Real Power Loss Minimization and Voltage Profile Improvement by Network Reconfiguration

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Abstract— *Distribution network reconfiguration is the method of changing the topology of the distribution system by altering the status of the open/closed switches. In distribution network reconfiguration our main objective is to implement an optimization algorithm to reduce the real power loss to a minimum value and to improve the voltage profile of the radial distribution network. We have used a load flow method that is backward/forward sweep method, which is one of the most effective and efficient methods for the load-flow study of the radial distribution system. By using this method, power losses for each bus branch and voltage magnitudes for each bus node are determined. The high-power loss is the most common yet one of the very difficult issues in the electrical distribution network. The reduction in voltage results in high real power loss in a distribution system which needs to be minimized. We are going to implement an optimized solution and PSO algorithm for the distribution network to minimize real power loss and enhancement of voltage profile. For simulation and result analysis we have used MATLAB 2015a tool.*

Keywords—*MATLAB, PSO (Particle Swarm Optimization) Algorithm, BFS (Backward Forward Sweep) Algorithm, Load Flow Analysis/Study, DNR (Distribution Network Reconfiguration).*

I. INTRODUCTION

Distribution networks assume a significant part in giving power to loads; in any case, the power loss in the framework is high, and the voltage guideline is poor. There are numerous ways of diminishing the power loss and further develop voltage-profile in distribution network, for example, remunerating responsive influence, expanding working voltage, adjusting loads, and expanding wire segment.

These strategies are feasible to send as far as specialized angle however need a lot of speculation cost. Network reconfiguration is known as a compelling technique to lessen the power misfortune and further develop the voltage profile fundamentally in influence frameworks while requiring very little speculation cost. The conveyance network reconfiguration is performed by opening/shutting changes to frame another organization structure for decreasing power misfortune while fulfilling activity imperatives.

Load flow analysis are performed on power frameworks to comprehend the idea of the introduced network. It is utilized to decide the static presentation of the framework. A power-stream concentrate ordinarily utilizes worked on documentation, for example, a one-line chart and per-unit

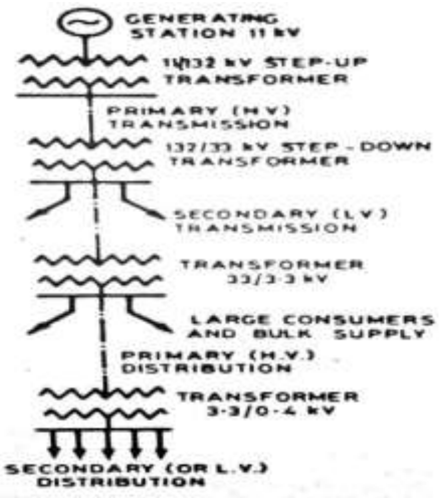


Fig. 1. Typical layout of Power System

A typical layout of the scheme has been shown in Fig.1. The transmission network is mostly at EHV level (at or above 66 KV). Overhead line conductors on steel towers are mostly utilized for bulk power transmission. The distribution network comprises of underground cables as feeders and distributors. They distribute power to service in consumer premises.

Transmission framework configuration will require an investigation of decision regarding transmission voltage, constants of transmission lines, line execution and plan, impedance with adjoining correspondence circuits other than line protection and crown issues. Also, it must be guaranteed that transmission lines have essential mechanical qualities like strength of supports, hang, pressure and so on under indicated conditions.

When systems are complex because of large generating capacities and interconnections, problem of system stability also requires to be investigated. In design of primary distribution networks principal problem is the type of distribution system while for the secondary distribution system choice of distribution substations-number, size, location and layout are important problems for which solutions have to be found. In the case of substations of different types, layout of equipment and comparison between different types are very essential.

With even increase in generation capacities and huge distances of transmission EHV AC and DC transmission is assumed an importance of its own.

III. SHORT DESCRIPTION ON THE PROJECT

The distribution networks because of the some of thefollowing special features fall in the category of ill-condition.

(i)Radial or weakly meshed networks(ii)High R/X ratios
(iii)Multi phase, unbalanced operation(iv)Unbalanced distributed load

Because of the above reasons the genuine power loss is high and we want to limit it and further develop the voltage profile. The Newton Raphson and other transmission framework calculations are fizzled with appropriation network because of its impossible to miss attributes. Hence, in reverse/forward clear strategy is to be utilized for the heap stream investigation in a dissemination network for the assurance of all out genuine power misfortunes and voltage profile at every one of the transports. It is intended to execute molecule swarm enhancement (PSO) calculation to decide the best ideal design of the circulation organization to accomplish the goals of the venture work.

IV. RADIAL DISTRIBUTION SYSTEM

Separate feeders are transmitting from a solitary substation and feed the merchants at only one end is called spiral framework. Outspread conveyance is the kind of force appropriation where the power is conveyed from the principalbranch to the sub stretches then it split out from the sub- branches again as found in Fig. 2, where the power is moved from root hub and afterward it is parted at L1. The outspread construction infers that there are no circles in the organization and each transport is associated with the source through precisely one way. It is the least expensive yet the most un-solid organization setup. The Radial circulation framework isgenerally utilized in meagerly populated regions.

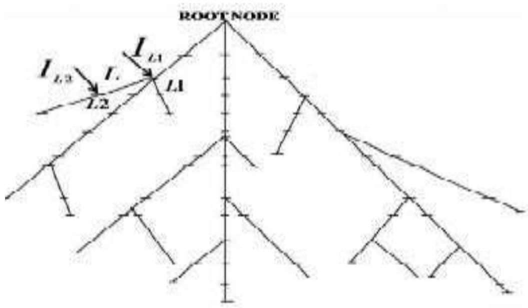


Fig. 2. Random Radial Network

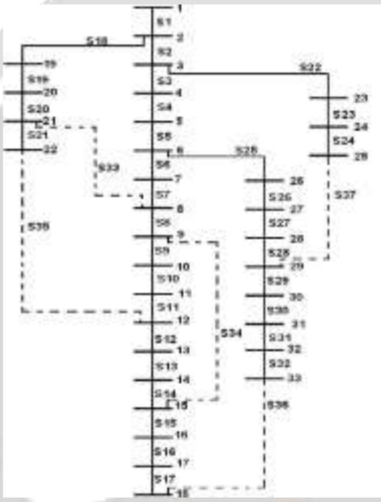


Fig. 3. IEEE 33-Bus Radial Network

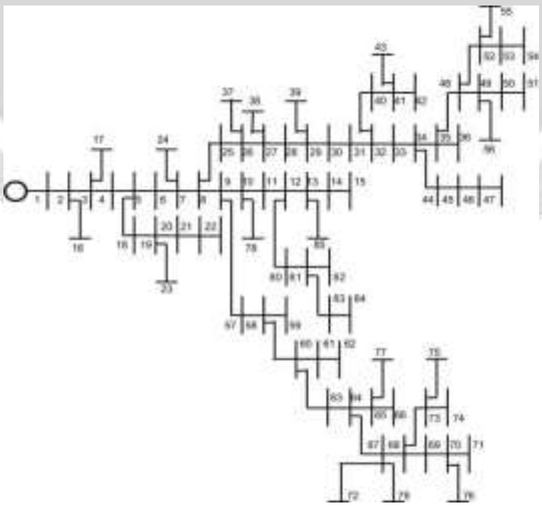


Fig. 4. Indian 85- Bus Network

An outspread organization leaves the station and goes through the organization region with no typical association with some other stock. This is normal in lengthy provincial lines with segregated load regions. In this kind of Radial Delivery Network (RDN) every hub is associated with the substation by means of somewhere around one way.

The following criterion is assumed for node and line numbering:

1. The nodes are numbered sequentially in ascending order proceeding from layer to layer, in such a way that any path from the root node to a terminal node numbered in the ascending order.
2. Each branch starts from the sending bus (at the root side) and is identified by the number of its (unique) ending bus.

The main advantage of radial network is its simple construction, low initial cost, useful when generation is at lowvoltage. Radial network is preferred when the station islocated at the center of the load.

V. PROBLEM FORMULATION FOR LOAD FLOW

Our main objective is to implement an optimized solution and algorithm for the distribution network to minimize real power loss and enhancement of voltage profile for which we will use an improved backward/forward load flow algorithm.By using this method, power losses for each bus branch and voltage magnitudes for each bus node are determined. We will use a 33-bus network and for simulation, result analysis we will use MATLAB 2015a.

The Power flows in a distribution system are computed by the following set of simplified recursive equations derived from the single-line diagram shown in Fig. 5.

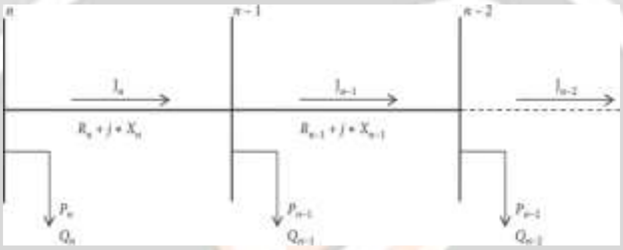


Fig. 5. Single Line Diagram

The power flow analysis can be used to obtain the voltagemagnitude, power losses of the 33-bus system. The objectivefunction is to find the power flow.

In-1=((Pn-1-jQn-1)/Vs<0) *;In-1, n= (In, n+1) +In; Vn=Vn-1-(Zn, n-1*In, n-1);

Ploss=I*I*R.

VI. BACKWARD/FORWARD SWEEP ALGORITHM

Allow us to think about a spiral organization, the regressive/forward clear strategy for the heap stream calculation is an iterative technique where, at every emphasis two computational stages are performed. The heap stream of a solitary source organization can be settled iteratively from two arrangements of recursive conditions. The originally set of conditions for computation of the power course through the branches beginning from the last branch and continuing the retrogressive way towards the root hub. The other arrangement of conditions is for working out the voltage greatness and point of every hub beginning from the root hub and continuing the forward way towards the last hub.through in reverse stroll with the present processed voltages and afterward the system is rehashed until the arrangement isjoined.

VII. FLOW CHARD OF BFS ALGORITHM

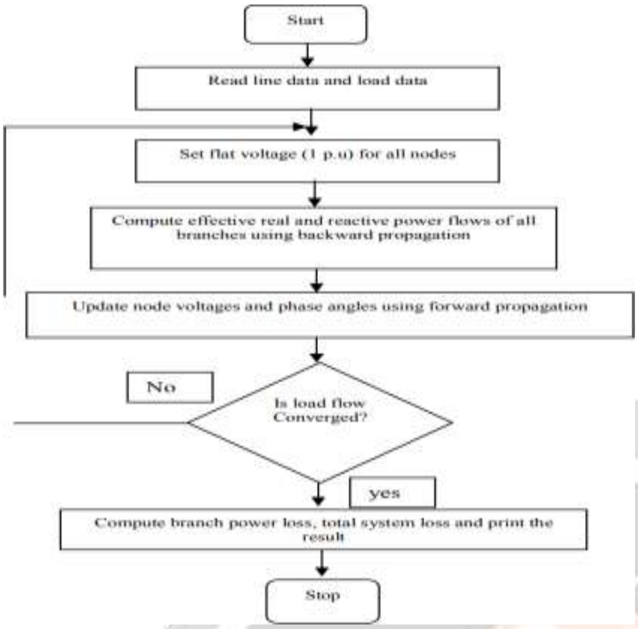


Fig. 6. Flow chart pf Backward/Forward Sweep Method

VIII. DATA INPUTS AND RESULT ANALYSIS OF BFS ALGORITHM

```
     %sn lp(k) lq(k)           r(k)              x(k)
linedata=[1     2        0.000922*0.624  0.000470*0.624
          2     3        0.004930*0.624  0.002511*0.624
          3     4        0.003660*0.624  0.001864*0.624
          4     5        0.003811*0.624  0.001941*0.624
          5     6        0.008190*0.624  0.007070*0.624
          6     7        0.001872*0.624  0.006188*0.624
          7     8        0.007114*0.624  0.002351*0.624
          8     9        0.010300*0.624  0.007400*0.624
          9     10       0.010400*0.624  0.007400*0.624
          10    11       0.001966*0.624  0.000650*0.624
          11    12       0.003744*0.624  0.001238*0.624
          12    13       0.014680*0.624  0.011550*0.624
          13    14       0.005416*0.624  0.007129*0.624
          14    15       0.005910*0.624  0.005260*0.624
          15    16       0.007463*0.624  0.005450*0.624
          16    17       0.012890*0.624  0.017210*0.624
          17    18       0.007320*0.624  0.005740*0.624
          2     19       0.001640*0.624  0.001565*0.624
          19    20       0.015042*0.624  0.013554*0.624
          20    21       0.004095*0.624  0.004784*0.624
          21    22       0.007089*0.624  0.009373*0.624
          3     23       0.004512*0.624  0.003083*0.624
          23    24       0.008980*0.624  0.007091*0.624
          24    25       0.008960*0.624  0.007011*0.624
          6     26       0.002030*0.624  0.001034*0.624
          26    27       0.002842*0.624  0.001447*0.624
          27    28       0.010590*0.624  0.009337*0.624
          28    29       0.008042*0.624  0.007006*0.624
          29    30       0.005075*0.624  0.002585*0.624
          30    31       0.009744*0.624  0.009630*0.624
          31    32       0.003105*0.624  0.003619*0.624
          32    33       0.003410*0.624  0.005302*0.624];
%         21    8        2.0000*0.624    2.0000*0.624];
%         9     15       2.0000*0.624    2.0000*0.624
%         12    22       2.0000*0.624    2.0000*0.624
%         18    33       0.5000*0.624    0.5000*0.624
%         25    29       0.5000*0.624    0.5000*0.624];
```

Fig. 7. Line data inputs

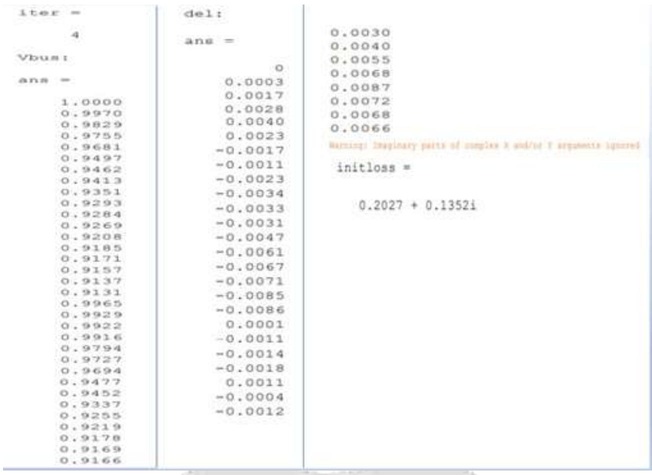


Fig. 8. Voltage profile at each node and power loss output

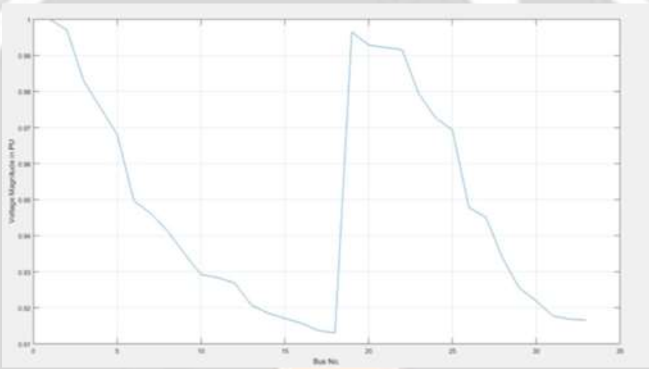


Fig. 10. Plot between bus no. and voltage magnitude

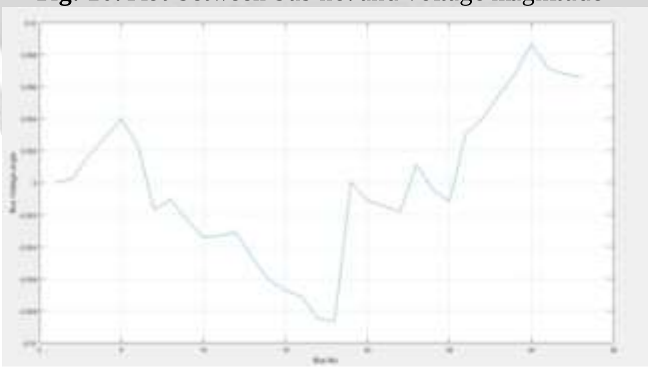


Fig. 11. Plot between bus no. and voltage angle

The above graphs show the voltage and voltage angle of each bus and also the real power loss of the 33-bus system.

IX. DISTRIBUTION FEEDER RECONFIGURATION FOR LOSS REDUCTION

Feeder reconfiguration is characterized as modifying the topological constructions of circulation feeders by changing the open/shut conditions of the sectionalizing and tie switches. In this task, a plan is introduced which uses feeder reconfiguration as a preparation or potentially continuous control device to rebuild the essential feeders. The numerical underpinning of the plan is given; the arrangement methodology is shown.

such an extent that directing many burdens stream reads up for every one of the potential choices becomes very wasteful from a computational viewpoint, yet in addition unfeasible as a continuous feeder reconfiguration technique.

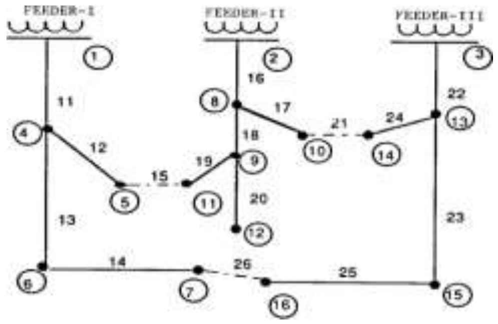


Fig. 12. Three-feeder example system

The issue being referred to is presently represented utilizing the three-feeder conveyance framework displayed in Fig. 12. The dabbed branches, 15, 21 and 26, address ties interfacing feeders, and ordinarily open tie switches are thought to be available on these branches.

For notational comfort, these tie switches will be recognized by the comparing tie numbers. Without loss of over-simplification, and aware of the viable circumstance, let us except for simplicity of clarification that there are sectionalizing turns on each part of the framework. Every oneof the thirteen sectionalizing switches will likewise be distinguished by the comparing branch numbers.

The essential goal in inferring the articulation for power misfortune decrease by means of burden move is to decide (i)whether a predefined exchanging choice would bring about amisfortune increment or lessening, and (ii) among the applicant exchanging choices, which choice would yield the best decrease in misfortunes. All in all, relative as opposed tooutright exactness is looked for here.

X. PARTICLE SWARM OPTIMIZATION ALGORITHM (PSO) As of late, numerous specialists have explored

conveyance feeder reconfiguration. Hereditary calculation (GA) is regularly discrete coded, and can deal with complex advancement issue well. Therefore, it is applied to conveyance network reconfiguration as man-made reasoningcalculation.

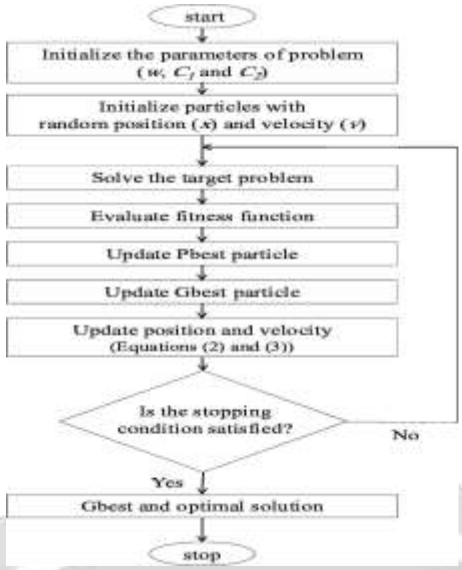
Particle swarm optimization (PSO) strategy is a populace based developmental calculation procedure created by Dr. Eberhart and Dr. Kennedy in 1995, enlivened by a social wayof behaving of bird rushing or fish tutoring. The Particle swarm idea started as a recreation of worked on friendly framework, and has been viewed as vigorous in tackling straight and nonlinear issues. PSO strategy can create great arrangements inside more limited estimation time and have more steady combination trademark than other stochastic techniques. PSO based approach is considered as quite possibly the most impressive strategies for settling the non- smooth worldwide advancement issue.

PSO imparts numerous similitudes to developmental calculation procedure like Genetic Algorithms. The two calculations start with a gathering of an arbitrarily created populace and both have wellness values to assess the populace. Both update the populace with arbitrary strategies. Nonetheless, PSO doesn't have hereditary administrators like hybrid and change. Particles update themselves with the inside speed. The system of data sharing is essentially uniquecontrasted with hereditary calculations. In hereditary calculations, chromosomes share the data with one another.

XI. STEPS FOR PSO ALGORITHMFLOW CHART OF PSO ALRORITHM

As we can see, real power loss is reduced by 31.656% and voltage is regulated and within the convergence limit.

The optimal tie switches are found to be 7, 9, 13, 32, 37 respectively and time needed for simulation is only 20 seconds.



XII. RESULT ANALYSIS OF PSO

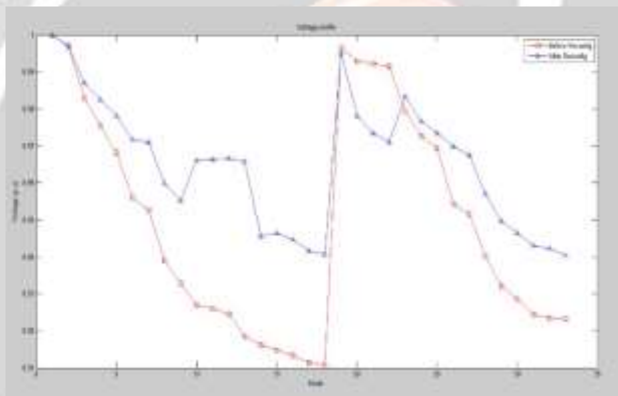


Fig. 14. Voltage Profile Before vs. After reconfiguration The voltage profile in pu of each 33 bus is plotted in the above graph and we can observe the significant improvement in voltage profile due to network reconfiguration.

SIMULATION RESULTS OF 33 BUS DISTRIBUTION NETWORK

	BEFORE RECONFIGURATION	AFTER RECONFIGURATION
Tie switches:	33 34 35 36 37	7 9 13 32 37
Power loss:	208.4592 kW	142.4653 kW
Power loss reduction:	_______	31.656 %
Minimum voltage:	0.91075 pu	0.9404 pu

Elapsed time is 19.787727 seconds.

Fig. 15. MATLAB final result

The above table gives the simulation results of IEEE 33- bus radial distribution network before and after reconfiguration.

CONCLUSION

The real power loss of each branch and the voltage magnitudes at each node are calculated in backward/forward propagation has been presented. The iterations have fast convergence ability. After that

Particle swarm optimization is implemented to determine the optimal configuration with the possible combination of tie switches for the IEEE 33-bus system. The results for IEEE 33 bus test system have been tabulated. It was found that real power loss is reduced by 31.656% and voltage is regulated and within the convergencelimit. The optimal tie switches are found to be 7, 9, 13, 32, 37 respectively and time needed for simulation is only 20 seconds. This reconfiguration method is found to be very efficient for power loss minimization and voltage profile improvement with in short computational time period.

ACKNOWLEDGMENT

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