# A METHOD OF SELECTION OF OPTIMAL SIZE OF CONDUCTOR IN RADIAL DISTRIBUTION SYSTEM- A REVIEW

**Atul Singh Chambiyal[1], Narendar KumarSadana[2], Shikhar Mahajan[3]**

*[1]EE, HIET, Shahpur , Himachal Pradesh, (India)*

*[2]EE, Baddi University Himachal Pradesh, (India)*

*[3]HPPCL, Sundernagar , Himachal Pradesh, (India)*

## ABSTRACT

*Distribution system is one from which the power is distributed to various users through feeders, distributors and service mains. Feeders are conductors of large current carrying capacity, carrying the current in bulk to the feeding points. Conductor is often the biggest contributor to distribution system losses. Economic conductor sizing is therefore of major importance. The power loss is significantly high in distribution systems because of lower voltages and higher currents, when compared to that in high voltage transmission systems. Studies have indicated that as much as 13% of total power generated is consumed as $I^2R$ losses in distribution level. Reduction of total loss in distribution systems is very essential to improve the overall efficiency of power delivery. The capital investment in laying distribution network lines accounts for a considerable fraction of total capital, investment. This paper presents a review on the technique for the selection of optimal size of conductor in radial distribution system.*

**Keywords - *Real Power Loss, Reactive Power Loss, Load Flow***

## I. INTRODUCTION

The distribution system is a largest portion of network in electrical power system [1]. It starts with the distribution substation that is fed by one or more sub transmission lines. Some of the substations are directly fed through the High-Voltage transmission line, in that case there is no sub transmission system. This depends upon company to company. Each distribution substation serve one or more primary feeders. Generally the feeders are radial, which means that there is only one path for power to flow from the Distribution substation to the user. It is the defined as the part of power system this distributes power to various customers in ready-to-use form at their place of consumption. Hence, utilities have to ensure reliable and efficient cost effective service, while providing service voltages and power quality within the specified range. This is a very challenging task. Utilities, traditionally determine future system developmentsbased on a top down approach, all over the world are competing forimprovement inservice to consumers. Mostly the power utilities emphasize on power generation and transmission system to reduce the overall cost of the system. Many of the distribution systems experience uncontrolled expansion, minimum monitoring, under/overutilization and development in unplanned manner. Therefore the following objectives shall be given prior importance in planning the distribution systems by any utility while distributing the power:

- Losses/ Performance
- Inadequate System Capacity
- Reliability
- Voltage and Power Quality Problems
- Protection
- Economics

The distribution networks typically located at everynook and corner to provide the electric power supplyfor all the individual customers. Obviously the distribution system is the most suitable system to meet the individual consumer requirements such as the electricity demand, reliability, power quality etc. As anexample, certainload centersneed high level of reliability and different load centers have different demand growth etc.

### 1.1. Challenges in distribution system analysis and design

The analysis of distribution systems is a matter ofpractical interest. A power system engineer must know the information about the number, size, location and type of the network elements in order to analyze the distribution system. Although the majority of distribution systems are operated radially, various challenges have tobe overcome in their modeling and analysis mainly due to the following reasons .

1.1.1System: The distribution system, consisting of a wide variety of components that have different phases, is complex and large. For examplemost of the loads connect toonly one ofthe three phases in the distribution system.

1.1.2 Load distribution**:**Load distributed over laterals and feeders is typically not the sameand hence the distribution system is unbalanced. The unbalanced systems are inefficient.

1.1.3 Data: The entire distribution system is operated with minimum monitoring and control. Therefore the actual system data available for its modeling and analysis is very limited. The designers needdetailed models anddesign alternatives for complex systems to overcome various problems associated with the planning, operation and control of the distribution systems. Solution of sometypical problemssuch as conductor selection, voltage regulation, capacitor placement and network reconfigurationrequire the detailed models and techniques. The analysis and design studies are to be performed by utilities to ensure the supply of quality power. The evaluation of behavior of any system or piece of system fulfills analysis studies whereas theEvaluation ofdecisions made for the system behaviorto be better is referred to as design studies. Some of the reasons that complicate the design aspects of distribution system are given below.

(i) Combinatorial aspects of distribution systems: Due to the interconnection of different distribution equipment, one component affects the technical performance and economics of other components in the system. This makes the evaluation of a techno-economical solution a surpassingly involved process.

(ii) Size:Many numbersof componentsconstitute a distribution system. It means thatidentification and analysis of toomany alternatives are possible. It is very laborious process to evaluate all the feasible alternatives set. Sometimes it may be impossible.

(iii) Uncertainty: In long term planning predicting future enhancements essential. Any uncertainty affects the distribution system planning .Sometimes the best planning priorities, load and financial forecasts leave uncertainty about the system future leading to inefficient distribution plan. Therefore it is necessary to plan the distribution system to meet, if not the most likely increased, future demand by avoiding uncertainty in forecasting the load and other related issues of distribution plan.

(iv) Other aspects of society: In the planning process, the power system designers must take into account many aspects of the society such as consulting the regulatory authorities, community groups, intervene, business leaders and other utilities. With regard to powerquality, pricing and equipment siting etc., these aspects necessarily to beconsidered. A great focus is put on the distribution system analysis and design over the past four decades. The largely adhoc and loosely assembled procedures adopted previously are going to be replaced by well-organized procedures with the help of quantitative and qualitative analysis and design studies of system elements. Now the advances in the technology of computers allowing the power engineers to store bulk volumes of data and face any obstacle relevant to the optimal planning of distribution systems. A wide variety of optimization algorithms are developed and successfully applied tosolve various complex problems, e.g. power flow analysis, conductor selection, network reconfiguration, capacitor placement, distributed generator placement, voltage regulator placement etc., in radial distribution systems. Some of the aspects presented in this work are power flow analysis, conductor selection, network reconfiguration, capacitor and voltage regulator placement in radial distribution systems.

## II. ADVANTAGE

By selecting the best conductor type for each branch of the system, resulting radial distribution system requires the least reconductoring costs yield the minimum power loss, and best voltage profile.

## III. DIFFERENT TYPES OF TECHNIQUE USED FOR THE SELECTION OF OPTIMAL SIZE OF CONDUCTOR IN RADIAL DISTRIBUTION SYSTEM

- Genetic Algorithm
- Evolutionary Strategies
- Maximum Loss Reduction
- Time varying load
- Mixed-Integer LP Approach
- Colonial Selection Algorithm
- Imperialist competitive algorithm
- Plant growth Simulation Algorithm (PGSA)

### 3.1. Optimal Conductor Selection for Radial Distribution Network using Conventional and Genetic Algorithm Approach

MuraliMohan Thenepalle had worked on the radial distribution systems by comparing the results obtained by conventional or analytical method and Genetic algorithm method (GA) [3]. By comparing the result the main objective of the author was to minimize the real and reactive power losses in the system and to maximize the total saving in cost of conducting material while maintaining the acceptable voltage levels. Several methods of loss reductions in distribution systems have been reported over years. Control of reactive power in distribution systems with end load and fixed load and varying load have been reportedgiving generalized equations for calculating peak and energy loss reductions .Other studies had been reported on reconductoring that used uniformly distributed load , a simple line feeder that had no lateral tree , or a simple lateral feeder without branches. All these may not be considered as realisticdistribution systems. Genetic Algorithms was proposed by the author for selecting the optimal size of Conductor for radial distribution networks. Load flow technique adopted by the author was Vector decoupled load flow (VDLF) method. In this method all voltage terms are eliminated from the equations for solving the load flows there by simplifying equations for iterative solution. Another advantage of VDLF method is that it requires less computer memory. The method presented for selecting the optimal size of conductors maintains the voltages at all buses within the limits, which results in better voltage regulation. The author proposed an algorithm which reduces the total power losses and minimizes total cost of the system. The proposed algorithm tested on distribution network of 13 bus system. The author compared the results obtained by genetic algorithm and conventional method .It was observed that genetic algorithm yields better results when compared to conventional method. The results obtained by genetic algorithm are quite promising and hence this method is very powerful in finding the solutions for conductor selection problems.

### 3.2 Optimal Conductor Size Selection in Radial Power Distribution Systems Using Evolutionary Strategies

F.Mendoza, et al, had presented a method, called Evolutionary Strategy (ES), for the selection of optimal size of conductor in radial Distribution Systems [4]. ES works on biologically inspired structures and operators such as recombination, mutation and fitness based selection. According to the author it had been proved that ES is more successful when compared with other iterative methods on most problems. In this paper, the proposed optimization problem consists in select a conductor type for each feeder of radial Power Distribution Systems. The optimization procedure is subject to some technical constraints, which are the Kirchhoff's current law constraints for all the nodes, the capacity constraints for the feeders and substations, and the voltage drop constraints. As a case study, the proposed method is applied to radial Power Distribution Systems with satisfactory results to calculate voltage drop of each node and the current flowing in each section. For the load flow author used a simple and an efficient load flow method for radial networks based in current injection is proposed. This study has presented an application of ES to solve the optimal conductor selection problem in a radial Power Distribution network. The Objective function was optimized considering several conductors. The cost for the obtained optimal solution has been calculated. The test case shows that the ES possess high robustness to find the optimal conductor sizes. From this reason, the evolution strategy can be used effectively to solve the optimization problem stated in this paper.

### 3.3 Combination of Optimal Conductor Selection and Capacitor Placement in Radial Distribution Systems for Maximum Loss Reduction

M.Vahid et al,had presented a technique for optimal placement of the capacitor banks and also optimal conductor selection in radial distribution networks to reduce the losses and enhancement of voltage[5]. The objective function included the cost of power losses, capacitors and conductors. Constraints included voltage limit, maximum permissible carrying current of conductors, size of available capacitors and type of conductors. [3] The optimization problem is solved by the genetic algorithm method and the size and the type of the capacitors and conductors is determined. By this technique author reduced economic costs and power losses to a considerable degree while enhancing the voltage profile. Author simulated the results and investigated on a radial distribution network consisting of 27 buses. Author had been defined the best place of the capacitor and best conductor by making a new objective function and solved the optimization problem by GA method.

### 3.4 Optimal selection of conductors in radial distribution systems with time varying load

H.Falaghi et al,had presenteda new and efficient algorithm to the optimal selection of conductors of feeder sections of radial distribution networks is proposed [6]. In optimization procedure, cost of conducting material, cost of energy losses, bus voltage profile and current carrying capacity of conductors are considered. According to author this algorithm is easy to programming and needs no approximation of actual condition. The proposed method can be applied for optimal planning of radial distribution systems. Author had shown the effectiveness of the proposed method by case study in a radial network. To calculate voltage drop of each node, current flowing in each section and power loss author applied a load flow technique. In this paper, author used a forward and backward propagation [1] to calculate current in each section and voltage at each node. This study had presented a novel approach to solve the optimal conductor selection problem in a radial distribution network. The main attempt had been made to minimize of capital investment and power loss, subject to voltage drop and current carrying capacity constraints.

### 3.5 Optimal Conductor Size Selection and Reconductoring in Radial Distribution Systems Using a Mixed-Integer LP Approach

J.F.Franco et al, hadpresented a mixed-integer linear programming model to solve the conductor size selection and reconductoring problem in radial distribution systems [7]. In the proposed model, the steady-state operation of the radial distribution system is modeled through linear expressions. Author used a mixed-integer linear model, which guarantees convergence to optimality using existing optimization software. The proposed model and a heuristic are used to obtain the conductor size selection and reconductoring problem considering two different objective functions. Author presented the result of one test system and two real distribution systems in order to show the accuracy as well as the efficiency of the proposed solution technique. Author used a system of 50 nodes and two real distribution systems of 200 and 600 nodes to show the performance and robustness of the proposed methodology. A mixed-integer linear programming model to solve the CSSR problem in radial distribution systems was presented.

### 3.6 Optimal Selection of Conductors Using Colonial Selection Algorithm (CSA) for productivityImprovement Radial Distribution Systems

Mahmood Joorabianet al, had given a new and efficient algorithm to the optimal selection of conductors in radial distribution networks[8]. In optimization procedure, cost of conducting material, cost of energy losses, bus voltage profile and current carrying capacity of conductors are considered. The availability of an adequate amount of electricity and its utilization is essential for the growth and development of the country. Method in this paperUsing intelligent methods of genetic algorithm (GA) for transferred continuous to discrete in algorithm [1]. Author had presented intelligent methods based on CSA and compared with algorithm PSO to minimize the overall cost of annual energy losses and unavailability of conductors in order to improve productivity. The back/forward sweep method is applied for load flow solution of proposed radial distribution system [1]. Author had carriedsimulations on 69-bus & 30-bus radial distribution networks. Results obtained with the proposed approaches are compared. Author had made an attempt to minimize the capital investment and power loss, subject to voltage drop and current carrying capacity constraints. Author proposed, with a goal of improvement using CSA compared PSO for optimal conductor selection in radial distribution systems. In these approaches, optimal selection of branch conductor is done by minimizing the sum of cost of energy losses and depreciation cost of feeder conductor. Author tested the proposed algorithms on 69-bus and 30-bus system.

### 3.7 Optimal conductor selection for radial Distribution networks using genetic algorithm

Dr. A.Lakshmi Devi et al, had presented the methodology for the selection of optimal conductors, in radial distribution systems [9]. The main objective is to minimize the real and reactive power losses in the system and also to maximize the total saving in cost of conducting material while maintaining the acceptable voltage levels. [3]Author obtained the optimal selections of conductor sizes by conventional method and genetic algorithm method. The conductor, which is determined by conventional method will satisfy not only the maximum current carrying capacity and maintain acceptable voltage limits. Apart from this it gives the maximum saving in capital cost of conductor and cost of energy loss in radial distribution system. The number of computations is more in conventional method that is why genetic algorithms are employed for the optimal selections of conductor sizes. The effectiveness of the proposed methods is tested by the author on the feeders of Andhra Pradesh southern power Distribution Company limited. For the load flow, vector distributed load flow method is used. Algorithms had been developed for the determination of optimal conductor selectionproblem. Author tested analgorithm on 28 bus system. The GA approach has demonstrated an ability to provide accurate and feasible solutions within reasonable computation time.

### 3.8 Conductor size selection in planning of radial distribution systems for productivity improvement using imperialist competitive algorithm

Ma. Mozaffari Legha et al,had examines the use of different evolutionary algorithms, imperialist competitive algorithm (ICA), to optimal branch conductor selection in planning radial distribution systems with the objective to minimize the overall cost of annual energy losses and depreciation on the cost of conductors and reliability to improve productivity[10]. Author adopted thebackward-forward sweep iterative method to solve the radial load flow analysis [1]. Author had carried out the simulation on 69-bus radial distribution network using ICA approach in order to show the accuracy as well as the efficiency of the proposed solution technique. Optimal selection ofconductor type for planning radial distribution systems using evolutionary approaches is presented with the objective to minimize the overall cost of annual energy losses and depreciation on the cost of conductors and reliability in order to improve productivity. The power losses, voltage magnitude, and current flow magnitudes are calculated using the backward-forward sweep method. The performance of the proposed evolutionary approaches (ICA) in comparison with a conventional method is investigated using a 69-bus radial distribution network. The power loss reduction and voltage profile improvement had been successfully achieved which demonstrate the effectiveness of the proposed approaches. The results offer potential of using ICA for improving plant productivity and economy.

### 3.9 Heuristic optimization techniques to determine optimal capacitor placement and sizing in radial distribution networks

A.Kartikeya Sarma et al, had examine the capacitor placement problem which solved using heuristic optimization techniques which are diverse and have been the subject of ongoing enhancements [11]. This paper presented a survey of the literature from the last decade that has focused on the various heuristic optimization techniques applied to determine optimal capacitor placement and size.

### 3.10 Optimal Selection of Capacitors for Radial Distribution Systems Using Plant Growth Simulation Algorithm

Deepak Sharma et al,had presented a new and efficient approach for capacitor placement in radial distribution systems that determine the optimal locations and size of capacitor with an objective of improving the voltage profile and reduction of power loss [12]. Author divided the methodology in two parts: in the first part the loss sensitivity factors are used to select the candidate locations for the capacitor placement and in the second part a new algorithm that employs Plant growth Simulation Algorithm (PGSA) is used to estimate the optimal size of capacitors at the optimal buses determined in the first part. According to the author the main advantage of the proposed method is that it does not require any external control parameters. The other advantage is that it handles the objective function and the constraints separately, avoiding the trouble to determine the barrier factors. Author proposed the technique on 33, 34 and 69-bus radial Distribution systems. The solutions obtained by the proposed method are compared with other methods. The proposed method has outperformed the other methods in terms of the quality of solution.

## IV. CONCLUSION

From the literature survey or review it is concluded that different types of technique used for the selection of optimal conductor size in Radial Distribution System. Work done on different type of conductors used in overhead line in distribution system such as Dog, Wolf, Panther, squirrel etc.by calculating the voltage and current. And on the basis of losses found in different types of Bus systems recconductoring is done.

## REFERENCES

[1] W. H. kersting, Distribution System Modelling and Analysis. New York: CRC, 2000.

[2]T.A.Short, Electric Power Distribution handbook, CRC Press, 2004.

[3]MurlimohanThenepalle, “A Comparative Study on Optimal Conductor Selection for Radial Distribution Network using Conventional and Genetic Algorithm Approach”International Journal of Computer Applications, Volume 17, pp-6-13,March 2011.

[4] F.Mendoza,DurlymRequena, Jose L. Bemal-Agustin,Jose A.Dominguez-Navarro, “Optimal Conductor Size Selection in RadialPower Distribution Systems Using Evolutionary Strategies”,pp-1-5, (©2006 IEEE).

[5] M.Vahid,NozariManouchehr, ShariatiDehaghanHossein, and AziziJamaleddin, “Combination of Optimal Conductor Selection and Capacitor Placement in RadialDistribution Systems for Maximum Loss Reduction”.

[6]H.Falaghi, M.Ramezani, M.R. Haghifam and K.RoshanMilani, "optimal selection of conductors in radial distribution systems with time varying load",CIRED 18th International Conference on Electricity Distribution Turin, pp-6-9 June 2005.

[7] J.F.Franco,Marcos J. Rider,Marina Lavorato and Rubén Romero, "Optimal Conductor Size Selection and Reconductoring in Radial Distribution Systems Using a Mixed-Integer LP Approach",IEEE transactions on power systems, vol. 28, pp-10-20, February 2013.

[8] Mahmood Joorabian and EhsanAfzalan, "Optimal Selection of Conductors Using Colonial Selection Algorithm (CSA) for productivity Improvement Radial Distribution Systems",28th Power System Conference Tehran, Iran, pp-1-7, 2013

[9] Dr. A.Lakshmi Devi, MD.AnisaShereen, "optimal conductor selection for radial distribution networks using genetic algorithm in spdcl, AP – a case study", Journal of Theoretical and Applied Information Technology,pp-674-685, 2009 JATIT.

[10] Ma. Mozaffari Legha, R. AbdollahzadehSangrood,A. ZargarRaeiszadeh,Mo. Mozaffari Legha, "conductor size selection in planning of radial distribution systems for productivity improvement using imperialist competitive algorithm", IJTPEJournal,pp-65-69,June 2013.

[11] A.KartikeyaSarma and K.MahammadRafi, "Optimal Selection of Capacitors for Radial Distribution Systems Using Plant Growth Simulation Algorithm", International Journal of Advanced Science and Technology, pp-43-54, May, 2011.

[12]Deepak Sharma,PriyaJha,S.Vidyasagar,"Optimal Conductor Selection Using Genetic Algorithm''International Journal of Engineering Research & Technology (IJERT), pp-660-665, April - 2013 ISSN.

[13] Smarajit Ghosh, Karma Sonam Sherpa., "An Efficient Method for Load Flow Solution of Radial Distribution Networks"World Academy of Science, Engineering and Technology International Journal of Electrical, Electronic Science and Engineering,pp-195-202, 2008.

[14] Rakesh Ranjan,AshviniChaturvedi, Parmal Singh Solanki and.das, "Optimal conductor selection of Radial Distribution Feeders using Evolutionary Programming"IEEE, pp-456-459,2003.

[15]Shah JahirulIslam,Mohd. RuddinAbd. Gahni, "Economical optimization of conductor selection in planning radial distribution networks"IEEE, pp-858-863, 1999.

[16]Abdullah AsuhaimiMohdZin,AlikhorasaniFerdavani, Azhar Bin Khairudin, and MafjanMortszavi, "Reconfiguration of Radial Electrical Distribution Network Through Minimum-Current Circular-Updating-Mechanism Method"IEEE, pp-968-974, 2, May 2012.

[17] J. S. Savier and Debapriya Das, "Impact of Network Reconfiguration on Loss Allocation of Radial Distribution Systems"IEEE, pp-2473-2480, 4, Oct. 2007.

[18] Ali K. Ferdavani, Abdulla AsuhaimiMohd. AzharKhairrudin and Marjan M. Naeini, "Reconfiguration of Radial Electrical Distribution Network through Neighbor-Chain Updating Method" IEEE, pp- 991-994, 2011.

[19] Ali KhorasaniFerdavani,Mohd. AzharKhairrudin and Marjan M. Naeini, "A Review on Reconfiguration of Radial Electrical Distribution Network through Heuristic Methods" IEEE.2011

[20]James Kennedy and Russell Eberhart, "Particle SwarmOptimization"IEEE, pp-1995.

[21] Smarajit Ghosh, Karma Sonam Sherpa, "An Efficient Method for Load Flow Solution of Radial Distribution Networks", World Academy of Science, Engineering and TechnologyInternational Journal of Electrical, Electronic Science and Engineering, pp-195-202, 2008.

[22] H. L. Willis, Power Distribution Planning Reference Book. New York: Marcel Dekker, 1997.