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Study of Simple Load Flow Technique for Distribution System

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Abstract

In this paper a simple load flow technique for Distribution system is studied, which includes evaluation of simple algebraic equation for computing receiving end voltage and does not include trigonometric functions. This method is particularly very fast and efficient for distribution system with high R/X ratio, where conventional method are inefficient and time consuming. This method is successfully implemented on 34 & 69 Bus distribution system.

key words: Radial System; Load Flow; Distribution System

I. INTRODUCTION

Now days with modernization of society power demand is also increasing. This demand in distribution networks varies during whole day from highest demand at peck time to lowest demands during night time. To monitor demand change and load forecasting in distribution networks, it is essential to carry out load flow analysis on the system repeatedly. Load flow analysis basically provides operating condition of system at different loading level. Load flow are also important for planning of reactive VAR compensation and state estimation. It is essential in planning, optimization and stability studies. To fulfill this requirement an efficient and fast load flow method is required[1].

Traditional load flow techniques like Newton Raphson and Fast Decouple Load Flow are inefficient to solve distribution system case as, in distribution system R/X ratio is quite high compared to transmission network, for which traditional method are insufficient[2][3]. Also, This traditional method are iterative and compose of trigonometric functions, that means this load flow techniques require more time and memory for solving iterative steps.

In this paper, simple yet unique method is described for solution of Distribution load flow. This method involves solution of simple algebraic equation to compute receiving end voltage and no trigonometric terms involved for solution. This method guarantee convergence even with high R/X ratio as in practical cases.

II. METHODOLOGY

A simple two bus distribution system is shown in Figure 1. In this system 2 bus with generator being at bus 1 and load at bus 2 is considered.

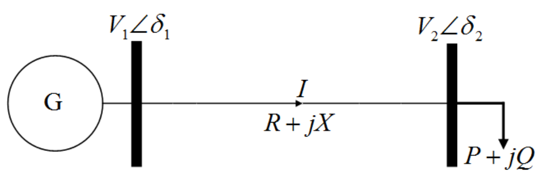

Figure 1. Simplest form of 2-Bus Network

From the above system we can write equation for current,

$$I = \frac{V_1\angle\delta_1 - V_2\angle\delta_2}{R + jX} \quad ...(1)$$

and power being,

$$P - jQ = V_2^{*} I \quad ...(2)$$

From the above equations, we can write

$$\frac{V_1\angle\delta_1 - V_2\angle\delta_2}{R+jX} = \frac{P-jQ}{V_2^*} \quad ...(3)$$

Further derivation of this equation will lead to,

$$V_2 = \sqrt{\left(\sqrt{\left(PR+QX-0.5V_1^2\right)^2 - \left(R^2+X^2\right)\left(P^2+Q^2\right)}\right) - \left(PR+QX-0.5V_1^2\right)} \quad ...(4)$$

From equation (4), we can directly calculate the voltage at receiving end.

Similarly equation for calculating power angle is,

$$\delta_2 = \delta_1 - \tan^{-1}\left(\frac{PX+QR}{PR+QX+V_1^2}\right) \quad ...(5)$$

Now power loss in system can be calculated as,

$$P_L = I^2R$$
$$Q_L = I^2X \quad ...(7)$$

Current I in equation (7) is same as branch current, so

$$P_L = \left(\frac{P^2+Q^2}{V_2^2}\right)R \quad ...(8)$$

$$Q_L = \left(\frac{P^2+Q^2}{V_2^2}\right)X \quad ...(9)$$

These equation (4) through (9) can be extended to use in distribution system where the system beyond receiving end bus is considered to be lumped at receiving bus. That means whole distribution network is divided in 2 bus system. We can apply the equation (4), (5),(8) and (9) to calculate voltage and losses in particular section.

In such case we will calculate bus from starting bus where system is being feed toward the end node. Detailed algorithm for this system is given in [3] and [4].

III. DISTRIBUTION SYSTEM TEST CASE

Modified IEEE 34 Bus & 69 Bus radial distribution system are considered for study of this simple load flow technique. Details of this system can be found in [4][5].

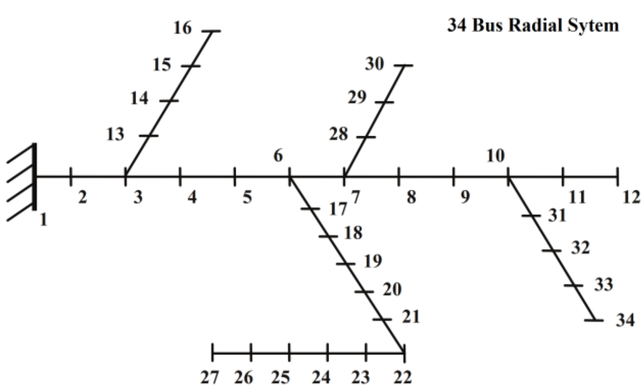

Figure 2. IEEE 34 Bus Radial system [3]

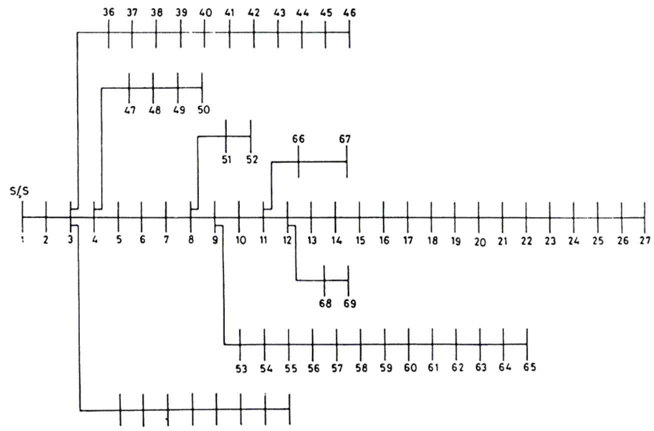

Figure 3. 69 Bus radial system

IV. RESULT AND ANALYSIS

After implementation of the proposed algorithm using the Simple Load Flow method on 34 Bus system, the result obtained are tabulated in Table 1. For comparison with conventional Newton Raphson method the system is also studied with NRLF and shown in Table 1.

Table 1. Voltage at each Bus in 34Bus system

Bus	Voltage in p.u.	
	Simple Load Flow	Newton Raphson Method
1	1	1
2	0.994345	0.9944
3	0.989395	0.9895
4	0.982625	0.9828
5	0.976773	0.9771
6	0.97123	0.9717
7	0.967425	0.968
8	0.965331	0.966
9	0.962869	0.9636
10	0.961685	0.9625
11	0.961227	0.9621
12	0.961091	0.9619
13	0.989062	0.9891
14	0.988756	0.9888
15	0.988674	0.9888
16	0.988614	0.9887
17	0.960973	0.9619
18	0.957302	0.9584
19	0.953236	0.9545
20	0.949958	0.9514
21	0.947103	0.9487

22	0.943836	0.9456
23	0.941145	0.9431
24	0.938612	0.9407
25	0.937392	0.9395
26	0.936923	0.9391
27	0.936783	0.939
28	0.967089	0.9677
29	0.966866	0.9675
30	0.966754	0.9674
31	0.961344	0.9622
32	0.961004	0.9618
33	0.960834	0.9617
34	0.960777	0.9616

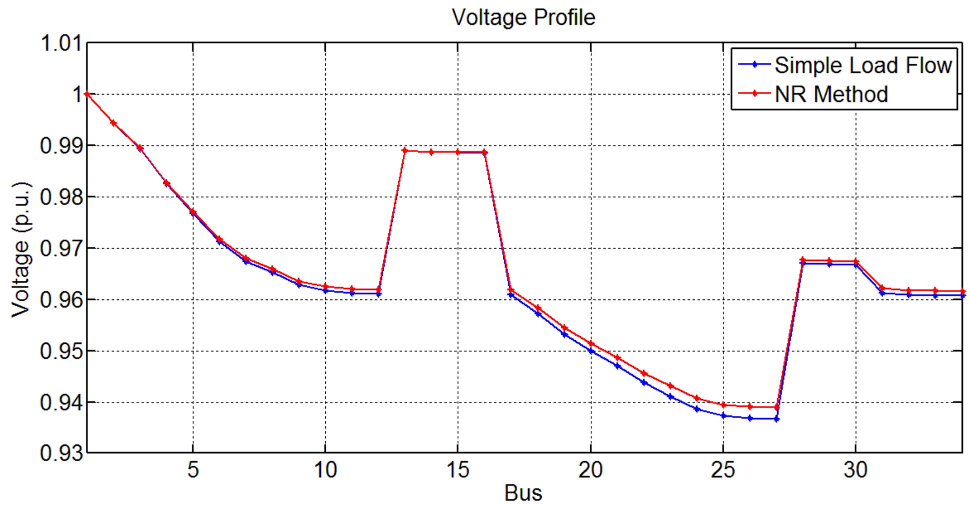

Figure 4. Voltage Profile Comparison for 34 Bus system

Table 2. Active and Reactive Power Losses in 34Bus system

	Active Power Loss	% Ploss	Reactive Power Loss	% Qloss
Simple Load Flow	213.41	4.60	95.28	3.31
NR method	201.25	4.34	88.93	3.09

Figure 4 shows the variation of voltage in p.u. at all the buses. The power losses are also calculated and presented in Table 2. It can be seen in Figure 4 that the studied Simple Load Flow method produce similar result in comparison with conventional complicated yet powerful NR method.

With the same Load Flow method 69 Bus distribution system is also studied and, the result obtained are tabulated in Table 3. Comparison of this simple load flow method with NR method is also tabulated in Table 3.

Table 3. Voltage at each Bus in 69Bus system

Bus	Voltage in p.u.	
	Simple Load Flow	Newton Raphson Method
1	1	1

2	0.999958	1
3	0.999915	0.9999
4	0.999797	0.9998
5	0.99878	0.9987
6	0.987627	0.9866
7	0.975886	0.9741
8	0.97308	0.9711
9	0.971647	0.9695
10	0.965036	0.963
11	0.963578	0.9616
12	0.959386	0.9576
13	0.955508	0.9539
14	0.951648	0.9503
15	0.94781	0.9468
16	0.947097	0.9461
17	0.945917	0.945
18	0.945906	0.945
19	0.945283	0.9445
20	0.944883	0.9441
21	0.944237	0.9436
22	0.944228	0.9436
23	0.944131	0.9435
24	0.943921	0.9434
25	0.943694	0.9432
26	0.943601	0.9431
27	0.943575	0.9431
28	0.999906	0.9999
29	0.999817	0.9998
30	0.999689	0.9997
31	0.999667	0.9997
32	0.999554	0.9996
33	0.999284	0.9993
34	0.998981	0.999
35	0.998892	0.9989
36	0.999897	0.9999
37	0.99967	0.9997
38	0.99946	0.9994
39	0.999399	0.9994
40	0.999396	0.9994
41	0.998472	0.9985
42	0.998085	0.9981

43	0.998034	0.998
44	0.998022	0.998
45	0.997892	0.9979
46	0.997891	0.9979
47	0.999731	0.9997
48	0.998089	0.9981
49	0.992988	0.993
50	0.992264	0.9922
51	0.973033	0.971
52	0.97302	0.971
53	0.968169	0.9657
54	0.964105	0.9613
55	0.95847	0.9552
56	0.95294	0.9492
57	0.923583	0.9183
58	0.90889	0.9032
59	0.903169	0.8973
60	0.896401	0.8904
61	0.88632	0.8803
62	0.885926	0.8799
63	0.885399	0.8793
64	0.882805	0.8767
65	0.882021	0.8759
66	0.963502	0.9615
67	0.963502	0.9615
68	0.958945	0.9571
69	0.958944	0.9571

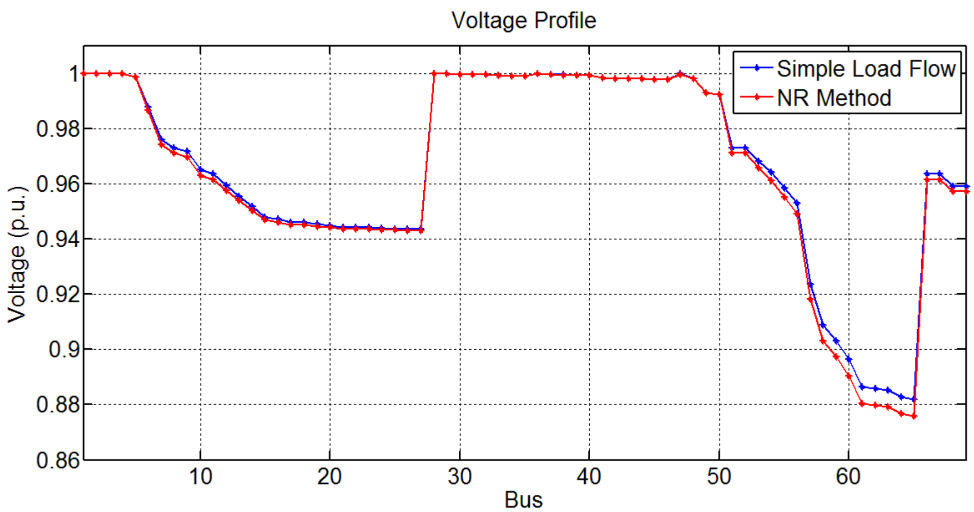

Figure 5. Voltage Profile comparison of 69Bus system

Table 4. Active & Reactive Power Losses in 69Bus system

	Active Power Loss	% Ploss	Reactive Power Loss	% Qloss
Simple Load Flow	285.93	7.54	128.92	4.78
NR method	313.54	8.30	141.95	5.28

Figure 5 shows comparison between Simple Load Flow technique implemented and Convention NR method. Active and Reactive power losses are tabulated in Table 4.

V. CONCLUSION

A Simple Load Flow is studied and validated by comparison with conventional Newton Raphson method. It is shown that the voltage magnitude and angle are similar to that of complicated Newton Raphson method. The method is very fast and accurate for solving distribution system load flow.

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