International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Power Loss Allocation of Balanced Radial Distribution Systems

Gundugallu Peddanna[1], Y. Siva Rama Kishore[2]

[1, 2] Electrical and Electronics Engineering Department, SRIT College, Ananthapuramu, A.P., India

Abstract: ***The distribution system is the final end component of the power system. It holds number of power consumers. These consumers should get power with quality. But when power travels from power stations to consumers power loss occurs. Here two types of loss exist in the power system such as transmission loss and distribution loss. Due to high resistance to reactance ratio in distribution system, losses are high in distribution system in comparison to transmission system. The evaluation of power loss gives an idea of power quality of a system. This paper gives loss calculation using backward and forward sweep based load flow method. The basic aim of this work is to evaluate the power loss and voltage schedule in the distribution system. In this paper two conditions are mainly considered in case of radial distribution system nature. The radial distribution system without laterals (only main feeder). The radial distribution system with laterals and sub laterals (main feeder along with laterals and sub laterals). The distribution system power flows are executed for both cases using simple equations. Here 10-bus, 12-bus, 15-bus, 28-bus, and 69-bus balanced radial distribution systems are analyzed.***

Keywords: Laterals-Sub Laterals, Load Flows, Main Feeder, Balanced Radial Distribution System, Loss Calculation.

1. Introduction

To calculate power loss of a radial distribution system, Newton method, Fast Decoupled method, and Gauss method are not used. Since the radial system is an ill-natured system due to high resistance to reactance ratio. Hence the number of authors' proposed different load flows methods for distribution system. Direct evaluation of radial distribution system is given by Goswami and Basu [1]. In this paper numbering of buses and branches is not possible and it can evaluate only for the nodes having below three branches. Based on node, evaluation of power loss and voltages is done by Das [2]. In this paper a load flow method is implemented to find number of nodes and branches beyond a node. At each node the total power fed is analyzed. This method takes less memory for evaluation. M.H. Haque [3] implemented recursive equations to calculate power loss for voltage dependent loads. Ghosh [4] calculated power loss by considering unit voltage at each bus. The losses are calculated by using a method which gives number of buses beyond a branch. First, load currents and charging currents are calculated after that branch currents are calculated. Next, the new voltages are updated at each node. Kersting [5] developed backward and forward sweep method by using ladder network principle. Rajieic [6] proposed a new method based on admittance technique. Driving point admittance fed by a node to a portion of system including that node is calculated in forward sweep method. Ranjan [7] used load flow algorithm with composite loads. Augugliaro [8] and Humouda [9] implemented an improved algorithm for load flows by calculating the buses beyond each branch.

In this paper simple equations based backward and forward sweep method is considered. This method is applied to different radial distribution systems with two above mentioned conditions. There is no need of node identification in this method. The radial distribution systems considered are balanced systems with constant power based loads.

2. Load Flows Methodology

Consider a branch which exit between two nodes. The impedance of the branch is Z = R+ j*X.

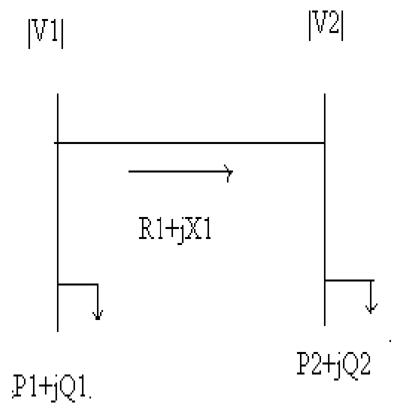

Figure 1: The branch between two nodes

1. Determination of load currents.

Load currents, $LC_i = (\frac{S_i}{V_i})^*$ (1)

For i= 1 to n.
Where
S is apparent power of load
V is bus voltage
LC is load current
n is the number of total nodes.

2. Determination of current at each branch.

The branch currents are calculated in back ward process by adding branch currents from end node to starting node.

$BC(SN(i)) = BC(SN(i)) + LC(RN(i))$ (2)

For i= 1 to nb
Where
BC is branch current
SN (i) is sending node of branch i
RN (i) is receiving node of branch i
nb is number of total branches

International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

3. Determination of voltage values at each node.

a) The voltage drop in a branch is

$delv(i) = Z(i) * BC(i)$ (3)

For i=1 to nb

b) The voltage at the receiving bus is

$V\big(RN(i)\big) = V\big(SN(i)\big) - delv(i)$ (4)

For i= 1 to n.

c) Voltage difference between fast values and new values in each iteration

$Delv = V_{old} - V_{new}$ (5)

Where

V_{old} is the voltage of previous iteration

V_{new} is the voltage of present iteration

d) Convergence criteria is given by

DEL=max (Delv) (6)

e) Replacing new voltage values

$V_{old} = V_{new}$ (7)

f) The total active power losses,

$PL(i) = \sum BC(i)^2 * R(i)$ (8)

For $i = 1$ to nb

The total reactive power losses,

$QL(i) = \sum BC(i)^2 * X(i)$ (9)

For $i = 1$ to nb

2.1 Algorithm for Load Flows

1. Read test system bus data and line data.
2. Assume all bus voltages equal to 1 p.u.
3. Determine bus currents using equation (1).
4. Determine branch currents using equation (2).
5. Determine bus voltages using equation (4).
6. Determine voltage mismatch using equation (6).
7. Update each bus voltage using equation (7).
8. If the voltage mismatch is less than 0.0001 then stop the load flows
9. Other wise move to step (3).
10. Determine total active power losses using equation (8).
11. Determine total reactive power losses using equation (9).
12. Stop.

3. Results and Analysis

Case (1): The radial distribution system without laterals (only main feeder):

Test system-1: IEEE-10bus radial distribution system

The BASEMVA and BASEKV for this system are 100 and 23. The bus and load data are taken from reference [10].

Table 1: The branch results of 10-bus radial distribution system.

Branch number	Branch currents (p.u.)	Branch loss (p.u.)
1	0.1315	0.0005
2	0.1130	0.0000
3	0.1032	0.0018
4	0.0848	0.0011
5	0.0689	0.0019
6	0.0518	0.0005
7	0.0433	0.0008
8	0.0304	0.0009
9	0.0192	0.0004

Table 2: The bus results of 10-bus radial distribution system

Bus number	Bus currents (p.u.)	Bus voltages (p.u.)
1	0	1.0000
2	0.0185	0.9929
3	0.0098	0.9874
4	0.0184	0.9634
5	0.0159	0.9480
6	0.0171	0.9172
7	0.0085	0.9072
8	0.0128	0.8889
9	0.0112	0.8587
10	0.0192	0.8375

The total real power loss = 783.8064 kW.
The total reactive power loss = 1.0369e+03 kVAr.
The minimum voltage value in p.u. = 0.8375
The bus number having minimum voltage = 10.

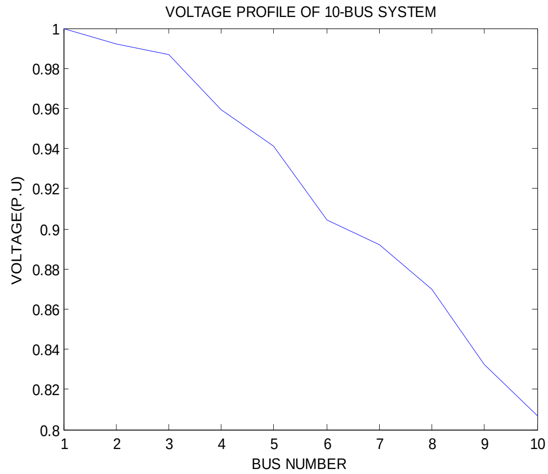

Figure 2: Voltage profile of 10-bus radial distribution system.

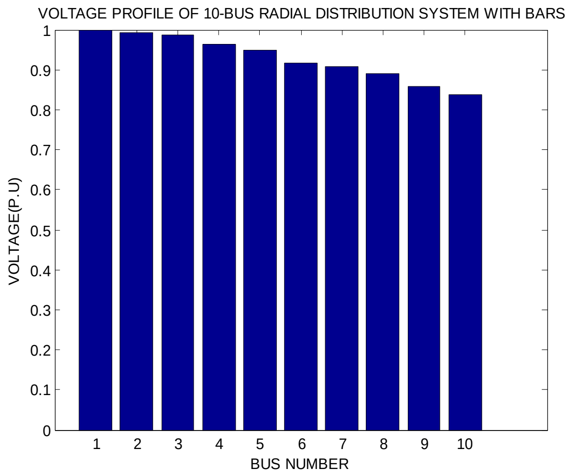

Figure 3: Voltage profile of 10-bus radial distribution system using bars

Test system-2: IEEE-12 bus radial distribution system

The data for this system is considered from reference [11]. The BASEMVA and BASEKV for this system are 10 and 11.

Table 3: The branch results of 12-bus radial distribution system.

Branch number	Branch currents (p.u.)	Branch real power loss (p.u.)*10^-3
1	0.0456	0.3417
2	0.0395	0.2747
3	0.0355	0.3980
4	0.0298	0.4220
5	0.0267	0.1148
6	0.0246	0.0906
7	0.0188	0.2277
8	0.0140	0.1573
9	0.0097	0.0368
10	0.0059	0.0071
11	0.0016	0.0005

Table 4: The bus results of 12-bus radial distribution system.

Bus number	Bus(load) currents (p.u.)	Bus voltages (p.u.)
1	0.0615	1.0000
2	0.0615	0.9943
3	0.0530	0.9890
4	0.0479	0.9806
5	0.0400	0.9698
6	0.0357	0.9665
7	0.0331	0.9638
8	0.0250	0.9553
9	0.0184	0.9473
10	0.0124	0.9445
11	0.0075	0.9436
12	0.0022	0.9435

The total real power loss = 20.7120 kW.
The total reactive power loss = 8.0405 kVAr.
The minimum voltage value in p.u. = 0.9435.
The minimum voltage is occurred at 12-bus.

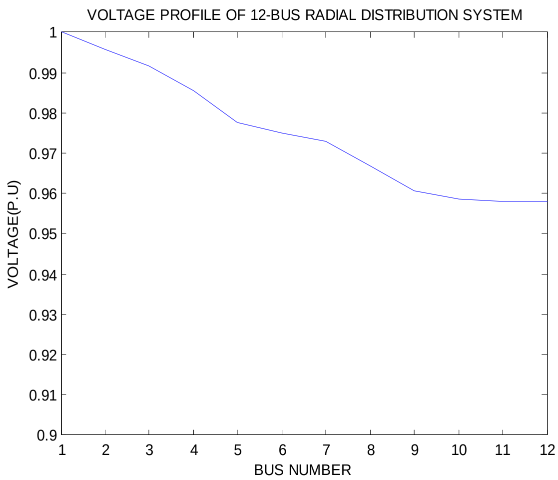

Figure 4: Voltage profile of 12-bus radial distribution system

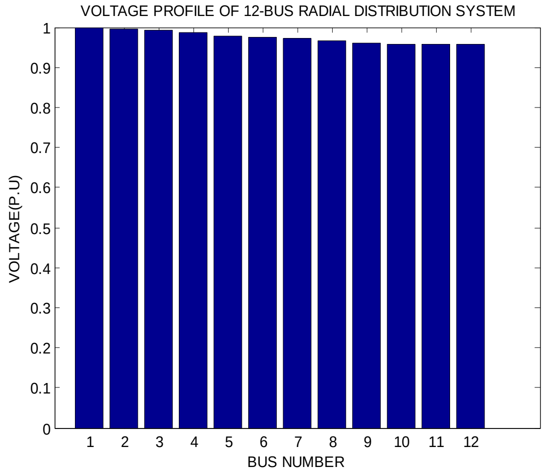

Figure 5: Voltage profile of 12-bus radial distribution system using bars

Case (2): The radial distribution system with laterals and sub laterals.

Test system-3: IEEE-15 bus radial distribution system
The system data is taken from ref [2]. The BASEKVA and BASEKV are 100 and 11.

Table 5: The branch results of 15-bus radial distribution system

Branch number	Branch currents (per unit)	Branch power losses (per unit)* 1.0e-03
1	0.0129	0.3769
2	0.0076	0.1129
3	0.0042	0.0244
4	0.0005	0.0006
5	0.0012	0.0047
6	0.0005	0.0006
7	0.0037	0.0577
8	0.0015	0.0039
9	0.0007	0.0011
10	0.0027	0.0218
11	0.0012	0.0060
12	0.0005	0.0007
13	0.0007	0.0020
14	0.0015	0.0044

Table 6: The bus results of 15-bus radial distribution system

Bus number	Bus currents (per unit)	Bus voltages (per unit)
1	0.0184	1.0000
2	0.0184	0.9713
3	0.0108	0.9567
4	0.0059	0.9509
5	0.0007	0.9499
6	0.0052	0.9582
7	0.0021	0.9560
8	0.0010	0.9570
9	0.0017	0.9680
10	0.0007	0.9669
11	0.0038	0.9500
12	0.0017	0.9459
13	0.0007	0.9446
14	0.0011	0.9486
15	0.0021	0.9485

The minimum bus voltage = 0.9446

The total active power loss = 61.7775 kW.
The total reactive power loss = 57.2820 kVAr.
At bus-13, the minimum voltage 0.9466 is obtained.

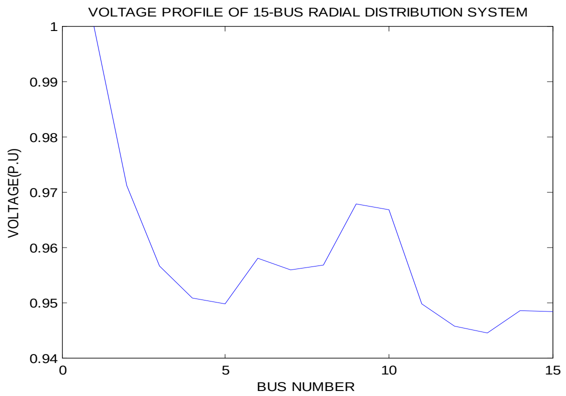

Figure 6: Voltage profile of 15-bus radial distribution system

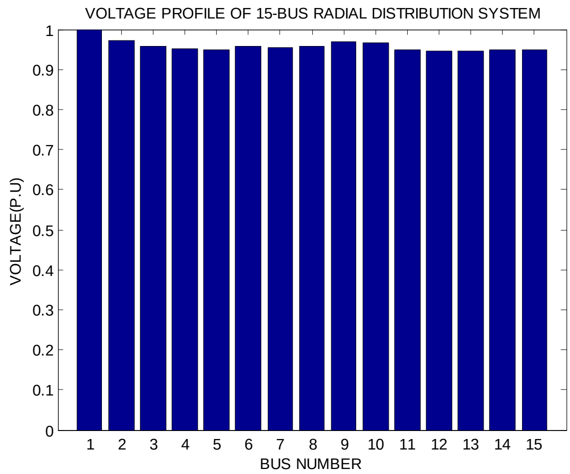

Figure 7: Voltage profile of 15-bus radial distribution system

Test system-4: IEEE-28 bus radial distribution system

The BASEMVA and BASEKV are 100 and 11. The line and bus data is considered from reference [11].

Table 7: The branch results of 28-bus radial distribution system

Branch number	Branch currents (per unit)	Branch losses (per unit) * 1.0e-03
1	0.0083	0.1350
2	0.0079	0.1852
3	0.0078	0.1297
4	0.0055	0.0925
5	0.0050	0.0621
6	0.0035	0.0377
7	0.0015	0.0043
8	0.0003	0.0001
9	0.0002	0.0000
10	0.0019	0.0165
11	0.0013	0.0032
12	0.0009	0.0014
13	0.0005	0.0002
14	0.0004	0.0001
15	0.0004	0.0006
16	0.0011	0.0028
17	0.0010	0.0014
18	0.0009	0.0022
19	0.0005	0.0007
20	0.0002	0.0001
21	0.0016	0.0065
22	0.0012	0.0026
23	0.0011	0.0019
24	0.0005	0.0002
25	0.0004	0.0001
26	0.0008	0.0005
27	0.0004	0.0001

Table 8: The bus results of 28 bus radial distribution system

Bus number	Bus currents (per unit)	Bus voltages (per unit)
1	0.0117	1.0000
2	0.0117	0.9862
3	0.0112	0.9665
4	0.0110	0.9524
5	0.0078	0.9382
6	0.0070	0.9277
7	0.0049	0.9185
8	0.0021	0.9161
9	0.0004	0.9158
10	0.0002	0.9156
11	0.0027	0.9462
12	0.0018	0.9444
13	0.0013	0.9434
14	0.0007	0.9431
15	0.0005	0.9429
16	0.0005	0.9371
17	0.0016	0.9259
18	0.0014	0.9249
19	0.0013	0.9233
20	0.0008	0.9225
21	0.0002	0.9219
22	0.0023	0.9157
23	0.0017	0.9141
24	0.0016	0.9130
25	0.0007	0.9128
26	0.0006	0.9127
27	0.0011	0.9156
28	0.0006	0.9155

The total active power losses are 68.7911 kW.
The total reactive power losses are 46.0231 kVAr.
The minimum bus voltage 0.9127 obtained at 26 bus.

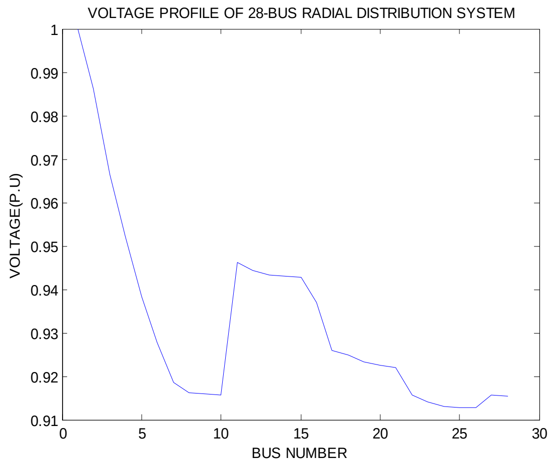

Figure 8: Voltage profile of 28-bus radial distribution system

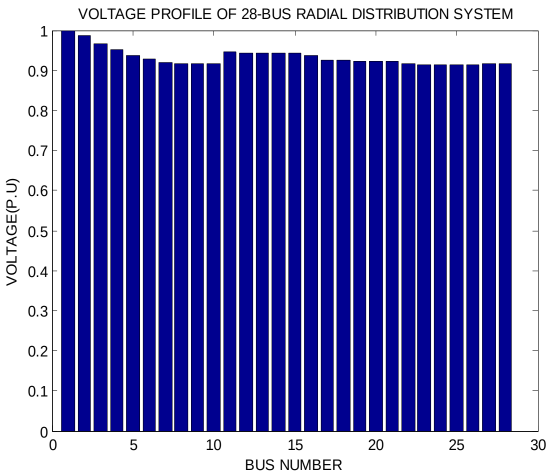

Figure 9: Voltage profile of 28-bus radial distribution system using bars

Test system-5: IEEE-69 bus radial distribution system
The BASEMVA is 100 and BASEKV is 12.66. Bus data and line data is considered from reference [12].

Table 9: The branch results of 69 bus radial distribution system

Branch number	Branch currents (per unit)	Branch power losses (per unit)* 1.0e-03
1	0.0403	0.0007
2	0.0403	0.0007
3	0.0375	0.0019
4	0.0290	0.0194
5	0.0290	0.2822
6	0.0290	0.2932
7	0.0285	0.0689
8	0.0273	0.0337
9	0.0080	0.0477
10	0.0077	0.0101
11	0.0058	0.0218
12	0.0037	0.0128
13	0.0037	0.0124
14	0.0036	0.0120
15	0.0036	0.0022
16	0.0031	0.0032
17	0.0025	0.0000
18	0.0019	0.0010
19	0.0019	0.0007
20	0.0018	0.0011
21	0.0006	0.0000
22	0.0006	0.0001
23	0.0006	0.0001
24	0.0003	0.0001
25	0.0003	0.0000
26	0.0001	0.0000
27	0.0009	0.0000
28	0.0007	0.0000
29	0.0004	0.0001
30	0.0004	0.0000
31	0.0004	0.0001
32	0.0004	0.0001
33	0.0003	0.0001
34	0.0001	0.0000
35	0.0019	0.0000
36	0.0016	0.0002
37	0.0013	0.0002
38	0.0013	0.0001
39	0.0011	0.0000
40	0.0009	0.0005
41	0.0008	0.0002
42	0.0008	0.0000
43	0.0008	0.0000
44	0.0008	0.0001
45	0.0004	0.0000
46	0.0085	0.0002
47	0.0085	0.0058
48	0.0077	0.0163
49	0.0039	0.0012
50	0.0005	0.0000
51	0.0000	0.0000
52	0.0190	0.0578
53	0.0190	0.0671
54	0.0187	0.0912
55	0.0185	0.0879
56	0.0185	0.4968
57	0.0185	0.2449
58	0.0185	0.0950
59	0.0174	0.1067
60	0.0174	0.1402
61	0.0035	0.0011
62	0.0032	0.0013
63	0.0032	0.0066
64	0.0007	0.0004
65	0.0004	0.0000
66	0.0002	0.0000
67	0.0006	0.0002
68	0.0003	0.0000

Table 10: The bus results of 69-bus radial distribution system

Bus number	Bus currents (per unit)	Bus voltages (per unit)
1	0.0490	1.0000
2	0.0490	1.0000
3	0.0490	0.9999
4	0.0456	0.9998
5	0.0352	0.9990
6	0.0352	0.9901
7	0.0351	0.9808
8	0.0346	0.9786
9	0.0331	0.9775
10	0.0097	0.9725
11	0.0093	0.9714
12	0.0070	0.9682
13	0.0045	0.9653
14	0.0044	0.9624
15	0.0043	0.9595
16	0.0043	0.9590
17	0.0037	0.9581
18	0.0030	0.9581
19	0.0023	0.9577
20	0.0023	0.9574
21	0.0022	0.9569
22	0.0008	0.9569
23	0.0007	0.9568
24	0.0007	0.9567
25	0.0004	0.9566
26	0.0004	0.9565
27	0.0002	0.9566
28	0.0011	0.9999
29	0.0008	0.9999
30	0.0005	0.9997
31	0.0005	0.9997
32	0.0005	0.9996
33	0.0005	0.9993

34	0.0003	0.9990
35	0.0001	0.9989
36	0.0023	0.9999
37	0.0019	0.9997
38	0.0016	0.9996
39	0.0016	0.9995
40	0.0013	0.9995
41	0.0010	0.9988
42	0.0010	0.9986
43	0.0010	0.9985
44	0.0009	0.9985
45	0.0009	0.9984
46	0.0005	0.9984
47	0.0105	0.9998
48	0.0105	0.9985
49	0.0095	0.9947
50	0.0048	0.9942
51	0.0006	0.9786
52	0.0000	0.9785
53	0.0231	0.9747
54	0.0230	0.9714
55	0.0227	0.9670
56	0.0224	0.9626
57	0.0224	0.9401
58	0.0224	0.9291
59	0.0244	0.9248
60	0.0210	0.9198
61	0.0210	0.9124
62	0.0043	0.9121
63	0.0039	0.9117
64	0.0039	0.9098
65	0.0008	0.9093
66	0.0005	0.9713
67	0.0002	0.9713
68	0.0007	0.9679
69	0.0004	0.9679

Total active power losses are 224.8799 kW.
Total reactive power losses are 102.1091 kVAr.
The bus voltage 0.9093 is obtained at bus 65.

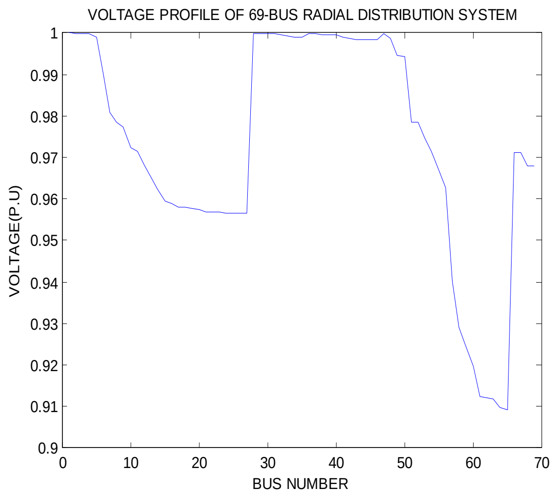

Figure 10: Voltage profile of 69-bus radial distribution system

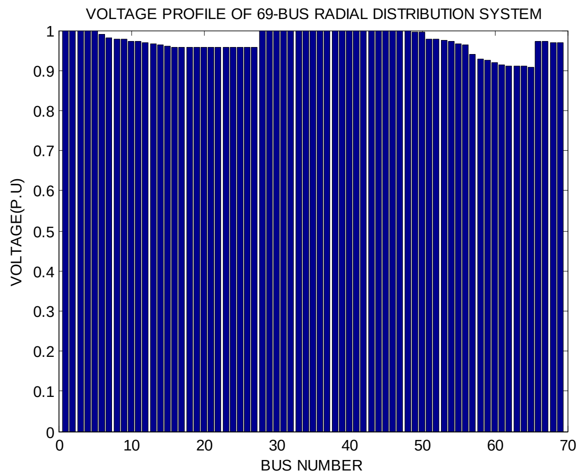

Figure 11: Voltage profile of 69-bus radial distribution system using bars

4. Conclusion

The proposed method is used for radial distribution systems effectively. The backward and forward based distribution load flows are given with simple equations. These load flows are analyzed for distribution system having only main feeder and the distribution system having the laterals, sub laterals. For these two cases, only simple equations are used. Here there is no requirement of node or branch identification. To find effectiveness of proposed method 5-bus, 12-bus, 15-bus, 28-bus and 69-bus test systems are used. With this loss evaluation one can find, where the power losses are more or low and voltage profile behavior. After this loss evaluation, the various loss minimizing methods and voltage profile improvement methods can be used.

References

[1] S.K. Goswami, S.K. Basu, "Direct solution of distribution system," IEE Proc. C 188 (1), 78-88 (1991).
[2] D. Das, D.P. Kothari, A. Kalam, "Simple and efficient method for load flow solution of radial distribution networks," Electr. Power Energy Syst. 17 (15), 335-346 (1995).
[3] M.H. Haque, "Load flow solution of distribution systems with voltage dependent load models," Electr. Power Syst. Res. 36 (3), 51-156 (1996).
[4] S. Ghosh, D. Das, "Method for load flow solution of radial distribution networks," IEE Proc. Gener. Transm. Distr. 146 (6), 641-648 (1999).
[5] W.H. Kersting, D.L. Mendive, "An application of ladder theory to the solution of three phase radial load flow problem," IEEE Trans. Power Appar. Syst. 98 (7), 1060-1067 (1976).
[6] D. Rajieic, R. Taleski, "Two novel methods for radial and weakly meshed network analysis," Electr. Power Syst. Res. 48, 79-87 (1998).
[7] R. Ranjan, B. Venkatesh, and D. Das, "Load flow algorithm of radial distribution networks incorporating composite load model," International Journal of Power and Energy Systems, vol. 23, no. 1, pp. 71-76, 2003.
[8] Augugliaro, "An efficient iterative method for load flow solution in radial distribution networks," IEEE Portp power tech conference, Porto, Portugal; 10-13 September 2001.

[9] Abdellatif Hamouda and Khaled, Zehar, "Improved algorithm for radial distribution networks load flow solution," Electric Power and Energy Systems, vol. 33, pp. 508-514, 2011
[10] Baghzouz Y, Ertem S., "Shunt capacitor sizing for radial distribution feeders with distorted substation voltages", IEEE Trans. Power Deliv., vol.5, 1990, pp. 650-657.
[11] Das, D., Nagi, H.S., and Kothari, D.P., "Novel method for solving radial distribution networks", IEE Proc. C, 1994, (4), pp. 291-298.
[12] Ranjan, B. Venkatesh, and D. Das, "Voltage stability analysis of radial distribution networks," Electric Power Components and Systems, vol. 31, pp. 501-511, 2003

Author Profile

Gundugallu Peddanna was born in Ananthapuramu, India on June 03, 1989. He received B. Tech Degree in Electrical and Electronics Engineering from JNTUA College of Engineering, Pulivendula, A. P. India in 2010. He completed M. Tech in Electrical Engineering with specialization in Electrical Power Systems from JNTUA College of Engineering, Ananthapuramu, A. P., India in 2014. Currently, he is Assistant Professor, at Department of Electrical & Electronics Engineering, Srinivasa Ramanujan Institute of Technology, Ananthapuramu, A. P, India. His area of interest includes Electrical Power Systems, Analysis of Distributed Generation, Optimization Techniques and Renewable Energy Sources.

Y. Siva Rama Kishore was born in ananthapuramu, India on 24 August, 1990. He received B.Tech degree in Electrical & Electronics Engineering from Aurora's Engineering College, Bhongiri, A.P. in 2013., India. Currently, he is pursuing M.Tech in Srinivasa Ramanujan Institute of Technology, Ananthapuramu, A.P., India. His area of interest includes Electrical Power Systems, Renewable Energy Sources.