A simple and effective method for Load-flow solution of radial distribution systems

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***Abstract* - This paper presents a simple and effective method to solve the load- flow problem in radial distribution system. This method is based on solving simple equations using Kirchhoff's laws in Mat lab platform In the proposed method it is assumed that three-phase radial distribution networks are balanced and charging capacitances are neglected The effectiveness of proposed method is demonstrated by solving a 33-bus radial distribution system.**

***Keywords* - Load flow, Feeder, Power, Voltage, Composite, Exponential**

I.INTRODUCTION

The exact electrical performance and power flows of the system operating under steady states required in efficient way known load flow study that provides the real and reactive power losses of the system and voltages at different nodes of the system. With the growing marketing the present time, effective planning can only be assured with the help of efficient load flow study. The distribution network is radial in. Nature having highR/Xratio whereas the transmission system is looping nature having high X/R ratio. Therefore, the variables for the load flow analysis of distribution systems are different from that of transmission systems. The distribution networks are known asill conditioned. The conventional Gauss Seidel (GS) and Newton Rap son (NR) does not converge for the distribution networks. A number of efficient load flow methods for transmission systems are available in literature. A few methods had been reported in literature for load flow analysis of distribution systems. The analysis of distribution systems is an important area of activity as distribution systems is the final link between a bulk power system and consumers[1–3].The methods proposed in[4,5] were very time consuming and increased the complexity. Kerstin and Men dive [6] and Kersting [7] proposed a load flow technique for solving radial distribution networks by updating voltages and currents using the backward and forward sweeps with the help of ladder network theory. Stevens *et al.* [8] Showed that the method proposed in [6, 7] became fastest but could not converge in five out of twelve case studied. Shirmo hammadi*etal.* [8] Proposed a method for solving radial distribution networks with the help of direct voltage application of Kirchhoff's law sand presented a branch numberings chemeto enhance numerical performance of the solution method. They also extended their method for solving the weakly meshed distribution networks. Their method needs a rigorous data preparation. BaranandWu [9] developed the load flow solution of radial distribution networks by iterative solution of three fundamental equations representing the real power, reactive power and voltage magnitude. Renato[10]proposed one method for obtaining load flow solution of radial distribution networks computing the electrical equivalent foreachnod summing all the loads of the network fed through then ode including losses and then starting from the source node, voltage of each receiving end node was computed. Chiang [12] presented three different algorithms for solving radial distribution networks based on the method of BaranandWu [9]. Goswamiand Basu [12] proposed an approximate method for solving radial and meshed distribution networks where any node in the network could not be the junction of more than three branches i.e., one incoming and two outgoing. They had used sequential branch and node numbering scheme. Jasmon and Lee [13] developed a load flow method for obtaining the load flow solution of radial distribution networks using the three fundamental equations representing the real power, reactive power and voltage magnitude that had been proposed by Baran and Wu [9]. Das*etal.* [14] Proposed a load flow method using power convergence with the help of coding at the lateral and sub lateral nodes. For large system that increased complexity of computation. Their 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. Rahaman et *al.* [15] proposed a method for the improved load flow solution of radial distribution networks .They had proposed a voltage equation of the order of four.Ghosh and Das [16] presented a load flow method for solving radial distribution networks based on the technique with nodes beyond branches using voltage convergence. They had considered flat voltage start. They had shown proof of convergence and also shown that incorporation of charging admittances reduces losses and improves voltage profile. The main drawback of this method was that it stores nodes beyond each branch. This method calculated current for each branch by adding load currents of nodes beyond the respective branch. Jamal *et al.* [17] presented a load flow technique based on sequential branch numbering scheme to design distribution network by considering committed loads. Aravindhababu *et al.* [18] had shown a simple and efficient branch-to-node matrix-based power flow(BNPF)for radial distribution systems and this method was unsuitable. In that methodany presence of sub laterals complicates the matrix formation. Mekhamer *et al.* [19] developed a method for load flow solution of radial distribution network susing terminal conditions. Afsari *et al.* [20]proposeda load flow method based on estimation of node voltage and assuming the load soft he node so flateral and their sub lateral are concentrate dat the originating node of the feeder. They had tried to reduce the computation time only .Butthe computation becomes very complex when the number of .Ranjan*et al.*[22]

proposed a new load flow technique using power on vengeance characteristic. They had calculated voltage of each node using forward sweep by the same voltage expression available in reference [14]. They had calculated the total power flow of each branch that is fed to the receiving end node of that branch. Their method also needed the storage of nodes beyond each branch. They also claimed that their algorithm could easily accommodate the composite load modeling if composition of load was known. The main disadvantage of this method was that their method needed a repetitive search for connection of receiving end node of each branch with other nodes. In their method, they claimed that the proposed method worked for arbitrary node numbering but remained silent regarding the branch numbering scheme Chakra borty and Das [23] had stated that he power convergence has the capability to handle composite load modeling. Ranjan *et al.*[24]had used the voltage convergence to handle the different composition of load for the same example used in reference[23].All the proposed methods need branch number, sending end node and receiving end node. The methods proposed in [13,15] needed sequential numbering scheme. In the all the proposed methods, the examples used were with sequential numbering scheme.
The main aim of the authors is to reduce the data preparation and to assure computation for any type of numbering scheme for node and branch. If the nodes and branch numbers are sequential, the proposed method needs only the starting feeder, each of lateral and each of sub lateral only. The proposed method needs only the set of nodes and branch numbers of feeder, each of lateral sand each of sub laterals only when node and branch numbers are not sequential. The proposed method computes branch power flow most efficiently and does not need to store nodes beyond each branch. The voltage of each node is calculated by using a simple algebraic equation. Although the present method is based on the forward sweep, it computes efficient load flow of any complicated radial distribution networks very efficiently even when branch and node numbering scheme are not sequential. The proposed method needs minimum data preparation compared to other methods. Two examples (33nodeand 69node radial distribution networks) with constant power (CP), constant current (CI), constant impedance (CZ), composite and exponential load modeling's for each of these examples are considered. The proposed method is compared with other existing methods [15, 17, and 22]. The initial voltage of all nodes is taken1+j0and initial power loss of all branches a real so taken zero.

II. ASSUMPTIONS

It is assumed that three-phase radial distribution networks are balanced and represented by their single-line diagrams and charging capacitances are neglected at the distribution voltage levels.

C=C+1,…,C+B.

III. LOADMODELLING

A balanced load that can be represented either a constant power, constant current, constant impedance or as an exponential load is considered here.
For constant power (CP) load, $a_0=b_0=1$ and $a_i=b_i=0$ for i=1,2,3.
For constant current (CI) load $a_1=b_1=1$ and a_i $b_i=0$ for i=0.
For constant impedance (CZ) load a_2 ,$b_2=1$ and $a_i=b_i=0$ fori=0,1,3.
Composite load modeling is combination of CP,C Land CZ.
For exponential load a $b_3=1$ and $a_i=b_i=0$ for i=0, 1, 2 and e1 and e2 are1.38 and 3.22 respectively [23].

IV.ALGORITHMFORCOMPUTATIONOFLOADFLOW

To calculate the node voltage sand branch current sand the total system loss, a initial guess of zero real and reactive power loss is assumed. Also flat voltage start is used. The convergence criteria is such that if

Max$|V_{old}$[FN(i,j)]V_{New}[FN(i,j)]|<Ԑ,fori=1,2,..,TNandj=1,2,….,N(i)=total number of nodes of FN(i).
The following are the steps for load flow calculation:
Step1 : Get the number of Feeder(A), lateral(s) (B)and sub lateral(s) (C).
Step2 : TN= A+B+ C
Step3 : Read total number of nodes N (i) of feeder, lateral(s)and sub lateral(s)for i= 1,2,…,TN
Step4 : Read the node sand branch numbers of feeder ,lateral(s) and sub lateral(s) i.e.,FN(i,j) for j=1,2,…,N(i)and i= 1,2,….,T N if these are not sequential..
Step5 : Read real and reactive power load at each node i.e., PL[FN(i,j)] and QL[FN(i,j)] for j=2,3,..,N(j) and i=1,2,..,TN.
Step6 : Initialize PL[FN(1,1)]=0.0 and QL[FN(1,1)]=0.0
Step7 : Read the branches of feeder, lateral(s)and sub lateral(s)i.e., FB(i,j) for j=1,2,…,N(i) 1and i =1,2,….,TN.
Step8 : Read resistance and reactance of each branch i.e R[FB(i,j)] and X[FB(i,j)] for j=2,3,..,N(j)1andI= 1,2,..,TN.
Step9 : Read basek Vand base MVA ,Total number of iteration(ITMAX), Ԑ(0.00001).
Step10 : Compute the per unit values of PL[FN(i,j)] and QL[FN(i,j)] for j = 2,3,..,N(j) and i=1,2,..,TNaswellasR[FB(i,j)] and X[FB(i,j)] for j=1,2,3,..,N(j)1 and i= 1,2,.. ,TN.
Step11 : Set PL1 [FN(i,j)] =PL[FN(i,j)] and QL1 [FN(i,j)]=QL[FN(i,j)] for j=2,3,..,N (j) and i= 1,2,..,TN
Step12 : SetLP[FB(i,j)]=0.0 And LQ [FB(i,j)]=0.0 for j=1,2,3,..,N(j) 1 and i= 1,2,.., TN.
Step13 : Set V[FN(i,j)] =1.0+j0.0 for j=1,2,…,N(i) and i= 1,2,….,TN and set V1[FN(i,j)]= V[FN(I,j)]for j=1,2,…,N(i)and i =1,2,….,TN.

Step14 : UsetheStep7 to Step.
Step15 : Set IT= 1
Step16 : Set PL[FN(i,j)] =PL1[FN(i,j)] and QL[FN(i,j)] =QL1[FN(i,j)] for j = 2,3,..,N(j) and i= 1,2,..,TN
Step17 : Use proper load modeling using(20)and(21).
Step18 : Compute voltage |V[FN(I,j)] | using (2) for j=2,3,..,N(j) and i= 1,2,..,TN.
Step19 : Compute| ▼V[FN(i,j)]|=|V1[FN(i,j)]| |V[FN(i,j)]|forj=2,3,..,N(j)And i= 1,2,..,TN.
Step20 : Compute current |I[FB(i,j)] |using(4)for j=1,2,3,..,N(j)1 and i= 1,2,..,TN.
Step21 : Set |V1[FN(i,j)]|= |V[FN(i,j)]| for j =1,2,3,..,N(j) and I=1,2,..TN.
Step21 : Compute LP[FB(i,j)] and LQ[FB(i,j)] for all j=1,2,…, N(i) 1 and i=1,2,….,TN using(5)and(6)respectively.
Step22 : Find ▼$V_{max}$from ▼V[FN(i,j)]| for j= 2,3,..,N(j)and I = 1,2,..,TN.

Step23 : If▼V_{min}d 0.00001 goto Step26.
Step24 : IT=IT+ 1
Step25 : If IT d ITMAX go to Step 16 else write "NOT CONVERGED" and go to
Step26 : Write "SOLUTION HAS CONVERGED" and display the results : Total Real and Reactive Power Losses , Voltages of each node, minimum value of voltage and its node number and total real and reactive power load for CP, CI ,CZ, Composite and Exponential Load Modeling.
Step27 : Stop

V. CONCLUSION

We have introduced the basic concepts of radial distribution. Although there is much more details we did not mentioned, the important parts are discussed in this paper. We provided an overview of various existing coding standards lossless image compression techniques.

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