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A Novel Load Flow Method for Radial Distribution Network

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Abstract*— This paper presents a new method for solving the load flow problem for radial distribution feeders without using conventional load flow methods like Gauss Seidel, Newton Raphson, Fast Decoupled methods. This method uses forward sweeping to calculate outgoing power from nodes and node voltage magnitudes and mismatches at the last nodes of main feeder and laterals and depending upon mismatches the substation injection is corrected judiciously and this process is repeated until convergence. Outgoing power from a node wherefrom a lateral starts to next node in main feeder and next node in lateral is modified depending upon ratio of mismatches in last nodes of subsequent network. This makes the algorithm very robust and numerically efficient for convergence for wide variation of distribution network. For a radial distribution test feeders with laterals load flow studies using the proposed method are presented as an example to illustrate this technique, validate the result and it is shown as superior to the existing methods.

***Keywords*— Distribution feeders; Injected powers; Laterals; Line losses; Load flow; Main feeder.**

I. INTRODUCTION

Load flow is an important tool for satisfactory design and operation of distribution networks. At the design stage, load flow analysis is used to check whether the voltage profiles are expected to be within limits throughout network. At the operation stage, it is run to explore different arrangements to maintain the required voltage profile and to minimize system losses. In addition to the direct use of load flow, in many other problems it is used as a sub problem, for instance in the contingency analysis of a system [1]. In recent years, introduction of system automation, power system deregulation and distributed generation have increased the need for powerful tools, including load flow, for the system analysis.

If the load flow converges solution will be same irrespective of the algorithm used, but the solution procedures and formulations may be approximated and values may be adjusted inside an iteration for different load flow algorithms. An acceptable load flow solution method should have high speed and low storage requirements, especially for real-time large system applications and should be highly reliable, especially for ill-conditioned problems, outage studies and real-time applications and should attain accepted versatility and simplicity.

The conventional load flow methods, e.g. Newton-Raphson and Fast Decoupled, are very efficient and reliable for transmission networks, but for distribution networks they are not so efficient and sometimes they may be unable to solve load flow. This is due to some inherent features of distribution networks like, radial or near to radial structure, high R/X ratios of lines etc. So, researchers dealing with the distribution system have proposed several special load flow solution techniques for distribution networks. A brief description of some salient work will follow.

Kersting *et al* [2] and Kersting [3] proposed a ladder-network theory based load flow method for solving the radial distribution networks assuming the network to be 'pure' ladder which is not suitable for meshed network. Stevens *et al* [4] showed that the ladder method is very fast method, but this method failed to converge for five out of twelve networks. Shirmohammadi *et al* [5-6] presented a Kirchhoff's voltage and current law based method for solving the distribution networks. Baran and Wu [7] proposed a technique by solving iteratively the three main equations of active power, reactive power and the voltage magnitude using Jacobean matrix and mismatches for load flow solution of distribution system. Chiang [8] presented three different algorithms for solving the radial distribution networks namely decoupled, fast decoupled and very fast decoupled load flow. Decoupled and fast decoupled methods were similar to method proposed by Baran and Wu. Cespedes [9] developed a load flow solution method for radial distribution networks. For each node, by summing all the loads of the network fed from that node, (including the losses) he derived equivalent circuit. Then, starting from the source node, he computed the voltage of each node. Hasmon and Lee [10-11] proposed a new method for distribution load flow. Ghosh and Das [12] proposed a method in which it was only necessary to solve some simple algebraic equations. This method could consider the combined loads, if their combination is known.

Mekhamer et al [13] have proposed an attractive method where they used the same equations as used by Baran and Wu[7] but instead of formulating Jacobean matrix the equations are used in simple algebric form to solve the load flow problem using an iterative technique based on the terminal conditions. But this method fails to converge for some distribution system having laterals. In their paper at a bus on the main feeder wherefrom a lateral starts outgoing real power from this junction bus to next bus in the main feeder and next bus in the lateral is shared according to real power of connected load in subsequent portion of the network. This ratio is fixed(does not vary in iteration) and all of them are positive. The increase in substation real power injection in j-th iteration is equal to algebraic summation of mismatches at last nodes of main feeder and laterals in the last(j-1 th) iteration. If for any system having lateral at any iteration algebraic summation of mismatches at last nodes become small though some of the individual real mismatches magnitude is more than tolerance then real power injection at substation will not increase and similarly for reactive power also and as a result real and reactive power from this junction to main feeder and lateral will not change and load flow will neither converge nor diverge for this type of cases.

In this paper we have proposed a modification in the method proposed by Mekhamer *et al* [13]. Here at the junction of main feeder and lateral at first, we calculate increment in outgoing real power from the junction node to next buses in main feeder in the current(j-th) iteration and lateral compared to last(j-1th) iteration and we share this increment in outgoing real power in proportion to the real power mismatches at last nodes in the subsequent network calculated in last(j-1 th) iteration. This ratio is iteration dependent may be negative also as some mismatches may be negative. In case the algebraic summation of real mismatches at last nodes is negligible, though the increment in substation real power injection is negligible and as a result increment in total outgoing real power flow from first junction node to main feeder and lateral is also negligible, increment (compared to last iteration) in outgoing real power flow from first junction node to main feeder and first junction node to lateral will have some significant value, one positive other negative and equal in magnitude (if the first junction is of one lateral and main feeder) and the power flow through different branches will change for rest portion of the network. Similarly in any junction node increment in outgoing real power is shared to main feeder and to lateral in proportion to the mismatches at last nodes in the subsequent portion of the network. Similarly for reactive power also this type of adjustment is done. This adjustments minimizes the mismatches magnitudes at last nodes and will lead towards convergence. If first junction is a junction of main feeder and two or more laterals and proposed method is used then increments in individual real(reactive) outgoing flows will be of significance though their algebraic summation is negligible, again adjusting to minimization of mismatches at last nodes and leading to convergence. The method is very fast compared to existing methods, and it is also very simple to understand and implement. The test system is a case where the algorithm proposed by Mekhamer et al[13] has failed but ours has succeeded due to above mentioned reason.

II. MATHEMATICAL FORMULATION

A balanced three-phase, radial distribution feeder with *n* branches in main feeder, n+1 nodes in main feeder, ℓ laterals and n_c shunt capacitors is assumed and can be represented by its equivalent single line diagram as in figure 1. Line shunt capacitance is negligible at the distribution voltage levels.

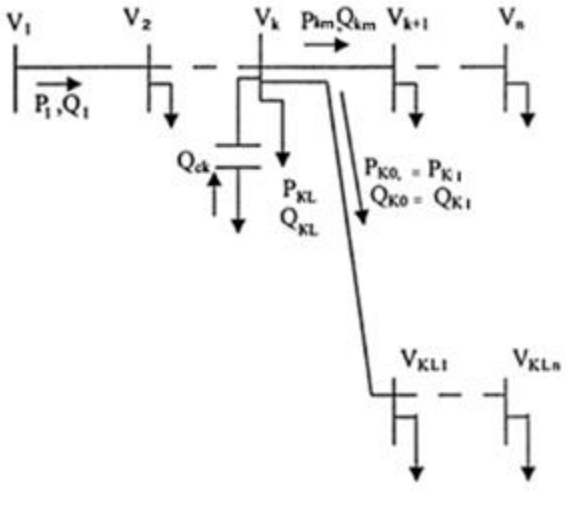

Figure 1: General model of a distribution feeder

The fundamental branch power flow equations are given by [6,12]:

$$P_{i+1} = P_i - \frac{r_i(P_i^2 + Q_i^2)}{V_i^2} - P_{Li+1} \quad \text{(1a)}$$

$$Q_{i+1} = Q_i - \frac{x_i(P_i^2 + Q_i^2)}{V_i^2} - Q_{Li+1} + Q_{Ci+1} \quad \text{(1b)}$$

$$V_{i+1}^2 = V_i^2 - 2(r_i P_i + x_i Q_i) + (r_i^2 + x_i^2) * \frac{(P_i^2 + Q_i^2)}{V_i^2} \quad \text{(1c)}$$

Here we have:

P_i, Q_i: real & reactive power flows at the sending end of branch *i* which connects node *i* and node *i+1* respectively.

V_i: bus voltage magnitude at node *i*

δ_i : bus voltage angle at node *i*

r_i, x_i: resistance & reactance of branch *i* respectively

Q_{Ci}: reactive power injection by the capacitor at node *i*

It can be shown that the voltage magnitudes of buses are independent of angles.
Suppose k is a bus on main feeder from which lateral starts.
At last node on main feeder (node no. n) as there is no branch beyond this node, there should not be any outgoing real power and reactive power. So, $P_{nsp} = 0$ and $Q_{nsp} = 0$. When load flow converges P_n, Q_n = should be less than or equal to pre-specified convergence tolerance (epsilon). Before convergence there is mismatch between these specified and calculated powers. Real and reactive power mismatches at last node of main feeder is defined as $\delta P_n = P_{nsp} - P_n = -P_n$ (2a),

and $\delta Q_n = Q_{nsp} - Q_n = -Q_n$ (2b), respectively.

Similarly for lateral starting from k node and ending at node kn these mismatches respectively are

$\delta P_{kn} = P_{knsp} - P_{kn} = -P_{kn}$ (2c)

and $\delta Q_{kn} = Q_{knsp} - Q_{kn} = -Q_{kn}$ (2d)

Similarly for all the laterals mismatches are defined.

P_k^j = Algebraic summation of outgoing real powers from bus k to next buses in main feeder as well as laterals starting from bus k in iteration no. j, j=1,2,3---------

P_{km}^j, P_{kl}^j ----Outgoing real powers from bus k to next bus in main feeder and lateral at bus k respectively in iteration no. j. where, j=1,2,3---------

Similarly the corresponding outgoing reactive powers are defined as Q_k^j, Q_{km}^j and Q_{kl}^j.

In paper [13] algebric summation of complex power mismatches at last nodes of main feeder and laterals are added at substation busses for minimizing the mismatches and convergence of load flow. In paper [13] outgoing real power from bus k to next bus in the main feeder (P_{km}^j) and to lateral (P_{kl}^j) are calculated by dividing total outgoing real power from bus k to next buses(P_k^j) according to ratio of algebric summation real powers of connected loads in the main feeder beyond node k & other laterals beyond node k and algebric summation real powers of connected loads in lateral at node k and similarly for reactive power. This ratio is fixed and positive and independent of iteration. This algorithm fails when algebric summation of real power mismatches at the last nodes of main feeder and laterals is negligible but all or some of the individual real mismatches are non-zero (being some of them positive, some others negative). As the increase in substation real power injection is negligible then outgoing real power(P_k^j) is same as P_k^{j-1}. So, $P_{km}^j = P_{km}^{j-1}$, $P_{kl}^j = P_{kl}^{j-1}$, and similarly for reactive power this happens may be in earlier iteration. So, the load flow will neither converge nor diverge. This will be discussed in details in the case studies.
Here we want to modify as follows.

III. PROPOSED MODEL

Let, $P_k^j - P_k^{j-1} = \Delta P_k^j$ =Increment in outgoing real power from a junction node k to next nodes towards lateral and main feeder in two successive iterations j-1 and j. where, j=2,3,4----

ΔP_k^j is shared according to real mismatches in the last nodes of the laterals and main feeder calculated in last(j-1 th) iteration.

Now we define the following terms.

ap_{km}^j = Algebraic summation of real power mismatches in the last node in main feeder and other laterals beyond node k except lateral at node k in last (j-1-th) iteration / Algebraic summation of real power mismatches in the last nodes in main feeder and all laterals beyond node k (including the lateral at k) in last(j-1-th) iteration, (3a) where j=2,3..

ap_{kl}^j =Algebric summation of real power mismatches in the last node in the lateral at k in last (j-1-th) iteration / Algebric summation of real power mismatches in the last nodes in the main feeder and all laterals beyond node k (including the lateral at k) in last (j-1-th) iteration. .. (3b) where j=2,3…

aq_{km}^j = Algebric summation of reactive power mismatches in the last node in main feeder and other laterals beyond node k except lateral at node k in last (j-1-th) iteration / Algebraic summation of reactive power mismatches in the last nodes in main feeder and all laterals beyond node k (including the lateral at k) in last (j-1-th) iteration, (3c) where j=2,3..

aq_{kl}^{j} =Algebric summation of reactive power mismatches in the last nodes in the lateral at k in last(j-1-th) iteration / Algebric summation of reactive power mismatches in the last nodes in the main feeder and all laterals beyond node k (including the lateral at k) in last (j-1-th) iteration. .. (3d) where j=2,3…

And we calculate them in j-th iteration. Then outgoing real powers from a junction node(k) to next node in main feeder (P_{km}^{j}) and to next node in lateral(P_{kl}^{j}) are calculated as follows.

$$P_{km}^{j} = P_{km}^{j-1} + ap_{km}^{j}\Delta P_{k}^{j} \quad \text{(4a), and}$$

$$P_{kl}^{j} = P_{kl}^{j-1} + ap_{kl}^{j}\Delta P_{kl}^{j} \quad \text{(4b)}$$

Similarly, the outgoing reactive powers from a junction node(k) to next node in main feeder (Q_{km}^{j}) and to next node in lateral(Q_{kl}^{j}) are calculated as follows.

$$Q_{km}^{j} = Q_{km}^{j-1} + aq_{km}^{j}\Delta Q_{k}^{j} \quad \text{(4c) and}$$

$$Q_{kl}^{j} = Q_{kl}^{j-1} + aq_{kl}^{j}\Delta Q_{kl}^{j} \quad \text{(4d)}$$

Note, that ap_{km}^{j}, ap_{kl}^{j}, aq_{km}^{j} and aq_{kl}^{j} change in every iteration.

As for the first iteration we do not know mismatch in last nodes we share P_{k}^{1} according to the ratio of connected load as proposed by Mekhamer *et al* [13]. From iteration no. 2 onwards the outgoing real and reactive powers from a junction node to next node in main feeder and laterals are calculated as discussed above.

For a distribution system having lateral the method proposed by Mekhamer et al[13] is likely to fail to converge and if for few cases of distribution system it succeeds and gives solution due to above mentioned reason the convergence will be slow and take more no. of iterations but our proposed method will be fast and converge for all distribution systems with or without laterals. Thus huge improvement in convergence is achieved with a few mathematical operation per iteration added and total no. of mathematical operations is much reduced.

IV. LOAD FLOW SOLUTION ALGORITHM

The method is summarized in the following steps.

Step 1: Read the main feeder data.

Step 2: Find the algebric summation of active and reactive demand for all nodes of each laterals and Find the algebric summation of local active and reactive demand for all nodes in the main feeder. Then find the whole active and reactive demand including all laterals and all local loads on the main feeder. Let these total active and reactive load powers be P_{DT} and Q_{DT}.

Step 3: Assume the substation power to be equal to the total load power, as initially losses are unknown i.e. $P_0 = P_{DT}$, $Q_0 = Q_{DT}$.

Step 4: Calculate the real and reactive power flow at starting end of branch 2,3,4… according to equation (1a) and (1b) and magnitudes of bus voltages of bus 2,3,4… etc using (1c) until a node(say k) in the main feeder comes from which a lateral starts. It can be shown that the voltage magnitudes of buses are independent of angles so we do not need to calculate angles while doing iteration. We calculate angles of buses only after load flow converges.

Step 5: (**For 1st Iteration only**) For each node(k) in the main feeder from which a lateral starts, the outgoing power from it is divided according to the connected loads of each lateral and main feeder in the following way. For example at node k: outgoing real power from junction node k to next node in main feeder $(P_{km}^{1}) = P_{k}^{1} \times$ sum of real powers of loads in all nodes beyond node k in the main feeder and laterals except lateral at node k / sum of real powers of loads in all nodes beyond node k in the main feeder and laterals including lateral at node k. Outgoing real power from junction node k to next node in lateral at node k $(P_{kl}^{1}) = P_{k}^{1} \times$ (sum of real powers of all loads in the lateral at k/sum of real powers of loads in all nodes beyond node k in the main feeder and laterals including lateral at node k. Repeat for reactive powers. Note, that this ratio of connected loads is constant and both the powers are positive.

Step 6: Apply the load flow equations (1a)-(1c) for the successive nodes in the main feeder to calculate real powers(P_i) and reactive powers(Q_i) outgoing from a node through a branch in main feeder and corresponding voltage magnitudes(V_i) of nodes on main feeder till we reach next lateral or last node of the main feeder. If we reach a lateral, outgoing power from main feeder to next node in main feeder and next node in this lateral are calculated as in step 5 and calculate real and reactive power mismatches at last node of main feeder as per equation (2a)-(2b).

Similarly for lateral starting at k taking $V_{k0} = V_k$, $P_{k0}^{j} = P_{kl}^{j}$ and $Q_{k0}^{j} = Q_{kl}^{j}$ and calculate real power (P_{ki}) and reactive powers(Q_{ki}) outgoing from a node through a branch in a lateral and corresponding voltage magnitudes(V_{ki}) of nodes on lateral using equations (1a)-(1c) till last node reaches on the lateral and calculate real and reactive power mismatch at last node(kn) on the lateral using equations (2c)-(2d). Similarly for other laterals the same calculations are done.

Step 7: If the absolute values of all real and reactive power mismatches at last nodes of main feeder and laterals are less than or equal to acceptable tolerance say, ($\leq 10^{-7}$ p.u), then we say, load flow has converged and solution is acceptable, then calculate bus angles using equation no (1d) and show the results, otherwise go to Step 8.

Step 8: For 1st node in the main feeder, set:

$$P_0 = P_0 + \delta P_n + \sum_{laterals} \delta P_{kn} \quad \text{5(a) and}$$

$$Q_0 = Q_0 + \delta Q_n + \sum_{laterals} \delta Q_{kn} \quad \ldots\ldots \text{5(b)}$$

Step 9: Calculate the real and reactive power flow at starting end of branch 2,3,4… according to equation (1a) and (1b) and magnitudes of bus voltages of bus 2,3,4… etc using (1c) until a node(say k) in the main feeder comes from which a lateral starts.

Step 10: (**From the second iteration and onwards**) Using the real and reactive power mismatches at the last nodes in main feeder and laterals as calculated in the last iteration using (2a)-(2d), calculate ap_{km}^{j}, ap_{kl}^{j}, aq_{km}^{j} and aq_{kl}^{j} using equation (3a)-(3d). Then calculate outgoing real and reactive powers from bus k to next bus in main feeder (P_{km}^{j}, Q_{km}^{j}) and next bus in lateral(P_{kl}^{j}, P_{kl}^{j}) using equations (4a)-(4d).

Step 11: This step is similar to step 6. Apply the load flow equations (1a)-(1c) for the successive nodes in the main feeder to calculate P_i and Q_i, V_i of nodes on main feeder till we reach next lateral or last node of the main feeder. If we reach a lateral, outgoing power from main feeder to next node in main feeder and next node in this lateral are calculated as in step 10 and calculate real and reactive power mismatches at last node of main feeder as per equation (2a)-(2b).

Step 12: This step is similar to step 7 for convergence checking and if then calculate bus angles using equation no (1d) and show the results, otherwise go to Step 13.

Step 13: This step is similar to step 8 for correction in substation injection, set:

$$P_0 = P_0 + \delta P_n + \sum_{laterals} \delta P_{kn} \quad \text{5(a) and}$$

$$Q_0 = Q_0 + \delta Q_n + \sum_{laterals} \delta Q_{kn} \quad \ldots\ldots\text{5(b) and go to step 9.}$$

Step 8 and 13 are step for correcting substation injection towards minimizing mismatch.

V. CASE STUDIES

A feeder consists of 34 nodes containing 12 nodes in main feeder and other nodes on 4 laterals is studied. The data of this feeder is given in Ref. [14]. The base voltage is 11 kv and the base mva is 5 MVA. Results are presented in table 1, 2 and 3). All values are in p.u. The tolerance is 10^{-7} p.u. No. of iteration required is 7 the bus voltages and angles, real and reactive power from buses through lines and real and reactive losses are shown in tabl1 1,2 and 3 respectively.

If we use the method in paper [13] for the 34 bus system then after 10 iterations maximum mismatch for reactive power is -0.0008261961 pu and it is at bus 27 and other reactive mismatches at last nodes are also significant but algebraic summation of reactive power mismatches at the last nodes of the main feeder and laterals become less than 10^{-12} and so there is no increase in reactive injection at substation bus. Similarly for real power after 11 iterations maximum mismatch for real power is -0.0030002237pu and is at bus 27 though algebraic summation of real power mismatches at the last nodes of the main feeder and laterals become less than 10^{-12}pu so there is no increase in real injection at substation bus and the algorithm fails to converge even thousands of iterations are run. But our method converges in only 7 iterations. So the algorithm of Mekhamer et al[13] has failed though they have studied the same system and surprisingly demanded that their algorithm has succeeded and converged in 11 iterations.

If we see the calculations of iteration 1, 2, 3 so on it seems that it is going toward convergence but actually there is something wrong. From iteration 2 some mismatch is –ve that means we are injecting wrongly more power than that is required as loss is less there. And thus though algebraic summation of mismatches are converging fast but actual mismatches being some of them positive some others negative are decreasing very slowly and it may be expected that it is likely to converge but surprisingly at iteration 10 and 11 it is seen that it will never converge. But in our proposed method sharing of incremental power in proportion to mismatch helps to minimize the mismatch and thus very powerful and much superior to existing methods.

TABLE I
VOLTAGE MAGNITUDES AND ANGLES FOR 34 BUS SYSTEM

Node No	Voltage Magnitude	Voltage Angle	Node No	Voltage Magnitude	Voltage Angle
1	1.000000	0.000000	6_2	0.962245	0.545793
2	0.994137	0.052691	6_3	0.958149	0.628487
3	0.989021	0.099040	6_4	0.954856	0.695425
4	0.982053	0.213288	6_5	0.951993	0.753917
5	0.976062	0.312720	6_6	0.948724	0.833100

6	0.970414	0.407466	6_7	0.946037	0.898543
7	0.966586	0.498514	6_8	0.943513	0.960331
8	0.964483	0.548370	6_9	0.942298	0.990189
9	0.962016	0.606987	6_9_1	0.941831	1.001684
10	0.960829	0.635148	6_9_2	0.941692	1.005123
11	0.960371	0.646136	7_1	0.966250	0.506911
12	0.960235	0.649390	7_2	0.966027	0.512512
3_1	0.988687	0.106888	7_3	0.965915	0.515313
3_2	0.988381	0.114043	10_1	0.960489	0.643120
3_3	0.988299	0.115964	10_2	0.960148	0.651098
3_4	0.988292	0.116095	10_3	0.959978	0.655089
6_1	0.965953	0.482769	10_4	0.959921	0.656420

TABLE II

OUTGOING REAL AND REACTIVE POWER FOR DIFFERENT BUSES

Node No	P(pu)	Q(pu)	Node No	P(pu)	Q(pu)
1	0.971645	0.587722	6_2	0.402718	0.246516
2	0.919410	0.556664	6_3	0.354649	0.217546
3	0.868297	0.526033	6_4	0.307177	0.188711
4	0.815137	0.495546	6_5	0.260063	0.159957
5	0.763307	0.465428	6_6	0.212950	0.131266
6	0.258679	0.159160	6_7	0.166197	0.102637
7	0.212375	0.130136	6_8	0.119643	0.074042
8	0.165800	0.101537	6_9	0.073451	0.045509
9	0.119272	0.072947	6_9_1	0.027405	0.017001
10	0.073449	0.045308	6_9_2	0	0
11	0.027405	0.016801	7_1	0.030011	0.019202
12	$-1x10^{-9}$	$-3x10^{-10}$	7_2	0.015002	0.009600
3_1	0.031514	0.019502	7_3	$-1x10^{-10}$	0
3_2	0.017102	0.010500	10_1	0.034221	0.020704
3_3	0.002700	0.001500	10_2	0.022806	0.013801
3_4	-0.000000	0.000000	10_3	0.011401	0.006900
6_1	0.450751	0.275581	10_4	0	0

TABLE III

REAL AND REACTIVE LOSSES FOR DIFFERENT BRANCHES

Node No	PL(pu)	QL(pu)	Node No	PL(pu)	QL(pu)
1-2	0.00623441	0.00255771	6_2-6_3	0.00206861	0.00047064
2-3	0.00518015	0.00212519	6_3-6_4	0.00147259	0.00033503
3-4	0.00716010	0.00198759	6_4-6_5	0.00111330	0.00025329
4-5	0.00582912	0.00161812	6_5-6_6	0.00111359	0.00019127
5-6	0.00518275	0.00143869	6_6-6_7	0.00075272	0.00012928
6-7	0.00127263	0.00021858	6_7-6_8	0.00055387	0.00009513
7-8	0.00057512	0.00009878	6_8-6_9	0.00019261	0.00003308
8-9	0.00052792	0.00009067	6_9-6_9_1	0.00004552	0.00000782
9-10	0.00018293	0.00003142	6_9_1-6_9_2	0.00000508	0.00000087
10-11	0.00004367	0.00000750	7-7_1	0.00001987	0.00000341
11-12	0.00000485	0.00000083	7_1-7_2	0.00000883	0.00000152
3-3_1	0.00001941	0.00000333	7_2-7_3	0.00000221	0.00000038
3_1-3_2	0.00001217	0.00000209	10-10_1	0.00002002	0.00000344
3_2-3_3	0.00000179	0.00000031	10_1-10_2	0.00001502	0.00000258
3_3-3_4	0.00000002	0.000000003	10_2-10_3	0.00000501	0.00000086
6-6_1	0.00269516	0.00074815	10_3-10_4	0.00000083	0.00000014
6_1-6_2	0.00203282	0.00056429			

VI. CONCLUSION

A new method for solving the load flow problem for radial distribution feeders without using conventional load flow methods like Gauss Seidel, Newton Raphson, Fast Decoupled methods is presented in this paper. This method uses simple algebraic equations to calculate iteratively the outgoing powers and voltage magnitudes of different nodes and mismatches at the last nodes of main feeder and laterals and depending upon mismatches the substation injection is corrected judiciously and this process is repeated until convergence. Outgoing power from a node wherefrom a lateral starts to main feeder and lateral is modified depending upon ratio of mismatches in last nodes of subsequent network. This makes the algorithm very robust and numerically efficient for convergence for wide variation of distribution network. Case study is done to validate the algorithm and compare it's superiority over existing methods.

REFERENCES

[1] W.H. Kersting, D.L. Mendive, "An Application of Ladder Network Theory to the Solution of Three Phase Load Flow Problem", *Proceedings IEEE PES winter meeting,* New York,1976

[2] W.H. Kersting, "A Method to Design and Operation of a Distribution System", *PAS-103,* pp. 1945- 1952, 1984.

[3] R.A. Stevens, D.T. Rizy, S.L. Purucker, "Performance of Conventional Power Flow Routines for Real-Time Distribution Automation Application", *Proceeding of 18th Southeastern Symposium on System Theory (IEEE Computer Society),* 96-200, 1986.

[4] D. Shirmohammadi, H.W. Hong, A. Semlyen, G.X. Luo, "A Compensation-Based Power Flow Method for Weakly Meshed Distribution and Transmission Networks", *PWS,* vol. 3, no. 2, pp. 753-762, 1988.

[5] C.S. Cheng, D. Shirmohammadi, "A Three-Phase Power Flow Method for Real-Time Distribution System Analysis", *PWS,* vol. 10, no. 2, 671-679, 1995.

[6] M. Baran, F.F. Wu, "Optimal Sizing of Capacitors Placed on a Radial Distribution System", *PWD,* vol. 4, no. 1, 735-743, 1989.

[7] R.G. Cespedes, "New Method for the Analysis of Distribution Networks", *PWD,* vol. 5, no. 1, 391-396, 1990.

[8] H.D. Chiang, "A Decoupled Load Flow Method for Distribution Power Network Algorithms, Analysis and Convergence Study", *Electric Power Energy Systems,* vol. 13, no.3, 9-13, 1991.

[9] G.B. Hasmon, L.H.C.C. Lee, "Distribution Network Reduction for Voltage Stability Analysis and Load Flow Calculations", *Electric Power Energy Systems,* vol. 13, no. 1, pp. 9-13, 1991.

[10] G.B. Hasmon, L.H.C.C. Lee, "Stability of Load Flow Techniques for Distribution System Voltage Stability Analysis", *IEE Proceedings C,* vol. 138, no. 6, pp. 479-484,1991.

[11] S. Ghosh, D. Das,"Method for Load-Flow Solution of Radial Distribution Networks", *IEE Proceedings C,* vol. 146, no. 6, pp. 641-648,1999.

[12] S.F.Mekhamer, S.A. Soliman, M.A. Moustafa, M.E. El-Hawary, "Load flow solution of radual distribution feeders: a new contribution", Electrical Power and Energy Systems, vol-24,Page: 701-707, 2002.

[13] Salma MMA, Chikhani AY. A simplified network approach to the VAr control problem for radial distribution systems.

