© 2016 IJEDR | Volume 4, Issue 1 | ISSN: 2321-9939

A Novel Method of Load Flow for Radial Distribution Network to Minimise Losses

NarinderSingh[1], Prof. Rajni Bala[2]
[1]M-Tech-Power Engineering, [2]EE department
[1]BBSBEC, Fatehgarh Sahib, [2]BBSBEC, Fatehgarh Sahib, Punjab, India.

***Abstract* - Load flow has always been a critical problem and has been approached by several researchers. The techniques like Newton Raphson and Gauss Siedel works well but has severe computational disadvantages. Since only two of the required four parameters are known, hence a load flow approach has to be implemented. This paper proposes a novel direct method to load flow for distribution systems using losses which saves computation power. The system has been simulated for constant power load considering losses. The methodology has been implemented on MATLAB R2013b and voltages of each bus is found out and real and reactive losses are calculated. Also the most sensitive node is found out. The results shows an improvement over traditional methods.**

***Index term* - Distribution network, load flow method, Direct method, reactive power**

I. INTRODUCTION

The increase in power demand and limited sources for electric power has resulted in an increasingly complex power grid system. Different attack in power line can cause network failures and permanent damage to various equipment in power generation plants. After the electricity is generated in power plants it is delivers to residential, commercial facilities and industrial facilities by transmission and distribution system. Electricity is at high voltage when it travels very long distances because electricity can be transferred more efficiently at high voltages. High voltage transmission lines are used to carry electricity for long distances to a substation. Reduction in voltage occurs at transmission substation for distributing to other points in the system through high voltage transmission lines. Transformers play a very crucial role in distribution system. Basically, utility transformer is used to step down the voltage of electricity going into the customer's buildings. This type of transformer is used to convert electricity from the high voltage level to voltages that can safely be used in offices and homes. Distribution transformers are one of the most important elements in the electric distribution system. Most industrial buildings, corporate office and other commercial offices require several low-voltage transformers to decrease the voltage of electricity received from the utility transformer to the levels used to power lights, computers, and other electric-operated equipment.

Those features cause the traditional load flow methods used in transmission systems, such as the Gauss-Seidel and Newton-Raphson techniques, to fail to meet the requirements in both performance and robustness aspects in the distribution system applications. In particular, the assumptions necessary for the simplifications used in the standard fast-decoupled Newton-Raphson method [4] often are not valid in distribution systems. Therefore, a novel load flow algorithm for distribution systems is desired. To qualify for a good distribution load flow algorithm, all of the characteristics mentioned before need to be considered.

In most of the load flow studies, a balanced three-phase systems is modelled in which positive-sequence values are represented in per unit as R, L, C, P, Q, S, Ω, V, and I with the notations having their usual meaning. The aim of the load flow studies is to calculate the voltages of the bus and power flows in the line. All these computations are done after specifying the network topology, value of impedances, values of loads, and generators, etc.

This paper proposes a novel algorithm of direct approach for distribution load flow problem considering losses. The method minimizes the computation effort compared to traditional methods. Section II describes the literature survey taken from various papers which have discussed relevant works. Section III discusses our problem statement and Section IV provides a description of our proposed methodology and results are put together in section V. Finally the paper concludes with a brief discussion the overall results.

II. LITERATURE SURVEY

Brownell et al. [11] proposed the recordings of increased load demand of a system and showed its voltage collapse. They also proposed urgent compensation of reactive power.

Jason and Lee [6] proposed a voltage stability analysis of radial distribution networks. They reduced the whole network by its single line diagram that is valid only at the derived operating point. They had put voltages of all nodes equal to 1.0 pu to simplify the derivation of voltage stability index. This method is unable to handle changing load pattern.

Gubina et al. [7] proposed a method to study voltage stability analysis of radial distribution networks reducing the system model to its single line equivalent.

Ranjan et al. [8] suggested a new voltage stability index to identify the most sensitive node of the network. They assumed the equality of end node of each branch–end node and receiving magnitude of voltage for sending while deriving voltage stability index. They have shown that critical loading for constant impedance load is maximum.

Mesut E. Baran et al. [9] proposed a method which is used for loss reduction and load balancing of distribution system. Mesut E. Baran also presented a new formulation of the power flow equations of radial distribution networks. By using this they tried to determine the optimal size of the capacitors placed on the nodes of radial distribution system so that the real power losses are minimized.
Uther M., Ostrava, Czech Republic et.al [12] proposed voltage analysis of the distribution network with renewable resources using EMTP-ATP.Renewable sources are an integral part of the today's power systems. They provide, however, many pitfalls in the form of feedback affecting the operation of the electricity system. The paper describes the analysis of voltage conditions in the power system with a majority share of electricity produced by photovoltaic power plant. There are also described the criteria used to evaluate the connectivity of renewable sources, including their limits.
Sharmin Jahan, Md. Abdul Mannan et. al. [13] Discusses the performance of static voltage stability of a 16 bus test system by varying the load ability with different sensitivities of distributed generation (DG). The synchronous generator, asynchronous generator and fuel cell are included in DG system. The performance analysis has been done by the simulation works using the DIGSILENT Power Factory 14.0. The analysis indicates a negative value of sensitivity with the increasing active power when using the asynchronous generator in various positions. The strength of different buses have been determined throughout the simulation according to the value of sensitivity and found that bus 7 is the weakest bus and bus 8 is the strongest bus.

III. PROBLEM FORMULATION

Distribution system is the part of power system which distributes electric power for local use. Distribution system has generally 3 main components: feeders, distributors and the service mains.A feeder is a conductor, which connects the sub-station to the area where power is to be distributed.

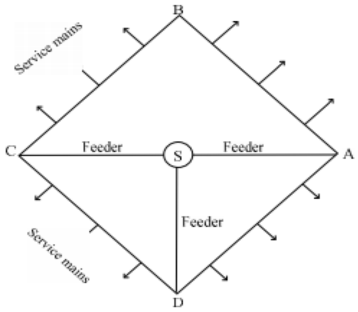

Fig.1: Single Line Diagram of a Typical Low Tension Distribution System

Generally, the current in the feeders remains the same throughout because there is no tapping taken out form feeders. A distributor is a conductor from which tapings are taken for supply to the consumers. The current through a distributor is not constant because tapings are taken at various different places**.** A service main is generally a small cable link which connects the distributor to the consumer's terminals.Electricity is generated and distributed in the form of alternating current. Alternating current is proffered over direct current due to fact that the alternating voltage can be changed in magnitude with the help of transformer. The A.C distribution system is divided into two parts namely primary distribution system and secondary distribution system

(i) Primary distribution system:

Primary distribution system is one of the types of ac distribution system. It operates at voltages higher than general utilization and handles large blocks of electric energy. The voltage used for this system is depends upon the amount of power to be conveyed and the distance of the sub-station required to be fed. The primary distribution system is done by 3-phase, 3-wire system. The most commonly used primary distribution voltages are 22 kV, 6.6 kV and 2.2 kV.

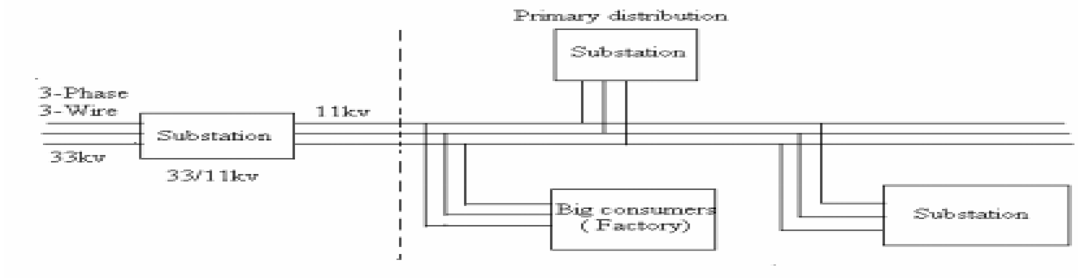

Fig. 2: Primary distribution system

(ii) Secondary distribution system:

Secondary distribution system includes the range of voltages at which the ultimate consumer utilizes the electrical energy delivered to him, the secondary distribution system is carried at 3-phase, 4- wire system. The most commonly used voltages for this distribution system is 400/230V.

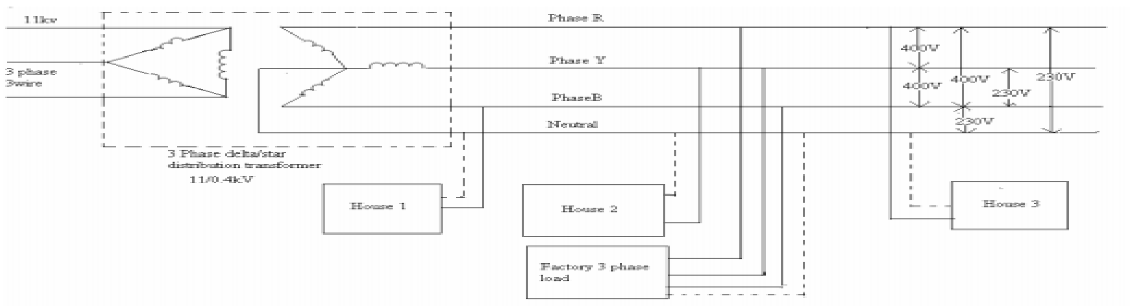

Fig. 3: Secondary distribution system

The paper work endeavours to derive a new expression of load flow using a direct approach and its applications in planning of power distribution system. The objectives are divided into the following:

- To derive a new expression of load flow using direct approach I to be computed for all nodes of the distribution networks.
- To identify the most sensitive nodes of the distribution networks.
- To compute the critical values of total losses and voltage of each buses.

IV. PROPOSED METHODOLOGY

A novel algorithm using simplified load flow scheme using direct method is utilised in this paper considering losses. The voltage of each bus is calculated and the most sensitive node is identified. A balanced load that can be represented either as constant power, constant current, constant impedance or as an exponential load is considered here. The general expression of load is shown below.

P(m2) = Pn[a0 + a1V(m2) + a2V2(m2) + a3Ve1(m2)] (1)

Q(m2)= Qn[b0 + b1V(m2) + b2V2(m2) + b3Ve1(m2)] (2)

where, Pn and Qn are nominal real and reactive power respectively and V(m2) is the voltage at node m2.

For all the loads, Eq.(1) and Eq.(2) are modelled as

a0 + a1 + a2 + a3 = 1.0 (3)

b0 + b1 + b2 + b3 = 1.0 (4)

For constant power (CP) load a0 = b0= 1 and ai= bi = 0 for i = 1, 2, 3.

There is a requirement of two additional equations at each bus. These are obtained from the KCL equation as given below:

$$P_i^{given} + jQ_i^{given} = P_i^{comp} + jQ_i^{comp} = V_i I_i^* = V_i \left[\sum_{j=1}^{N} y_{i,j} V_j \right]^* \quad (5)$$

A building algorithm for Bus admittance matrix is developed. For a distribution system with -branch section and -bus, the dimension of the bus admittance matrix is taken. If a line section is located between bus and bus, copy the column of the n_{th} bus of the admittance matrix to the column of the m_{ath} bus and fill to the position of the m_{th} row and the n_{th} bus column. The above step is repeated until all line sections are included in the admittance matrix. The building algorithm for matrix can be developed as follows. For a distribution system with m branch section and n bus, the dimension of the admittance matrix ismxn . If a line section is located between bus and reference, above repeat procedure until all line sections are included in the admittance matrix.

$$\begin{bmatrix} \Delta V \\ 0 \end{bmatrix} = \begin{bmatrix} A & MT \\ M & N \end{bmatrix} \begin{bmatrix} I \\ Bnew \end{bmatrix} \quad (6)$$

V. RESULTS AND CONCULSION

The methodology has been implemented for 33 bus system and 69 bus system.The real loss and reactive loss found in 33 bus system is 221.47 and 10.9643 respectively.

Table 1 : Voltage Magnitude For 33 Bus System

Node no	Voltage magnitude for 33 bus system	Node no	Voltage magnitude for 33 bus system	Node no	Voltage magnitude for 33 bus system
1	1	11	0.926674868224614	21	0.962169030673215
2	0.991221363550053	12	0.918478725663194	22	0.942669986642204
3	0.988571186533584	13	0.917796172947488	23	0.942650520329172
4	0.987230229523551	14	0.917583802732984	24	0.940947316449577
5	0.985814822649021	15	0.913854974658135	25	0.938924390231141
6	0.974935160301966	16	0.913824384810913	26	0.936177394725079
7	0.962041484563635	17	0.913160031832065	27	0.935095402279344
8	0.956316191614944	18	0.988863498325795	28	0.932542410036933
9	0.950780663271551	19	0.988576192458168	29	0.928326187998719
10	0.943087667839713	20	0.978541531741700	30	0.922040299046139
	0.927974757800008		0.970709623308684		0.920151569843648

Table 2: Voltage Magnitude For 69 Bus System

Node no.	Voltage Magnitude for 69 bus system	Node no.	Voltage Magnitude for 69 bus system	Node no.	Voltage Magnitude for 69 bus system	Node no.	Voltage Magnitude for 69 bus system
1	1	19	0.979913291361918	36	0.957717349159503	53	0.936457236745288
2	0.999629262069275	20	0.979657425682278	37	0.957536195759282	54	0.935994521582055
3	0.999047834439901	21	0.979399339670101	38	0.956932605179195	55	0.934857213914495
4	0.995683990506671	22	0.979210367771948	39	0.956222757602896	56	0.934615742347725
5	0.993931656834955	23	0.978962297236788	40	0.956022111336709	57	0.933934641800836
6	0.993745957699745	24	0.977132878494370	41	0.954574268741982	58	0.933533709768297
7	0.993294289760245	25	0.975102796636416	42	0.954494107130225	59	0.932742619521307
8	0.993245132359127	26	0.973030188448090	43	0.953178872707782	60	0.930504423570919
9	0.991467778385553	27	0.972001298721215	44	0.951841444687869	61	0.926933011079867
10	0.989607503322102	28	0.971867239434960	45	0.950716425908269	62	0.926624506893615
11	0.988910044573706	29	0.969564332241972	46	0.947673672121857	63	0.925658910145022
12	0.988056479555275	30	0.968017388072088	47	0.944862839748799	64	0.925279145261665
13	0.987809758482462	31	0.965486893802916	48	0.940147872574103	65	0.923048153531596
14	0.987025415344541	32	0.964585738417964	49	0.939701672457720	66	0.976827046441563
15	0.986748101640018	33	0.963956672119800	50	0.939423981671142	67	0.976232472088773
16	0.984272379965503	34	0.962448748715344	51	0.938007162823080	68	0.974890376548273
17	0.981681842502654	35	0.962136892087782	52	0.937666621591839	69	0.964297759269878
18	0.980518002502001						

In the 69 bus system, real loss and reactive loss is found to be 214.69 and 99.5792 respectively.

CONCLUSION

A novel approach of direct load flow technique has been proposed using only losses for 69 and 33 bus system. The real and reactive power losses are considered and calculated. The most sensitive node is found out. The results shows and improvement over existing techniques and in future other algorithms will be implemented for constant load also.

REFERENCE

[1] T.V. Custem and R. Mailhot, "Validation of a Fast Voltage Stability Analysis Method on Hydro–Quebec System", IEEE Transactions on Power Systems, Vol. 12, No. 1, pp. 282–292, 1997.

[2] P. Kundur, "Power System Stability and Control", McGraw Hill, New York, Vol. 1, 1994

[3] C.W. Taylor, "Power System Voltage Stability", McGraw Hill, New York, Vol. 2, 1994

[4] B. Gao, G.K. Morison and P. Kundur, "Voltage Stability Evaluation Using Modal Analysis", IEEE Transactions on Power Systems, Vol.7, No.4, pp.1529 –1542, 1992.

[5] W.C. Merrit, C.H. Taylor, R.C. Burchett and H.H. Happ, "Security Constrained Optimization – a Case Study", IEEE Transactions on Power Systems, Vol.3, No.3, pp.970 –977, 1988.

[6] G.B. Jasmon and L.H.C.C. Lee, "Distribution Network Reduction for Voltage Stability Analysis and Load Flow Calculations", International Journal of Electrical Power and Energy Systems, Vol.13, No. 1, pp. 9 –13, 1991.

[7] F. Gubina and B. Strmcnik, " A Simple Approach to Voltage Stability Assessment in Radial Networks", IEEE Transactions on Power Systems, Vol. 12, No. 3, pp. 1121 –1128, 1997.

[8] R. Ranjan, B. Venkatesh and D. Das, "Voltage Stability Analysis of Radial Distribution Networks", International Journal of Electric Power Components and Systems, Vol. 31, No. 2, pp. 501–11, 2004.

[9]M.E. Baran and F.F. Wu, "Network Reconfiguration in Distribution Systems for Loss Reduction and Load Balancing", IEEE Transactions on Power Delivery; Vol. 4, No. 2, pp. 1401 – 1407, 1989.

[10]A.M. Chebbo, M.J.H. Sterling and M.R. Irving, "Reactive Power Dispatch Incorporating Voltage Stability", Proceedings IEE Part C (GTD), Vol. 139, No. 3, pp. 253 –260, 1992.

[11]G. Brownell and H. Clark, "Analysis and Solutions for Bulk System Voltage Instability" , IEEE Computer Applications in Power, Vol. 2, No. 3, pp. 31–35, 1989.

[12] Uther M.,Ostrava ,Czech," voltage analysis of the distribution network with renewable resources using EMTP-ATP",proceeding IEEE of 2014 15^{th} international scientific conference ,pp. 131-136 ,may 2014.

[13] Sharmin Jahan,Md. Abdul Mannan, "A Voltage Stability Analysis of a 16-bus Distribution Network Based on Voltage Sensitivity Factornd Engineering", Vol. 5, No. 4, International Journal Of Multidisciplinary Sciences And Engineering, Vol. 5,pp.1-5,April 2014.