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A Novel Back Tracking based Load Flow Solution for Distribution Systems

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Abstract: Power-flow or load-flow studies are very important in determining the overall operation of the existing system as well as for planning of future expansion following the constraints under steady state conditions. Load flow or power flow will give the systematic mathematical approach for obtaining the voltages at the buses, currents through branches and active and reactive power flow through different branches in the given system. In this paper, a new load flow method based on back tracking search algorithm, which in turn uses compensating factors. The system parameters are updated locally and as well as globally to obtain the solution without any iterative processes. The complete methodology is explained with supporting numerical and graphical results for Radial-33 node and Radial-69 node test systems.

Keywords: Distribution load flow, Back tracking search algorithm, Local compensating factor, Global compensating factor.

I. INTRODUCTION

Distribution load flow algorithms play vital role to estimate system performance under normal and severe conditions. The solution to this problem estimates voltage magnitude, voltage angle at the system nodes, active and reactive power flows in the branches of a given distribution system. The constraints in the load flow problem are in the form of minimum and maximum limits of voltages and reactive powers at the buses in the system.

Usually, static non-linear load flow equations are developed for solving the load flow problem. For this, there are iterative methods such as Gauss Seidel, NR methods are used for solving those equations. But the distribution systems are having high R/X ratio compared to the transmission system, due to this reason, the traditional iterative methods mentioned above may provide inaccurate results and may not converge. So many researchers have proposed different load flow methods for both radial and weakly meshed distribution systems.

Fan Zhang and Carol S. Cheng [1] developed modified Newton method for radial distribution systems without decreasing the size of the problem for achieving robust convergence and high efficiency. A. Blengini [2] presented a new open source algorithm based on the object oriented technique to develop load flow solutions in radial distribution systems consisting of all load models. Arturo Losi and Mario Russo [3] presented object oriented load flow based on Newton-Raphson technique by considering some approximations in the Jacobian matrix and derived some convergence conditions. Wei Wu et.al. [4, 5] developed a probabilistic load flow based on the approach using the combination of multiple integral method and cumulate method to reduce the computational burden for achieving satisfactory accuracy. M.H. Haque [6] presented a very simple method of load flow calculation for general distribution system for a meshed network having more than one feeding node.

From the careful review of the literature, it is noticed that, most of the literature is concentrated in finding the solution for the load flow problem using iterative processes. But, in this work, a new methodology based on compensating factors is developed to maximize the solution accuracy and to minimize the computational time by avoiding iterative process. In this process, two compensating factors namely, local compensating factor and global compensating factors are calculated and there by the system parameters are updated. The developed methodology is tested on Radial-33 node and Radial-69 node test systems with supporting numerical and graphical results.

II. EXISTING DISTRIBUTION LOAD FLOW

M.H. Haque [1] proposed a general load flow method for distribution systems. To exemplify this, a sample radial distribution system shown in Fig.1 is considered. Which consists of a branch connected between nodes k and m, having the resistance Ri and inductance Xi. Let the loads at node-k and node-m are $\left(P_L^k + jQ_L^k\right)$ and $\left(P_L^m + jQ_L^m\right)$ respectively.

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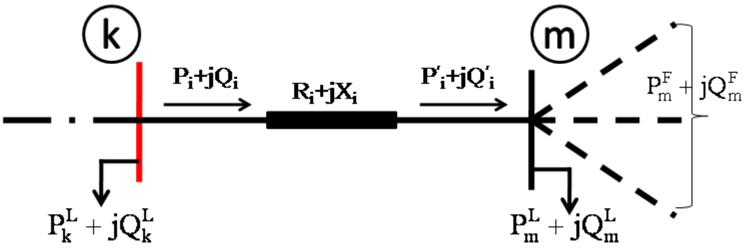

Fig.1 Two node distribution system

The active (Pi) and reactive (Qi) power flow through the branch i near node k can be written as

$$P_i = P_i' + R_i \frac{(P_i')^2 + (Q_i')^2}{V_m^2} \tag{1}$$

$$Q_i = Q_i' + X_i \frac{(P_i')^2 + (Q_i')^2}{V_m^2} \tag{2}$$

Where, $P_i' = P_m^L + P_m^F$ and $Q_i' = Q_m^L + Q_m^F$

The superscripts L, F represents the load, flow respectively. The flow is the sum of power flow through all the downstream branches that are connected to nodee-m. Eqns (1) and (2) can be used in backward direction to find the power flow through all branches in the system.

Once the power flows are known, the voltage magnitude and phase angle at node m can be calculated from the following equation

$$V_m = \sqrt{V_k^2 - 2(P_i^1 R_i + Q_i' X_i) + ((P_i')^2 + (Q_i')^2)(R_i^2 + X_i^2)/V_k^2} \tag{3}$$

$$\delta_m = \delta_k - \tan^{-1}\left(\frac{a_1}{a_2}\right) \tag{4}$$

Where, $a_1 = \frac{(P' X_i - Q_i' R_i)}{V_k}$ and $a_2 = V_k - \frac{(P' X_i + Q_i' R_i)}{V_k}$

III.PROPOSED BACK TRACKING LOAD FLOW METHOD

The proposed methodology starts the process from numbering of nodes and branches and followed by identification of end nodes. At first, for a given distribution system, first node is assumed to be the substation node. The remaining nodes of the main feeder are assigned with the sequential number. The laterals are numbered starting from the substation. The nodes of the lateral are numbered according to the increasing order followed by the main feeder.

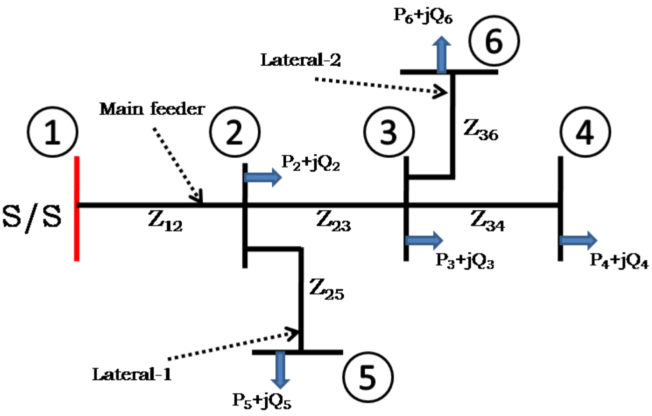

Fig.2 Sample radial distribution system

For example, consider a radial distribution system shown in Fig.2. For this system, the substation node is numbered as node-1 and the remaining buses of the main feeder are numbered sequentially from node-2 to node-4. The laterals

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connected to main feeder are numbered starting from substation node i.e. lateral connected to node-2 is lateral-1 and lateral connected to node-3 is lateral-2. The nodes of the lateral are numbered in increasing order followed by the main feeder i.e. node connected to later-1 is numbered as node-5 and the node connected to lateral-2 is numbered as node-6.

After this process, the end nodes are identified for the main feeder and as well as the laterals by following the highest node number. For example, for the system shown in Fig.2, the end bus for the main feeder is node-4, lateral-1 is node-5 and for lateral-2 is node-6.

Start the next process by assuming flat voltage profile at the end buses ($\bar{V}_n$) i.e. the voltage at the end nodes to be 1+j0 p.u. Next, current in the braches connected to end node/current at the end nodes (i.e. main feeder/laterals) is calculated as

$$\bar{I}_{m-n} = \bar{I}_n = \frac{P_n - jQ_n}{\left(\bar{V}_n\right)^*} \quad ; \quad n = \text{end nodes} \tag{5}$$

Where, Pn, Qn are the active and reactive loads connected to nth end node and node-m is the node connected before the end node. For this system, the branch and node current at end nodes (n=4, 5, 6) is calculated as $\bar{I}_{3-4} = \bar{I}_4$, $\bar{I}_{3-6} = \bar{I}_6$ and $\bar{I}_{2-5} = \bar{I}_5$.

The voltage magnitude at the mth node i.e. $\bar{V}_m$ is computed based on the number of branches or/and loads connected to it. This can be expressed as

$$\bar{V}_m = \bar{V}_n + \bar{I}_{m-n} \times \bar{Z}_{m-n} \tag{6}$$

Where, $\bar{Z}_{m-n}$ is impedance of the branch connected between nodes m and n. Here, $\bar{V}_n$ is assumed to be (1+j0) p.u. For the considered system, the voltage at node-3 is calculated as

From node-4, $\bar{V}_3^4 = \bar{V}_4 + \bar{I}_{3-4} \times \bar{Z}_{3-4}$

Similarly, from node-6, $\bar{V}_3^6 = \bar{V}_6 + \bar{I}_{3-6} \times \bar{Z}_{3-6}$

After calculation of voltage at node-m, the local compensating factor (LCF) for maintaining similar voltage at node-m can be calculated as

$$\text{LCF} = \frac{\bar{V}_m\,(\text{highest value})}{\bar{V}_m\,(\text{lowest value})} \tag{7}$$

For the considered system, the LCF is calculated as

$$\text{LCF} = \frac{\bar{V}_3^6}{\bar{V}_3^4} \left(\text{by assuming } \bar{V}_3^6 > \bar{V}_3^4\right)$$

The current in the branch connected to end which yields lowest voltage is updated as

$$\bar{I}_{m-n}^{\text{new}} = \bar{I}_{m-n}^{\text{old}} \times \text{LCF} \tag{8}$$

For the considered system, current in the branch connected between nodes 3 and 4 is updated (since $V_3^6 > V_3^4$) as

$$\bar{I}_{3\text{-}4}^{\text{new}} = \bar{I}_{3\text{-}4}^{\text{old}} \times \text{LCF}$$

The above procedure is repeated for all the remaining nodes including substation node. For the considered system, voltage at nodes 2 and 1 is calculated.

In this process, calculated voltage (Vcal) at source node is different from the specified voltage (Vsp). For making unified calculate voltage with the specified voltage, a global compensating factor (GCF) is calculated as

$$\text{GCF} = \frac{\text{Specified Voltage}\,(\bar{V}_{sp})}{\text{Calculated Voltage}\,(\bar{V}_{cal})} \tag{9}$$

Finally, using GCF, the voltage at remaining nodes other than substation node are updated as

$$\overline{V}_m^{new} = \overline{V}_m^{old} \times GCF \tag{10}$$

For the considered system, voltages at the remaining nodes are updated for m=2, 3, 4, 5 and 6.
After calculation of new voltages, branch currents are calculated as

$$\bar{I}_{m-n} = \frac{\left(\overline{V}_m - \overline{V}_n\right)}{Z_{m-n}} \tag{11}$$

Similarly, active and reactive power losses in the branches can be calculated as

$$P_{m-n} = \bar{I}_{m-n}^2 \times R_{m-n} \tag{12}$$

$$Q_{m-n} = \bar{I}_{m-n}^2 \times X_{m-n} \tag{13}$$

IV. ALGORITHM FOR LOAD FLOW SOLUTION

The following algorithm followed to solve load flow problem for both radial and meshed distribution systems.
Step 1: Read distribution system data i.e. line resistance and reactance data, active and reactive load data.
Step 2: Give number to the nodes as per the procedure explained in section-III.
Step 3: Identify end nodes for both the main feeder and laterals.
Step 4: Calculate node voltage using the Eqn (6) and calculate LCF using Eqn (7).
Step 5: Update the line current using Eqn (8).
Step 6: Calculate GCF and updated voltages using Eqns (9) and (10).
Step 7: Calculate line current and there by the losses using Eqns (11) to (13).

V. RESULTS AND ANALYSIS

To demonstrate the effectiveness of the proposed load flow methodology over the existing load flow methodology, two test systems namely Radial-33 node and Radial-69 are considered [7, 8].
The entire analysis is performed for the following four cases.
Case-1: Load flow problem is solved for the radial-33 and distribution system using the existing and proposed methodologies (explained in sections II and III).
Case-2: Load flow problem is solved for the radial- 69 node distribution system using the existing and proposed methodologies (explained in sections II and III).

A. Case-1

In this case, Radial-33 node distribution system with 32 branches, 3715 kW active load and 2300 kVAr reactive load is considered.

In case 1, the load flow problem is solved using existing and proposed load flow methodologies and obtained results are tabulated in Table.1. From this table, it is observed that, the voltage profile of the proposed methodology is very slightly higher when compared to the existing methodology. This is because of the updating system parameters locally and as well as globally without considering any simplifications. The variation of voltage magnitude is shown in Fig.5.

TABLE.1 LOAD FLOW RESULTS FOR CASE-1

Node No	Existing method [8]		Proposed Method	
	Voltage Magnitude (p.u.)	Voltage Angle (deg)	Voltage Magnitude (p.u.)	Voltage Angle (deg)
1	1	0	1.0000	0.0000
2	0.997	0.0148	0.9974	0.0124
3	0.983	0.0985	0.9851	0.0846
4	0.9755	0.1658	0.9787	0.1424
5	0.9682	0.2341	0.9724	0.2006
6	0.9498	0.1446	0.9568	0.1249
7	0.9463	-0.0872	0.9538	-0.0676
8	0.9415	-0.0539	0.9497	-0.0358
9	0.9352	-0.1312	0.9444	-0.0956

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10	0.9294	-0.198	0.9395	-0.1468
11	0.9286	-0.1914	0.9387	-0.1406
12	0.9271	-0.1812	0.9375	-0.1307
13	0.921	-0.2778	0.9323	-0.2063
14	0.9187	-0.3585	0.9304	-0.2717
15	0.9173	-0.3976	0.9292	-0.3031
16	0.916	-0.4223	0.9280	-0.3225
17	0.914	-0.5017	0.9263	-0.3869
18	0.9134	-0.512	0.9258	-0.3949
19	0.9479	0.0039	0.9969	0.0018
20	0.9453	-0.0636	0.9933	-0.0639
21	0.9339	-0.0831	0.9927	-0.0830
22	0.9257	-0.1036	0.9920	-0.1030
23	0.9222	0.0673	0.9817	0.0557
24	0.918	-0.022	0.9754	-0.0275
25	0.9171	-0.0662	0.9723	-0.0686
26	0.9168	0.1858	0.9551	0.1584
27	0.9794	0.2443	0.9530	0.2061
28	0.9727	0.3386	0.9432	0.2774
29	0.9694	0.4249	0.9362	0.3439
30	0.9965	0.5338	0.9332	0.4329
31	0.9929	0.4534	0.9297	0.3620
32	0.9922	0.4312	0.9289	0.3426
33	0.9916	0.4237	0.9286	0.3362

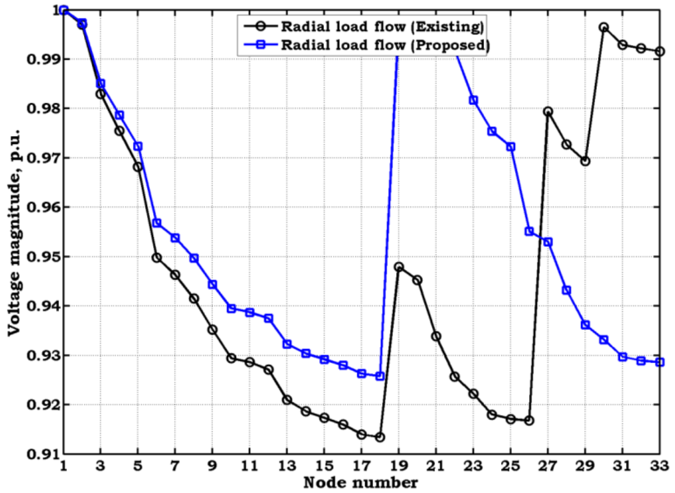

Fig.5 Variation of Voltage Magnitude for case 1

Similarly, the active and reactive power losses in each of the branch for the existing and proposed load flow methodologies are tabulated in Table.2 and the respective variation is shown in Fig.6

TABLE.2 POWER LOSSES FOR CASE 1

Branch No	Sending Node	Receiving Node	Existing method [8]		Proposed method	
			Ploss (kW)	Qloss (kVAr)	Ploss (kW)	Qloss (kVAr)
1	1	2	12.1927	6.2154	12.0168	6.1257
2	2	3	51.5711	26.2668	50.7392	25.8430
3	3	4	19.7934	10.0806	19.3907	9.8755
4	4	5	18.5931	9.4697	18.2012	9.2702
5	5	6	38.0256	32.8256	37.2126	32.1237

6	6	7	1.9131	6.3238	1.8726	6.1900
7	7	8	4.8342	1.5976	4.7257	1.5617
8	8	9	4.1773	3.0012	4.0771	2.9292
9	9	10	3.5575	2.5216	3.4707	2.4601
10	10	11	0.5531	0.1829	0.5394	0.1783
11	11	12	0.8802	0.2911	0.8582	0.2838
12	12	13	2.6638	2.0958	2.5960	2.0425
13	13	14	0.7286	0.9590	0.7098	0.9344
14	14	15	0.3569	0.3176	0.3475	0.3093
15	15	16	0.2813	0.2054	0.2739	0.2000
16	16	17	0.2515	0.3358	0.2448	0.3268
17	17	18	0.0531	0.0416	0.0517	0.0405
18	2	19	0.1610	0.1536	0.1608	0.1535
19	19	20	0.8322	0.7498	0.8315	0.7492
20	20	21	0.1008	0.1177	0.1007	0.1176
21	21	22	0.0436	0.0577	0.0436	0.0576
22	3	23	3.1812	2.1737	3.1635	2.1616
23	23	24	5.1432	4.0613	5.1140	4.0382
24	24	25	1.2873	1.0073	1.2798	1.0014
25	6	26	2.5940	1.3213	2.5348	1.2911
26	26	27	3.3211	1.6909	3.2440	1.6517
27	27	28	11.2766	9.9424	11.0105	9.7078
28	28	29	7.8180	6.8108	7.6318	6.6487
29	29	30	3.8881	1.9805	3.7948	1.9329
30	30	31	1.5928	1.5742	1.5529	1.5347
31	31	32	0.2131	0.2484	0.2077	0.2421
32	32	33	0.0132	0.0205	0.0128	0.0199
Total Power Loss (KW)			201.8925	134.6413	198.011	132.002

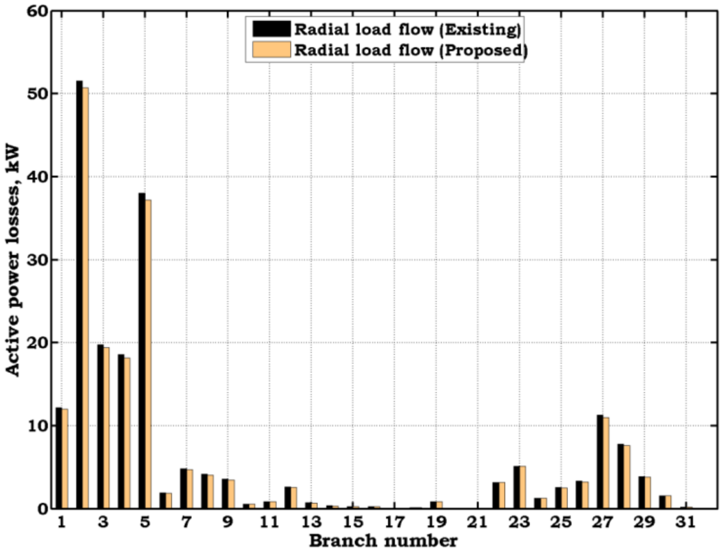

Fig.6 Variation of active power losses for case 1

Similarly, the consolidated results for this case are tabulated in Table.3. From this table, it is identified that, due to effectiveness of the proposed load flow methodology, the total active power losses are decreased when compared to the existing load flow methodology. Similarly, with the proposed method, the low voltage node is identified to be 18, which is farer from the source node. It is also observed that, due to reduced complexity of mathematics and minimized number of mathematical computations in the proposed method, computational time taken is reduced drastically when compared to existing load flow method.

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TABLE.3 CONSOLIDATED LOAD FLOW RESULTS FOR CASE 1

Parameter	Existing radial load flow method [8]	Proposed load flow method
Total active power losses (kW)	201.8925	198.011
Total reactive power losses (kVAr)	134.6413	132.002
Minimum voltage node	18	18
Minimum voltage (p.u)	0.9134	0.9258
Computational time (sec)	0.17	0.06

B. Case-2

In this example, Radial -69 node distribution system with 68 branches, 3802 kW active load and 2695 kVAr reactive load is considered.

In case 2, the load flow problem is solved using existing and proposed load flow methodologies and obtained results are tabulated in Table.4. From this table, it is observed that, the voltage profile of the proposed methodology is very slightly higher when compared to the existing methodology. This is because of the updating system parameters locally and as well as globally without considering any simplifications. The variation of voltage magnitude is shown in Fig.7.

TABLE.4 LOAD FLOW RESULTS FOR CASE 2

Node No	Existing method [8]		Proposed Method	
	Voltage Magnitude (p.u.)	Voltage Angle (deg)	Voltage Magnitude (p.u.)	Voltage Angle (deg)
1	1	0	1.0000	0.0000
2	1	-0.0012	1.0000	-0.0011
3	0.9999	-0.0024	0.9999	-0.0022
4	0.9998	-0.0057	0.9999	-0.0053
5	0.999	-0.0168	0.9991	-0.0163
6	0.9901	0.0672	0.9914	0.0417
7	0.9809	0.156	0.9834	0.1028
8	0.9787	0.1774	0.9815	0.1175
9	0.9776	0.1885	0.9805	0.1251
10	0.9726	0.2775	0.9759	0.2022
11	0.9715	0.2973	0.9748	0.2193
12	0.9683	0.3531	0.9336	0.7822
13	0.9654	0.4028	0.9310	0.8247
14	0.9625	0.4528	0.9285	0.8675
15	0.9597	0.5019	0.9259	0.9094
16	0.9592	0.5111	0.9255	0.9173
17	0.9583	0.5262	0.9247	0.9302
18	0.9583	0.5264	0.9247	0.9303
19	0.9578	0.5354	0.9243	0.9381
20	0.9575	0.5413	0.9240	0.9432
21	0.957	0.5507	0.9236	0.9513
22	0.957	0.5509	0.9236	0.9514
23	0.957	0.5523	0.9235	0.9526
24	0.9568	0.5554	0.9234	0.9553
25	0.9566	0.5587	0.9232	0.9581
26	0.9566	0.5601	0.9232	0.9593
27	0.9566	0.5605	0.9232	0.9597
28	0.9999	-0.0026	0.9999	-0.0025
29	0.9999	-0.0052	0.9999	-0.0051
30	0.9997	-0.0031	0.9997	-0.0029
31	0.9997	-0.0027	0.9997	-0.0026
32	0.9996	-0.0008	0.9996	-0.0007
33	0.9993	0.0036	0.9994	0.0037
34	0.999	0.0094	0.9990	0.0096

35	0.9989	0.0105	0.9990	0.0106
36	0.9999	-0.0029	0.9999	-0.0027
37	0.9997	-0.0093	0.9998	-0.0091
38	0.9996	-0.0117	0.9996	-0.0115
39	0.9995	-0.0124	0.9996	-0.0122
40	0.9995	-0.0125	0.9995	-0.0122
41	0.9988	-0.0235	0.9989	-0.0232
42	0.9986	-0.0282	0.9986	-0.0278
43	0.9985	-0.0288	0.9985	-0.0284
44	0.9985	-0.0289	0.9985	-0.0286
45	0.9984	-0.0307	0.9984	-0.0304
46	0.9984	-0.0307	0.9984	-0.0304
47	0.9998	-0.0075	0.9998	-0.0071
48	0.9985	-0.0528	0.9986	-0.0513
49	0.9947	-0.1935	0.9948	-0.1887
50	0.9942	-0.2135	0.9942	-0.2083
51	0.9786	0.1777	0.9814	0.1178
52	0.9786	0.1779	0.9814	0.1180
53	0.9748	0.2173	0.9781	0.1435
54	0.9716	0.2509	0.9754	0.1651
55	0.9671	0.2979	0.9717	0.1951
56	0.9628	0.3441	0.9680	0.2247
57	0.9407	0.7998	0.9491	0.5562
58	0.9298	1.0324	0.9398	0.7246
59	0.9256	1.1252	0.9362	0.7917
60	0.9206	1.2438	0.9320	0.8782
61	0.9133	1.3341	0.9258	0.9352
62	0.913	1.3377	0.9256	0.9374
63	0.9126	1.3425	0.9252	0.9405
64	0.9107	1.366	0.9236	0.9552
65	0.9102	1.3731	0.9232	0.9597
66	0.9714	0.2984	0.9364	0.7351
67	0.9714	0.2985	0.9364	0.7351
68	0.968	0.3594	0.9333	0.7879
69	0.968	0.3594	0.9333	0.7879

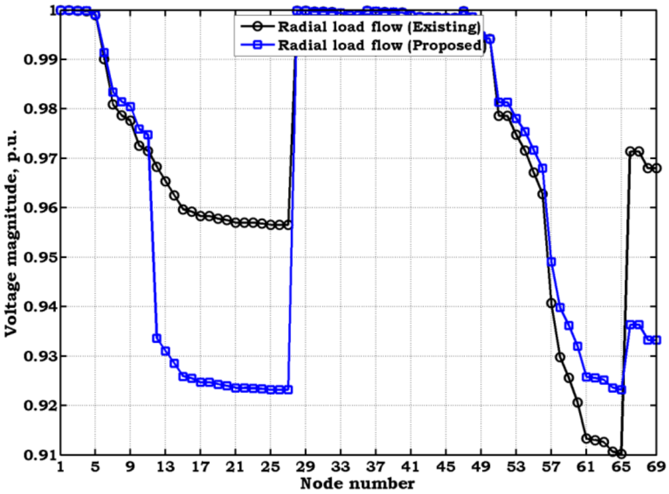

Fig.7 Variation of Voltage Magnitude for case 2

Similarly, the active and reactive power losses in each of the branch for the existing and proposed load flow methodologies are tabulated in Table.5 and the respective variation is shown in Fig.8

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TABLE.5 POWER LOSSES FOR CASE 2

Branch No	Sending Node	Receiving Node	Existing method [8]		Proposed Method	
			Ploss (kW)	Qloss (kVAr)	Ploss (kW)	Qloss (kVAr)
1	1	2	0.0749	0.1798	0.0748	0.1795
2	2	3	0.0749	0.1798	0.0748	0.1795
3	3	4	0.1947	0.4674	0.1944	0.4665
4	4	5	1.9339	2.2653	1.9294	2.2599
5	5	6	28.2001	14.362	28.1338	14.3283
6	6	7	29.2986	14.9261	29.2297	14.8910
7	7	8	6.8844	3.5094	6.8685	3.5013
8	8	9	3.3698	1.7157	3.3626	1.7120
9	9	10	4.7772	1.579	5.0447	1.6674
10	10	11	1.0148	0.3355	1.0740	0.3551
11	11	12	2.1920	0.7244	2.3555	0.7784
12	12	13	1.2868	0.4248	1.3819	0.4562
13	13	14	1.2464	0.4059	1.3384	0.4359
14	14	15	1.2055	0.3983	1.2946	0.4278
15	15	16	0.2240	0.0741	0.2406	0.0795
16	16	17	0.3207	0.106	0.3444	0.1139
17	17	18	0.0026	0.0009	0.0028	0.0010
18	18	19	0.1043	0.0345	0.1120	0.0370
19	19	20	0.0671	0.022	0.0720	0.0236
20	20	21	0.1076	0.0356	0.1155	0.0382
21	21	22	0.0005	0.0002	0.0006	0.0002
22	22	23	0.0051	0.0017	0.0055	0.0018
23	23	24	0.0112	0.0037	0.0120	0.0040
24	24	25	0.0060	0.002	0.0065	0.0021
25	25	26	0.0025	0.0008	0.0027	0.0009
26	26	27	0.0003	0.0001	0.0004	0.0001
27	3	28	0.0003	0.0009	0.0003	0.0009
28	28	29	0.0026	0.0063	0.0026	0.0063
29	29	30	0.0058	0.0019	0.0058	0.0019
30	30	31	0.0010	0.0003	0.0010	0.0003
31	31	32	0.0051	0.0017	0.0051	0.0017
32	32	33	0.0123	0.0041	0.0123	0.0041
33	33	34	0.0104	0.0034	0.0104	0.0034
34	34	35	0.0005	0.0002	0.0005	0.0002
35	3	36	0.0014	0.0034	0.0014	0.0034
36	36	37	0.0151	0.0369	0.0151	0.0369
37	37	38	0.0173	0.0202	0.0173	0.0202
38	38	39	0.0050	0.0058	0.0050	0.0058
39	39	40	0.0002	0.0002	0.0002	0.0002
40	40	41	0.0487	0.0569	0.0487	0.0569
41	41	42	0.0201	0.0235	0.0201	0.0235
42	42	43	0.0027	0.0031	0.0027	0.0031
43	43	44	0.0005	0.0006	0.0005	0.0006
44	44	45	0.0061	0.0077	0.0061	0.0077
45	45	46	0.0000	0	0.0000	0.0000
46	4	47	0.0233	0.0575	0.0233	0.0575
47	47	48	0.5828	1.4265	0.5827	1.4263
48	48	49	1.6334	3.9968	1.6333	3.9963
49	49	50	0.1159	0.2835	0.1159	0.2835
50	8	51	0.0018	0.0009	0.0017	0.0009
51	51	52	0.0000	0	0.0000	0.0000

52	52	53	5.7696	2.9378	5.6185	2.8609
53	53	54	6.6978	3.4116	6.5221	3.3221
54	54	55	9.1059	4.6362	8.8645	4.5134
55	55	56	8.7718	4.4685	8.5372	4.3490
56	56	57	49.5809	16.6423	48.2550	16.1973
57	57	58	24.4381	8.2011	23.7846	7.9818
58	58	59	9.4859	3.137	9.2322	3.0531
59	59	60	10.6485	3.2323	10.3610	3.1451
60	60	61	13.9966	7.1293	13.6187	6.9368
61	61	62	0.1118	0.0569	0.1087	0.0554
62	62	63	0.1346	0.0685	0.1309	0.0666
63	63	64	0.6597	0.336	0.6414	0.3267
64	64	65	0.0411	0.0209	0.0400	0.0204
65	11	66	0.0026	0.0008	0.0028	0.0009
66	66	67	0.0000	0	0.0000	0.0000
67	12	68	0.0233	0.0077	0.0251	0.0083
68	68	69	0.0000	0	0.0000	0.0000
Total Power Loss (KW)			224.5867	101.9848	221.526	100.720

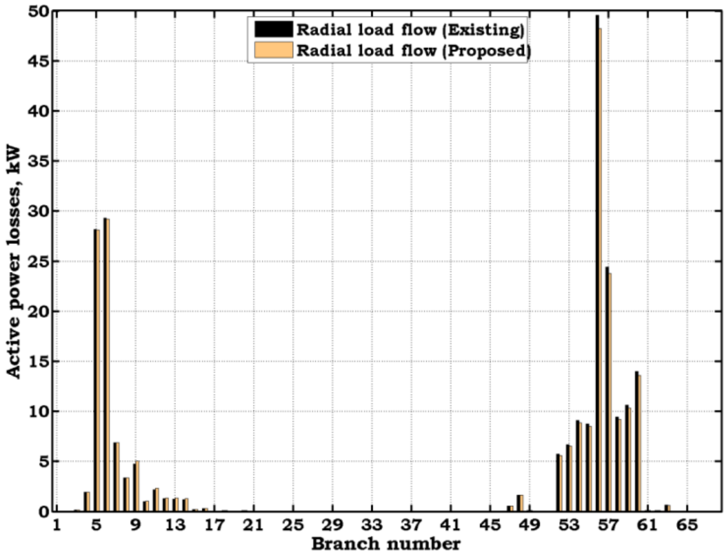

Fig.8 Variation of active power losses for case 2

Similarly, the consolidated results for this case are tabulated in Table.6. From this table, it is identified that, due to effectiveness of the proposed load flow methodology, the total active power losses are decreased when compared to the existing load flow methodology. Similarly, with the proposed method, the low voltage node is identified to be 65, which is farer from the source node. It is also observed that, due to reduced complexity of mathematics and minimized number of mathematical computations in the proposed method, computational time taken is reduced drastically when compared to existing load flow method.

TABLE.6 CONSOLIDATED LOAD FLOW RESULTS FOR CASE 2

Parameter	Existing radial load flow method [8]	Proposed load flow method
Total active power losses (kW)	224.5867	221.526
Total reactive power losses (kVAr)	101.9848	100.720
Minimum voltage node	0.9102	0.9232
Minimum voltage (p.u)	65	65
Computational time (sec)	0.27	0.12

VI. CONCLUSIONS

In this paper, a new methodology to solve load flow problem has been presented with necessary mathematical derivations. The back tracking radial load flow method has been used to solve load flow problem for radial distribution systems. From the analysis, it has been summarized that, updating system variables locally and as well as globally, the proposed methodology yields better results when compared to existing methodologies. The entire methodology has been tested on Radial-33 node and Radial-69 node test systems with supporting numerical and graphical results.

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