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A Review Article of Reduction Power Loss with Optimization of 33 Bus Load Flow System

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***Abstract*- Power flow analysis stands out as the foundation of power system preliminary research as well as design. They are really essential for planning, operation, economic scheduling and interchange of power between utilities. The primary facts concerning power flow analysis are to identify the magnitude and phase angle of the voltage at every single bus and the real and reactive power flowing in each transmission system lines. The load flow study in a power system comprises a study of extremely important significance. The analysis uncovers the electrical performance and power flows (real and reactive) for stipulated circumstances whenever the system is functioning under the consistent state. This paper gives an overview of various techniques useful for load flow study under distinctive stipulated conditions.**

***Keywords*-Load Flow Studies, Y-matrix and Z-matrix iteration, Newton-Raphson method, Fast Decoupled method, Fuzzy logic.**

I.INTRODUCTION

In the modern world, day by day the load demand increases rapidly due to Industrial and Domestic needs. On the other hand the conventional energy sources are decreasing rapidly. In this case we need an alternative method to meet the load demand, distributed generation is meant for that. It has huge potential benefits about which this paper is concerned. The distributed generation has been defined by many researchers [1,2], but in general distributed generation is nothing but a small generator which is connected at the consumer terminal. Placement of DG is an important factor because the improper location may leads to voltage instability. The Newton Rapson load flow method used in [3].

This method reduces the power loss and the cost factor very effectively, but the conventional method of load flow analysis was not applicable for distribution system because of its high R/X ratio, a large value of resistance and reactance of the line and radial structure of the distribution system. Tuba Gozel used loss sensitivity factor for the determination of the optimal size and location of DG to minimize total power loss [4]. Andrew used the Linear Programming Technique for placement of DG with multiple constraints [5]. Mallikarjuna used Simulated Annealing for determining the optimal location and size of DG units in a microgrid, given the network configuration and heat and power requirements of various load points [6]. Krueasuk used PSO to find optimal location and size of DG [7]. Lalitha used fuzzy approach to find optimal DG localization [8]. Hughifam used multi-objective function to minimize cost of energy losses, Investment cost of DG and Operation and maintenance cost [9]. Ochoa minimized real power loss and simple phase short circuit level [10]. Celli used multi objective approach, based on the non-dominated sorting Genetic Algorithm has been adopted to solve the optimal placement of different types of generation simultaneously. He saved the energy in the form of greenhouse gas emission reduction[11]. Vinoth Kumar addressed minimizing the multi objective index using genetic algorithm for the optimal Placement of DG[12].

II. METHODOLOGIES FOR NETWORK RECONFIGURATION, CAPACITOR, DG, AND ALLOCATION TECHNIQUES FOR PLANNING AND OPERATION

Several methods have been implemented for the operation and planning of distribution networks. In this section, various methodologies for network reconfiguration, capacitor, DG, and allocation techniques for planning and operation in distribution systems are presented.

1. Network reconfiguration

The research publications which are related to loss minimization by using network reconfiguration in low voltage distribution systems are presented in this subsection. It is a vital technique to minimize loss. In a primary distribution system, two switches are present: they are sectionalizing switches (closed switches) and tie switches (open switches). The process involved in network reconfiguration is the simultaneous operation of sectionalizing and tie switches in feeders which varies the topological structure. The main advantages of reconfiguration are:

- service restoration during feeder faults
- network maintenance through outages planning
- network overload relief, bus voltage improvement, and

- loss minimization.

The basic control action involved in reconfiguration is the switching operation. However, due to several candidate-switching combinations and discrete switch nature, reconfiguration is a complex problem. In general, classical methods prevent to solve this complex problem of reconfiguration due to radiality and discrete switch nature. Hence, the majority of the methods in the literature for solving this problem are based on heuristic techniques. In general, one can handle the process of reconfiguration through algorithm categorization in two types:

1.1 Branch exchange—The algorithm has to open and close candidate switch pairs and operates the system in a feasible radial configuration.

1.2 Loop cutting—The algorithm has to open candidate switches to attain a feasible radial configuration for the completely meshed system.

Several algorithms have been implemented based on branch exchange method for loss minimization in the literature. The concept of reconfiguration for loss minimization was first proposed in 1975 by Merlin and Back through branch and bound. Shirmohammadi and Hong in 1989 modified the above method for the same application. Civanlar et al used a load flow method to evaluate the change in network loss during reconfiguration. Baran and Wu considered network reconfiguration for two purposes:

one is power loss minimization and other is load balancing. Hereafter, several researchers have proposed various methods for solving the network reconfiguration problem on different networks which are summarized. Consequently, after going through the extensive literature survey, it can be noticed that for solving network reconfiguration problem, several researchers investigated and implemented various algorithms like genetic algorithm, simulated annealing, mixed integer hybrid differential evolution. ant colony search algorithm, quadratic programming, plant growth simulation algorithm. particle swarm optimization, harmony search algorithm.

bacterial foraging optimization algorithm, firework algorithm, cuckoo search algorithm, and bat algorithm. The method of network reconfiguration was considered as a complex decision making process for DNO to choose; it often needs widespread numerical computation, and it also disturbs the protective device coordination. In the aforementioned network reconfiguration techniques, it is normally assumed that the coordination between the protective devices has not been disturbed after the reconfiguration, but actually, the planning and coordination of protective devices are only suitable for fixed configuration.

2. Capacitor allocation

The research publications which are related to loss minimization in distribution networks by using capacitor allocation are presented in this subsection. The method of capacitor allocation is found to be viable in high voltage distribution systems. The main advantages of capacitor allocation in electric distribution systems are:

- power flow control,
- power and energy loss minimization,
- voltage stability improvement,
- handles voltage profile, and
- power factor correction.

The capacitor is a reactive power source which reduces the amount of inductive reactance of the line loading; it can minimize the reactive power losses by the allocation of shunt capacitors. Several researchers have carried out their research on capacitor allocation initially for voltage control and later for loss minimization.

The major challenges in capacitor allocation techniques are:

- appropriate selection of capacitor units,
- location or placement of capacitors, and
- sizing of capacitors to achieve the following results, ie,

a. power loss minimization,
b. better voltage regulation, and
c. power factor control.

The method of varying the capacitive volt-amp reactive (VARs) with respect to the load variation has been recognized from the 1940s. Before the 50s, the capacitors are installed at the substation for loss minimization; however, the trend of installing capacitors near to the loads on the primary distribution feeders rather than at substation has been started from the decade of 50s. Evaluation of loss equation for capacitor allocation is explained by considering a uniformly loaded primary feeder.

The elementary reactive loss equation is given by

$$\text{Total losses (due to reactive current)} = \min \int [I(1-x)]^2 R\,dx = \min \int i^2 R\,dx$$

Where
I is the reactive current at substation;
x is the distance from the substation;
R is the total resistance.

The above formula has been used in several literatures, in many forms for sizing and placement of capacitors so as to obtain reduced losses. Neagle and Samson has proposed rule-of-thumb for capacitor allocation in 1956, and an extension to this Schmill considered both switched and fixed capacitors allocation in a primary distribution feeder with uniformly distributed and randomly distributed loads for loss minimization without voltage regulation in 1965. Duran has used the method which identifies when capacitors are not economically justified in 1968. In 1978, Bae has used an analytical method for optimum reactive-compensation level and maximum reduction in yearly loss. The drawbacks of the aforementioned methods are:

- limited reactive-load distribution,
- usually feeder wire size is assumed to be uniform,
- problem of voltage regulation is not considered,
- restrictions in the number of capacitor consideration at a time,
- solutions obtained considering these assumptions may vary what they get under real situations, and
- practically not compatible (lack of generality).

In 1986, Grainger and Lee have removed some unrealistic assumption made by previous researchers and implemented easily and readily modified, adapted, and extended based on system conditions, and also presented single radial feeder with possibly several sections for different wire sizes, and for any known reactive load spread along the feeder irrespective of load distribution, one can determine the size and location of the shunt capacitors.

In 1982, Bunch et al developed a control strategy and digital processor algorithm for improved voltage control and reactive power compensation at both distribution substation and feeder level; also, this work has been advanced as a part of the development of the integrated distribution control and protection system prototype for electric power and research institute. In 1983, Grainger et al introduced continually controlling, capacitive compensation strategy for a primary feeder which assists DAS being considered for implementation of electric utilities who heavily depend on substation based computers for reactive power control primary distribution feeders.

However, none of the aforementioned techniques have investigated for the capacity release benefits, effects of growth in load and load factor, during off-peak demand voltage rise issues, and change in energy cost. All these methodologies are not capable of identifying the optimal capacitors number, their type whether fixed or switched, and unavailability standard industry size of the capacitor.

III.REQUIREMENTS OF A DISTRIBUTION SYSTEM

It is mandatory to maintain the supply of electrical power within the requirements of many types of consumers. Following are the necessary requirements of a good distribution system:

1. Availability of power demand- Power should be made available to the consumers in large amount as per their requirement. This is very important requirement of a distribution system.

2. Reliability- As we can see that present day industry is now totally dependent on electrical power for its operation. So, there is an urgent need of a reliable service. If by chance, there is a power failure, it should be for the minimum possible time at every cost. Improvement in reliability can be made upto a considerable extent by

- Reliable automatic control system.
- Providing additional reserve facilities.

3. Proper Voltage- Furthermost requirement of a distribution system is that the voltage variations at the consumer terminals should be as low as possible. The main cause of changes in voltage variation is variation of load on distribution side which has to be reduced. Thus, a distribution system is said to be only good, if it ensures that the voltage variations are within permissible limits at consumer terminals.

4. Loading - The transmission line should never be over loaded and under loaded.

5. Efficiency - The efficiency of transmission lines should be maximum say about 90%.

IV. CLASSIFICATION OF DISTRIBUTION SYSTEM

A distribution system may be classified on the basis of:-

1. Nature of current: According to nature of current, distribution system can be classified as

- AC distribution system.
- DC distribution system.

2. Type of construction: According to type of construction, distribution system is classified as

- Overhead system
- Underground system

3. Scheme of operation: According to scheme of operation, distribution system may be classified as:

- Radial delivery network
- Ring main system
- Interconnected system

With the growing market in the present time, power flow analysis has been one of the most fundamental and an essential tool for power system operation and planning. In RDN, each of its branch or link has a unique path for power flow from the substation (source of energy) i.e. source node to end (leafs) nodes.

V.LITERATURE SURVEY

In the literature, there are a number of efficient and reliable load flow solution techniques, such as; Gauss-Seidel, Newton-Raphson and Fast Decoupled Load Flow. In 1967, Tinney and Hart developed the classical Newton based power flow solution method. Later work by Stott and Alsac made the fast decoupled Newton method. The algorithm made by remains unchanged for different applications. Even though this method worked well for transmission systems, but its convergence performance is poor for most distribution systems due to their high R/X ratio which deteriorates the diagonal dominance of the Jacobian matrix. For this reason, various other types of methods have been presented. Those methods consist of backward/forward sweeps on a ladder system. The formulation of the algorithm for those methods were different from the Newton's power flow method, which made those methods hard to be extended to other applications in which the Newton method seemed more appropriate.

Tripathy et al. Presented a Newton like method for solving ill-conditioned power systems. Their method showed voltage convergence but could not be efficiently used for optimal power flow calculations. Baran and Wu , proposed a methodology for solving the radial load flow for analyzing the optimal capacitor sizing problem. In this method, for each branch of the network three non-linear equations are written in terms of the branch power flows and bus voltages. The number of equations was subsequently reduced by using terminal conditions associated with the main feeder and its laterals, and the Newton- Raphson method is applied to this reduced set. The computational efficiency is improved by making some simplifications in the jacobian.

Chiang had also proposed three different algorithms for solving radial distribution networks based on the method proposed by Baran and Wu .He had proposed decoupled, fast decoupled & very fast decoupled distribution load-flow algorithms. In fact decoupled and fast decoupled distribution load-flow algorithms proposed by Chiang were similar to that of Baran and Wu.

Goswami and Basu had presented a direct method for solving radial and meshed distribution networks. However, the main limitation o f their method is that no node in the network is the junction of more than three branches, i.e one incoming and two outgoing branches.

Jasmon and Lee had proposed a new load-flow me thod for obtaining the solut ion o f radial distribution networks. They have used the three fundamental equations representing real power, reactive power and voltage magnitude derived. They have solved the radial distribution network using these three equations by reducing the whole network into a single equivalent.

Das et al. had proposed a load-flow technique for solving radial distribution networks by calculating the total real and reactive power fed through any node using power convergence with the help of coding at the lateral and sub lateral nodes for large system that increased complexity of computation. This method worked only for sequential branch and node numbering scheme. They had calculated voltage of each receiving end node using forward sweep. They had taken the initial guess of zero initial power loss to solve radial distribution networks. It can solve the simple algebraic recursive expression of voltage magnitude and all the data can be easily stored in vector form, thus saving an enormous amount of computer memory.

Haque presented a new and efficient method for solving both radial and meshed networks with more than one feeding node. The method first converted the multiple-source mesh network into an equivalent single-source radial type network by setting dummy nodes. Then the traditional ladder network method could be applied for the equivalent radial system. Unlike other method effect of shunt and load admittances are incorporated in this method because of which it can be employed to solve special transmission networks. This method has excellent convergence for radial network.

Eminoglu and Hocaoglu presented a simple and efficient method to solve the power flow problem in radial distribution systems which took into account voltage dependency of static loads, and line charging capacitance. The method was based on the forward and backward voltage updating by using polynomial voltage equation for each branch and backward ladder equation. The proposed power flow algorithm has robust convergence ability when compared with the improved version of the classical forward backward ladder method, i.e., Ratio-Flow.

VI.SCOPE OF THE RESEARCH

Literature survey shows that a number of methods had been proposed for load-flow solution of radial distribution networks. In some cases authors had used the data as it is without reducing data preparation and in some cases authors have tried to reduce the data preparation. Since the distribution system is radial in nature having high R/X ratio, the load flow methods become complicated. The aim of this thesis work is to reduce the data preparation using the sequential numbering scheme and the radial feature of distribution networks. The proposed method not only reduces the data preparation but also increases the efficiency of the load flow.

VII.LOAD GROWTH

For future expansion and planning of the distribution systems, it is desirable that a system engineer must know the future estimate of the system solutions for planning and expansion or the efficient operation of distribution systems. The load growth (LG) pattern is essential to know for future planning and expansion of the distribution systems. In this paper work, load growth is modeled as:

Loadi = Load * (1 + r)m

Where, r = annual growth rate

m = plan period up to which feeder can take the load In conventional load flow studies, it is presumed that active and reactive power demands are specified constant values, regardless of the amplitude of voltages in the same bus. In actual power systems operation, different categories and types of loads such as residential, industrial, and commercial loads are present. The nature of these types of loads is such that their active and reactive powers are dependent on the voltage and frequency of the system. Moreover, load characteristics have significant effects on load flow solutions and convergence ability. Common static load models for active and reactive power are expressed in a polynomial or an exponential form. The characteristic of the exponential load models can be given as:

$$P = P_0 \left(\frac{v}{vo}\right)^{np}$$

$$Q = Q_0 \left(\frac{v}{vo}\right)^{nq}$$

Where np and nq stand for load exponents, P0 and Q0 stand for the values of the active and reactive powers at the nominal voltages. Vand V0 stand for load bus voltage and load nominal voltage, respectively.

VIII.CONCLUSIONS

The discussion shows the different methods involved in solving the nonlinear load flow problems. Further research work can be done for finding more powerful methods to solve the power flow equations with more efficiency in terms of time, computer memory storage as well as robustness.

Future scope:

Using graph theory concept and exploiting multi-cores architecture, the proposed method for load flow can be further investigated for obtaining more optimized solutions.

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