system which has been taken as the benchmark problem for network reconfiguration in many IEEE papers. The standard 32 bus system is shown in figure 2.

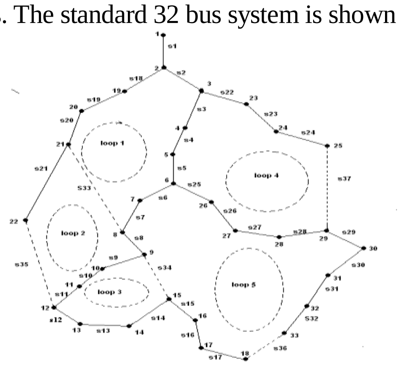

Fig. 2 32 bus system

Switching indices for all the loops of 32-bus system are found using the algorithm and the loss reduction is shown in table 1.1.

Table 1.1. Loss analysis of 32 bus system

CASE	OPEN SWITCH	LOSS (MW)	LOSS REDUCTION (%)
Initial network	33,35,34,37,36	0.2025	-
Reconfiguration Network	7,9,14,37,32	0.1395	31.11

B) 11kV DISTRIBUTION SYSTEM OF MUSS HASSAN

The proposed algorithm has been implemented to the 11kV distribution system which is radiating from Master Unit Sub Station Hassan. It has five closed loops and the 20, 21, 22, 23 and 24 are the tie switches.

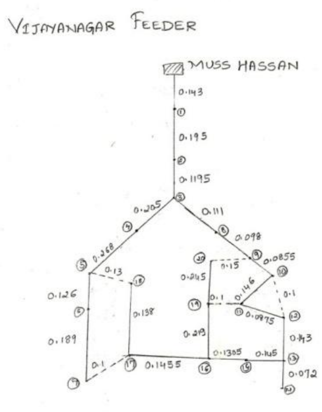

Fig. 3 Vijayanagar Feeder MUSS Hassan

Switching indices for all the loops of network are found using the algorithm and the loss reduction is shown in table 1.2.

Table 1.2. Loss analysis of Vijayanagar feeder

Case	Open switch	Loss(MW)	Loss reduction (%)
Initial network	21, 22, 20, 24, 23	0.1089	-
Reconfiguration network	16, 17, 24, 15, 11	0.0959	11.938

V. CONCLUSION

There are several operational schemes in power distribution systems and one of these is network reconfiguration. A new algorithm has been proposed in this work for network reconfiguration. In some existing algorithms, the solution is largely depend upon selection of tie branches and if the tie branches are not at appropriate locations, the results could be far away from optimal solution. The new algorithm proposed in this network is independent of satisfying the tie branches in the data. The proposed algorithm has been applied to a standard 32 bus system. It is interesting to note that there is a reduction of 31.11% of technical losses in reconfigured network. The proposed algorithm has been implemented on a 11kV distribution system which is radiating from the Master Unit Substation, Hassan and it was found that the technical losses were reduced by 11.938% in the configured network.

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