# RELIABILITY IMPROVEMENT AND LOSS MINIMIZATION IN RADIAL DISTRIBUTION NETWORKS USING SWARM OPTIMIZATION TECHNIQUE

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***Abstract:***
*The purpose of the paper is to find the best distributed generators (DGs) location for improving reliability and reducing power loss using distribution system reconfiguration. This is implemented in the presence of the tie-switches. It proposes a search-based algorithm for the reconfiguration problem. Individual DG placement is obtained for all system configurations, and analytical hierarchy process tool is used for finding the overall best location. This is carried out for various system loadings. The proposed method identifies the placement of distributed generation at distribution systems for reliability improvement and power loss reduction which is one of the present day needs for fulfilling the raising power consumers. The proposed methodology has been tested on standard 33-node and 69-node test distribution systems and also implemented 120-node system.*

***Keyword:***
*Reconfiguration, Distributed network, Voltage Profile, Swarm Optimization.*

## I. INTRODUCTION

In the current scenario the Electricity is become the very important part of the human beings without the electricity the life of humans is miserable. The supply of electricity is become the important part of the large scale distribution systems, where the powers has to travel for far distances from the source, the sources are basically placed in the distance place from the residence areas. Since from two decades the distribution of network reconfiguration is dealing having the objective of minimize the power loss and to balance loads to improve the voltage[1]. In the distribution network we have basically two kinds of switches those are sectionalizing switches(Closed) and tie switches. The process of reconfiguration will alter the current status of switches those switches which are change the topological structure of the system. The advantages of reconfiguration is that; it can be real power loss reduction, balancing the load of the network, voltage profile of bus improvement, the quality of power improvement, more system security, less time taken for power supply restoration and minimum undersupplied power[2]. Distribution System Reconfiguration (DSR) is basically the process of altering the topological structure of distribution feeders by changing the open/closed states of sectionalizing and tie switches. DSR is applied to achieve the following:
Power loss minimization.
Voltage profile improvement.
Load balancing.
Reliability improvement.
Distributed Generation (DG) also called as on-site generation, dispersed generation, embedded generation, decentralized generation is basically small scale generation and is connected directly to the distribution network or on the consumer side of the meter[3].

## II. RELATED WORK

In the reconfiguring the network in the literature work some works have been reported by using various methods, in that Dai and Sheng [1] has reported the network reconfiguration problem by combining a two-stage optimization problem, and only loaddata uncertainty was considered. Gomes and Carneiro [2] is reported an improved heuristic algorithm tofind optimal network structures. They took all weak loops into consideration at once and established a maneuvering list, then tried to open each weak loop according to the list, till the network became radial again. In [3], krill herd (KH) algorithm and its oppositional version called oppositional KH algorithm were applied to solve the optimal configuration problem in conjunction with capacitor placement. In [4], the modified bacterial foraging algorithm has been applied to optimize network configuration such that network losses are reduced. The binary particle swarm optimization (BPSO) method has been applied in [5] to determine the optimal network configuration for minimizing network losses as well as maximizing service reliability.

Distributed generation are a promising solution for the improvement of efficiency and reliability of a distribution system. The impact of DG on power losses varies with network topology and location, as well as type of DG size [6]. Analytical expression was considered for DG placement in [7] for power loss reduction. PSO technique adopted for different types of DG placement in [8].Switches are closed /opened to establish optimal network using a heuristic algorithm in [9] Many techniques such as genetic algorithm (GA)[10], improved tabu search [11] and Harmony search algorithm(HSA) used in[12] for reduction of active power loss using Network Reconfiguration Reliability evaluation techniques for Distribution system planning studies and operation are presented in [13].

This dissertation work investigates the method to reconfigure a radial distribution network in the presence of DG for power loss minimization considering constraints on voltage magnitude at different busses, power flows in different lines and radial structure of the network.

- To solve the reconfiguration problem, PSO based method has been proposed in this paper
- The developed methodology has been tested on a 33-bus, 69-bus IEEE distribution network, based on the standard bus network designed 120-bus distribution network.
- The impact of DG on losses of reconfigured distribution network has also been analyzed.

## III. DG ON RELIABILITY

The problem is so formulated to get the maximum PLoss reduction in the distributed system which is considered to be sum of power loss reduction due to reconfiguration as well as installation of DG [7], which is subjected to power flow, voltage, current and reliability indices as shown below:

$Maximize\ f = max\Delta P_{Loss}$

Node voltages: and current limits:

$V_i, min \leq V_i \leq V_i, max$ and $I \leq I_b$

**Reliability evaluation**

Reliability analysis also plays a key role in planning for up-gradation of the distribution network, thus meeting new and ever-increasing demands. To evaluate reliability of system, load point indices are used.

Average failure rate($\lambda_s$)

$\lambda_s = \sum_{i=1}^{N} f/yr$

Average annual outage ($U_s$)

$U_s = \sum_{i=1}^{N} \lambda_i r_i hrs/yr$

Average outage time ($rs$)

$rs = Us/\ \lambda s\ \ hrs$

## IV. PROPOSED METHOD

The proposed methodology is tested on 33-node and 69- node and 120 node test distribution systems. The distribution network reconfiguration with distributed generation for the improvement of reliability and minimization of real power losses is proposed. The coding is carried in Matlab 2016a and is used. It is assumed for all the test systems that the system is fully automatized with sectionalizing switches in all the lines. Initially, tie-switches are placed at end nodes considering geographical constraints and then preceded by optimal siting and sizing of DGs at these tie-switch locations. DG placement is carried out at the terminal nodes of the system with alteast one DG at tie-switch as constraint and for sizing *fmincon* solver which is a constrained nonlinear optimization method is used. The data for the tie-switches are considered same as the lines connected adjacent to them.

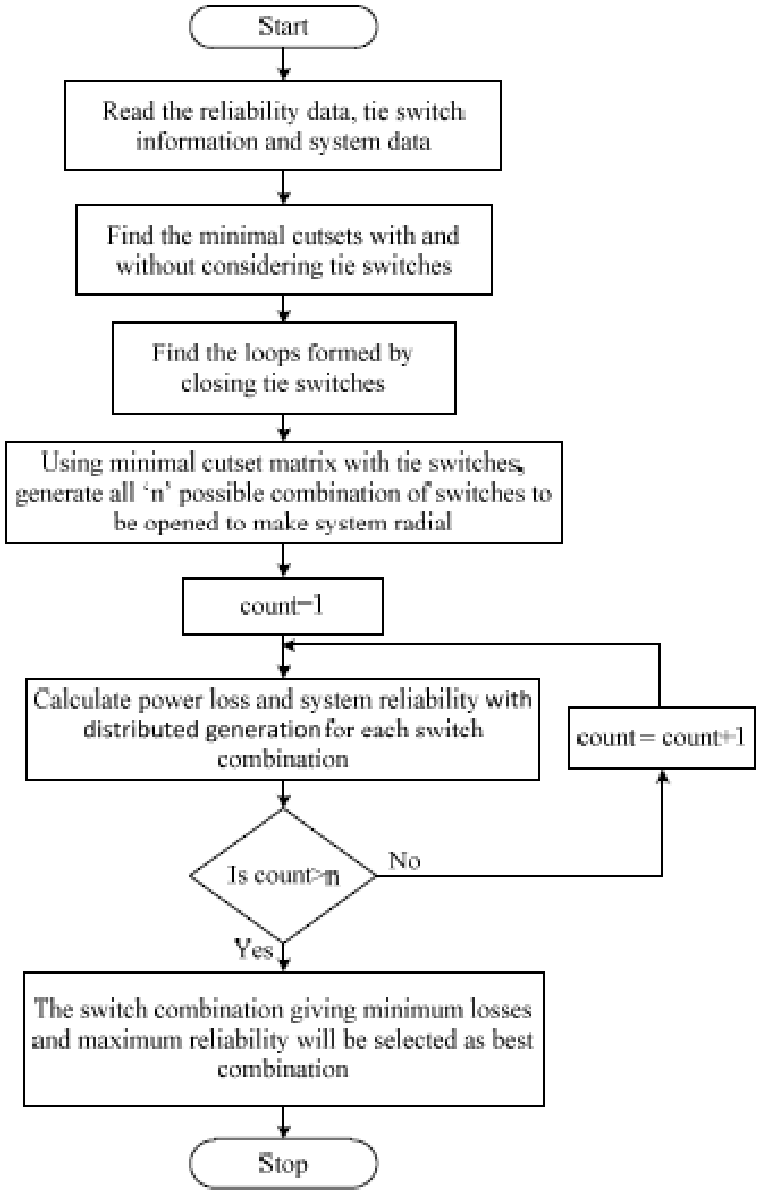


Fig 1. Flow chart for the network reconfiguration[9]

The final step is the network reconfiguration considering reliability and power loss. A search algorithm is formulated for the reconfiguration problem which is explained with the help of a flow chart shown in Fig 1. The reconfiguration algorithm runs as many times as total switch combinations excluding the tie-switches. In each iteration, those lines sectionalizing switch will be opened in such a way that system radial nature is preserved and the power loss and the system reliability is calculated. The switch configuration which is giving minimal losses and high reliability will correspond to the optimal network configuration and the same is explained in the flow chart.

## VI. RESULTS

### A. 33-node distribution system

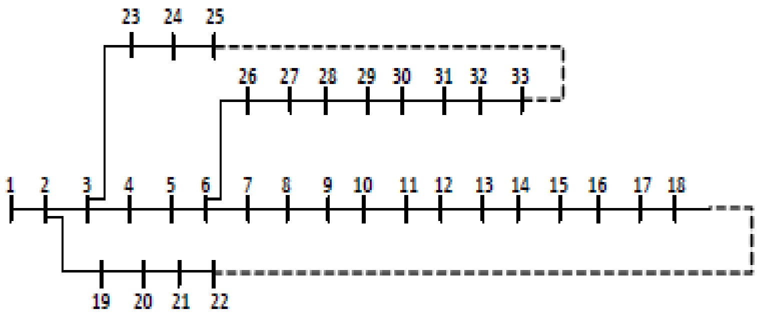


Fig2. Modified 33 node distribution system

The procedure explained in the previous section is followed for the 33 node test system too. The system is as shown in Fig. 2 with tie-switches as dotted lines. Initially, tie-switch placement is carried out taking geographical constraints. The tie-switch locations selected are 18-22 and 25-33 and they will be in open position before reconfiguration. Now DGs are placed at these tie-switch node with atleast one DG at a tieswitch. The positions for DGs are obtained as nodes 18 and 33. The DG size problem is done using *fmincon* solver using objective and constraints as given in eqs. (6)-(11).

Table 1 Optimal size of DG for 33 node system

| | Bus 18 | Bus 33 |
|---|---|---|
| $P_{DG}$ | 647 | 1143 |
| $Q_{DG}$ | 400 | 708 |

It can be observed that after DG placement, losses got reduced by 76% and with reconfiguration algorithm considering both DG and tie-switches reduced the losses by 78% and reliability also improved. The real and reactive power generation fed from substation after DG placement reduced 49.7% and after network reconfiguration it further got reduced to 33.4%.

```
Power loss:                 208.4592 kW                       148.6552 kW
------------------------------------------------------------------------------
Power loss reduction:       _______                           33.006 %
------------------------------------------------------------------------------
Minimum voltage:            0.91075 pu                        0.94234 pu
------------------------------------------------------------------------------
Injected value Kse:             1
------------------------------------------------------------------------------
Qupqc(MVAr):                    0.8 pu
------------------------------------------------------------------------------
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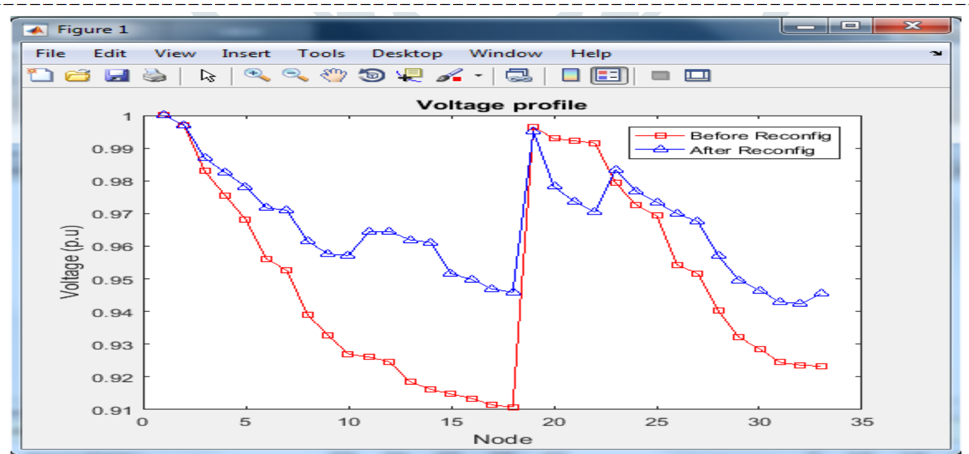


Fig 3. Voltage profile for base and after DG placement for 33 node system

**B. 69-node distribution system**

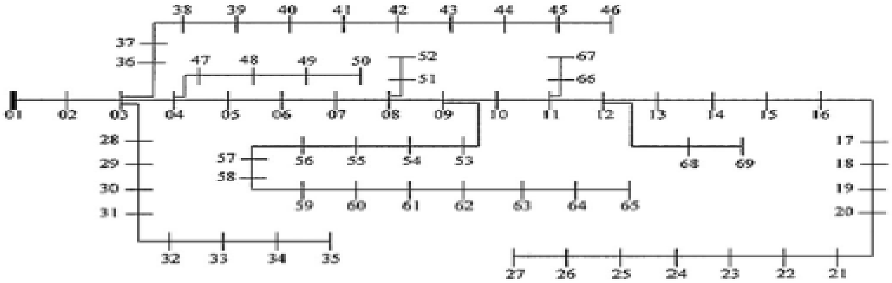


Fig 4. 66 node test distribution system

The tie-switch placement is carried out at end nodes. In this test system shown in Fig. 4, the end nodes are 27, 35, 46, 50, 52, 65, 67 and 69. The tie-switches are placed at 27-35, 50- 52, 46-67 and 65-69 and these will be in open position. Now DG siting and sizing is carried out in two steps. Initially DG placement at the tie-switch locations is done with constraint as atleast one DG at a tie-switch and is done using simple binary integer programming. The optimal DG locations are 35, 50, 65 and 67. The DG sizing has been carried out using *fmincon* solver with loss minimization as objective and the constraints are meeting load, power balance equations and voltage limits as in eqs. mentioned in section 3. Table-2 gives the real and reactive optimal DG size for this test system.

| | Bus 35 | Bus 50 | Bus 65 | Bus 67 |
|---|---|---|---|---|
| $P_{DG}$ | 297 | 556 | 1317 | 888 |
| $Q_{DG}$ | 210 | 394 | 933 | 629 |

```
Tie switches:            61  62  63  64  65            7  11  32  34  37
--------------------------------------------------------------------------------
Power loss:              208.4592 kW                   151.1352 kW
--------------------------------------------------------------------------------
Power loss reduction:    _______                       31.8163 %
--------------------------------------------------------------------------------
Minimum voltage:         0.91075 pu                    0.93996 pu
--------------------------------------------------------------------------------
Injected value Kse:          0.5
--------------------------------------------------------------------------------
```

The simulation results for 69 node system is shown below

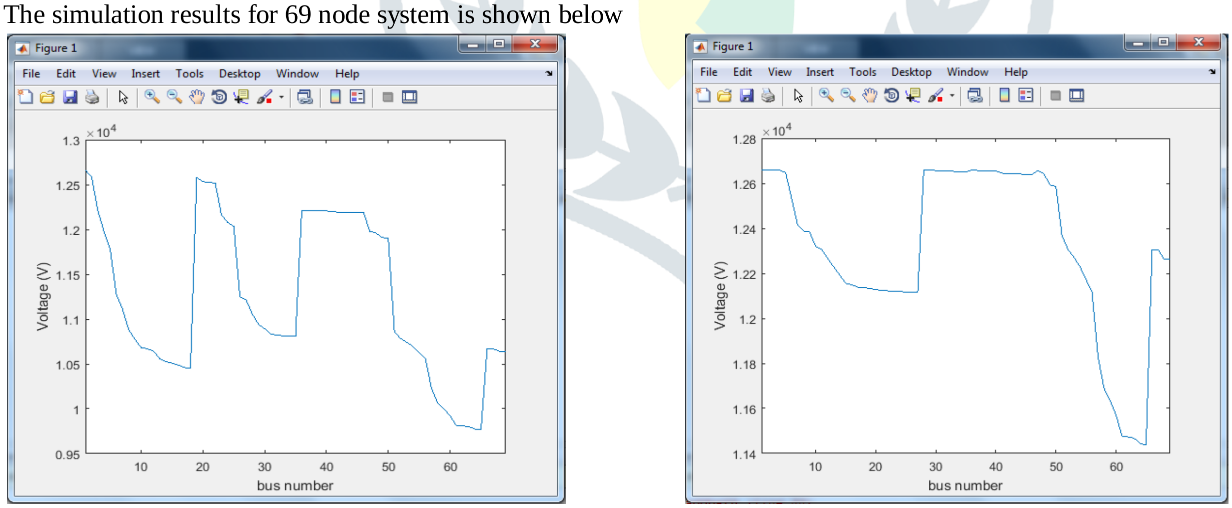


Fig 5. a. Voltage profile of 69 node system before reconfiguration b. Voltage profile 69 Node system after reconfiguration

### C. 120 Node distribution system

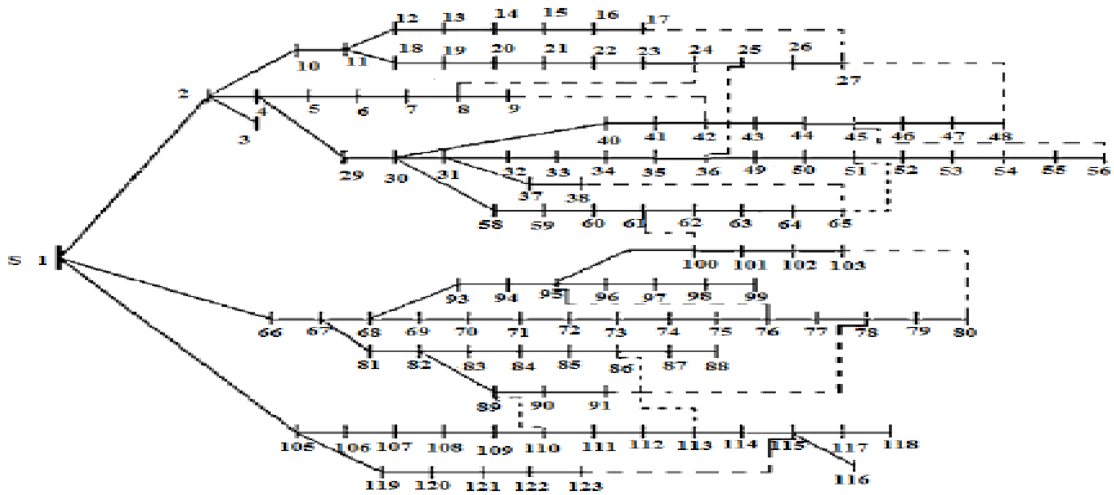


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Fig 6. 120 node test distribution system

The real and reactive power losses and real and reactive power generation fed from substation for the base case, with optimal DG size and after network reconfiguration with both DG and tie-switches. The system losses reduce by 85% with DG placement and further reduce to 90% with network reconfiguration. The 120 bus structure is shown above. The voltage varies 0.94vto 1.4v for 120bus system.

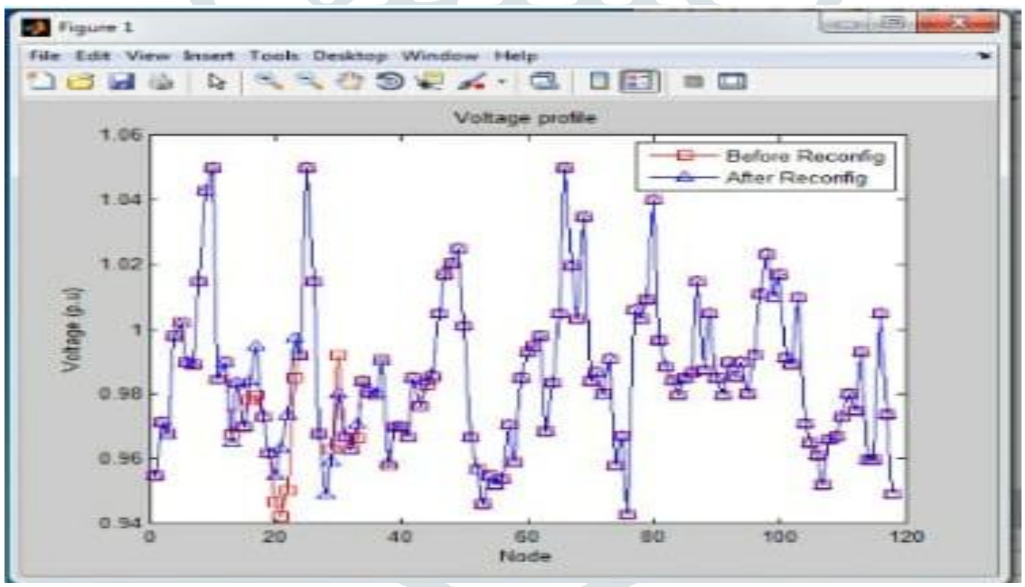


Fig 7. Voltage profile for base and after DG placement for 120 node system

## VI. CONCLUSION

The network reconfiguration with optimal DG siting and sizing and tie-switch placement for the reliability improvement and loss minimization is proposed. Tie-switches are placed at terminal nodes with geographical constraints and will be open position. DG siting and sizing is carried out using integer programming with objective minimum DGs and minimization of losses respectively. A search based reconfiguration algorithm has been formulated for finding the optimal switch configuration for the radial distribution system with DG. It can be observed from the results that there is considerable amount of reduction in the losses and improvement in the reliability obtained using the proposed method. The performance of the algorithm is tested on three test distribution systems and the gives better results.

## VII FUTURE SCOPE

With the rapid development of various emerging distributed technologies such as Grid computing, the reliability and loss minimization factor need to be improved. The optimization techniques like firefly algorithm, grey wolf optimization , grasshopper optimization etc can be implemented for obtaining better performance in electric distribution networks by reducing the power loss.

Therefore, integration of networking and distributed computing systems becomes an important research to solve problem for building the next-generation high performance radial distribution networks.

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