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THE LOAD FLOW APPROACH FOR RADIAL NETWORK DISTRIBUTION SYSTEMS BASED ON NETWORK TOPOLOGY

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ABSTRACT

The distribution power flow is a significant tool for distribution system analysis. It's employed both in the operational and planning levels. The recent trend toward distribution automation has shifted the attention to load flow solutions that are both reliable and efficient. The problem of load flow in distribution systems has been modelled using a novel technique based on the particular topological traits of radial distribution networks, which has been thoroughly explored to allow for a direct solution. The use of time-consuming decomposition or Bus admittance matrix in standard load flow methods is no longer essential due to the suggested method's direct solution. By comparing the rows and columns of the branch path matrix, this novel approach derives the elements of the impedance matrix. Because it only employs one matrix in its method, the suggested load flow algorithm requires less memory for any size distribution network. As a result, it achieves faster convergence with fewer iterations and is more stable. The suggested method's effectiveness is tested on a variety of standard IEEE test systems for various load models and compared to current techniques. The proposed method's validity is demonstrated by the test results.

I. INTRODUCTION

The most fundamental technique for analysing power systems is load flow analysis. In distribution systems, studies of load flow are analyzed to determine the voltage, true& reactive power flows via the lines. The bulk power generated at the power plant is transported via high-voltage transmission lines before being delivered to customers via lower-voltage distribution systems. At distribution level, the load profile will be extremely fluctuating in nature because of different kinds of loads like industrial, commercial and domestic loads, which causes imbalance in the power flow leading to power loss. Therefore, reduction of power loss in distribution systems is an significant aspect. It is indicated in the studies that waste of distribution network losses is 13percent of total power generated. Distribution network power loss can be effectively decreased by the generation of active & reactive power in proper amounts at strategic locations.

The requirement of reactive power will be more in distribution system. To keep the voltage profile stable and meet the active power demand, reactive power is necessary. Load flow studies are needed to analyze diverse conditions in the power system for reactive power control, reconfiguration, and loss estimation, among other things. With the advent of digital computers, the evolution methods such as the Newton Raphson method, Gauss Seidal method, Decoupled in addition to Fast Decoupled methods simplified the load flow solution, but such methods are ideal for Transmission systems. However, unlike transmission systems, distribution systems have a number of well-known features as listed below:

- Weakly meshed or radial structure
- Feeders with a high ratio of R/X
- Unbalanced load distribution
- A colossal number of nodes and branches

Due to above stated characteristics, conventional techniques are ineffective for resolving load flow issues in the distribution systems and the solutions frequently diverge because they are developed for mesh architectures. A Detailed literature review on various load flow algorithms [1-24] was studied by taking advantage of the distribution system's radial structure. In all applications that demand load flows, the reliability of the solution approaches is critical. W.G. Tinney and C.E. Hart [1] suggested an ac power flow problem that Newton's approach can handle efficiently. It converges quickly for five iterations, when compared with Guass-Seidel method which requires seven iterations for convergence. The main drawback of this technique is that the amount of memory, time needed varies in directly proportionate to the size of the problem.

B.Stott and O.Alsac [2] have proposed an algorithm for an accurate off-line & on-line load flows and contingency analysis for any size radial network can be implemented efficiently on computers with limited memory requirement. Brian Stott [3] discusses the various numerical strategies for calculating load-flow in power systems using a digital computer. Using a compensating technique with several ports and fundamental concepts of Kirchhoff's principles, Shrimoharmmadi et al[4] proposed a power flow method to solve poorly meshed transmission & distribution networks.Kersting [5] used the iterative approach to design a strategy for tackling the load flow problem for networks of radial distribution relying on ladder network theory. This method displays good convergences characteristics for radial systems. But, the disadvantage of this methods of Ladder network are it's probably best for radial networks with a high R/X ratio on one sending end.

Luo and semlyen [6] provided a method for determining the load flow solution for networks with weak meshing. M.H.Haque [7,8] provided a strategy that may be applied to radial as well as mesh networks. The mesh network may be transformed by connecting a distribution system of radial some dummy buses to break the loops. By formulating & evaluating simple algebraic equations relating the values of voltages with the variation among real power as well as reactive power as a criteria for convergence. Kothari and Das [9] formed a simple & efficient approach for solving problem of load flow in distribution networks of radial (RDN). Backward sweep approach was developed by Afsari et al. [10] to determine the load flow solution by calculating the voltages at the node's terminals at the start. S. Ghosh and D. Das [11] created an easy and capable method for addressing distribution networks of radial that only requires the assessment of a receiving end voltages that is expressed algebraically.

A. Hamouda and K. Zehar [12] proposed a new method for solving the problems of load flow in radial distribution systems with side by side that is collectively efficient, simple for applying. S. Singh and T.Ghose[13] used an unique matrix transformation technique to solve the calculation of flows of branch in distribution networks of radial directly, increasing the efficiency and speed of the forward-backward sweep-based load flow method. By comparing the most generally used two methods, Nanda et al. [14] demonstrated a novel solution for handling the load flow problem and its application under various practical scenarios i.e., Ladder network methods and forward backward sweep methods and their suitability to practical applications D.P.Sharma [15] employs a simple and flexible numbering scheme that makes full advantage of the distribution system's radial topology. The radial network is reorganised using this technology, which assigns variable numbering schemes to buses and portions.

A computerised technique of determining imbalanced fault currents or load flow on multi-grounded distribution circuits of radial has been proposed by E.S.Hawkins, W.W.Plelines, R.Berg [16]. Xiao-Ping and Zhang [17] review two novel approaches for three-phase load flow studies: sequence decoupling and compensation fast–decoupled (SDCFD), sequence decoupling and compensation Newton-Raphson (SDCNR). Hieu Le Nguyen [18] proposed a new algorithm for solving three phase (asymmetric) assessment of flow of power for transmission, distribution systems. Regarding radial distribution system's assessment of three phase load-flow, G.W. Chang etal devised an enhanced backward / forward sweep algorithm [19].

The voltage of forward bus of every transformer branch's or line voltage is calculated using KCL and KVL Laws in the backward sweep. K. Krushna Murthy etal develops a backward and forward sweep Algorithm (BFSA) [20]. This proposed algorithm employs a simple and flexible numbering system that makes full advantage of the distribution system's radial layout. The radial network is reorganised using this technology, which assigns variable numbering schemes to buses and portions.

Murthy KVSR et al. [21] and Nagaraju K et al. [22] use network topology to construct two matrices for distribution system of radial load flow solutions. The distribution systems of radial structure are characterised by their radial nature with high ratio of R/X. J. H. Teng [23] and Saidulu [24] employs multiplication of two matrices to form distribution load impedance (PLF) matrix. In RDS automation algorithms, an effective approach for forming PLF plays a crucial role in fault isolation, network reconfiguration, and service restoration.Thus, a detail literature survey on various load flow algorithms made to propose a new load flow algorithm which is robust and applicable to larger distribution systems. A topologically based strategy is used for modelling distribution system load flow's problem in this study. The use of decomposition which is time delaying or Bus admittance matrix(Y) in standard methods of load flow is not essential due to the suggested method's direct solution. Because it simply uses primitive impedance matrices in its method, this load flow technique requires less memory for any size distribution network. The suggested method is compared to current algorithms and evaluated on IEEE test systems.

II. PROPOSED LOAD ALGORITHM

Consider the formation of load flow for the suggested algorithm using the simple radial distribution network demonstrated as in figure 2.1. Multiplication of the BIBC and BCBV matrices yields the PLF impedance matrix.

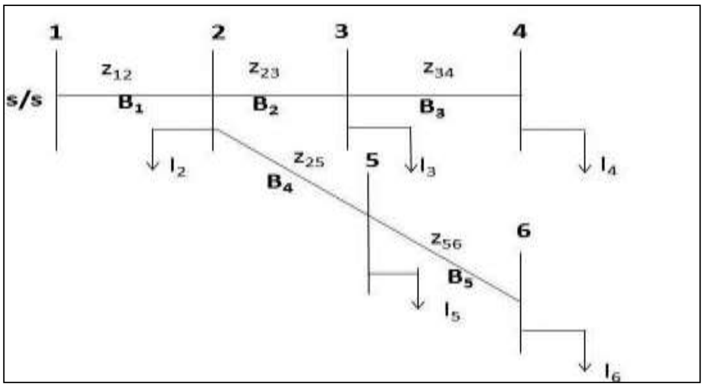

Figure 1: Simple 6 bus radial system.
Source: Authors, (2025).

II.1 STRUCTURE OF BIBC (BUS INJECTION VIA BRANCH CURRENT MATRIX):

For systems of distribution, equation 2.1 calculates the complex power at bus I while equation 2.2 calculates the equivalent current.

$$S_i = (P_i + jQ_i) \ \text{i=1,2...n} \tag{1}$$

$$I_i = (S_i / V_i)^* \tag{2}$$

Where, S_i = complex apparent power for 'i^{th}' bus, the real power is P_i for 'i^{th}' bus, reactive power is Q_i for 'i^{th}'bus, n = total no. of nodes in the system. I_i = ith node current. V_i = voltage at i^{th} node. The current injections at corresponding node for above sample system is as shown in the Fig.2.1 i.e., I_2 , I_3 etc.

Apply KCL to the distribution system depicted in Fig.2.1, the branch currents being represented by variable C in terms of comparable current injections as

$$C_1 = I_2 + I_3 + I_4 + I_5 + I_6 \tag{3}$$

$$C_2 = I_3 + I_4 \tag{4}$$

$$C_3 = I_4 \tag{5}$$

$$C_4 = I_5 + I_6 \tag{6}$$

$$C_5 = I_6 \tag{7}$$

In matrix form it can be represented by

$$\begin{bmatrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} I_2 \\ I_3 \\ I_4 \\ I_5 \\ I_6 \end{bmatrix} \tag{8}$$

Rearrange the above branch current equations as shown below.

$$[C] = [BIBC][I] \tag{9}$$

II.2 STRUCTURE OF BCBV (BRANCH CURRENT VIA BUS VOLTAGE) MATRIX:

The currents in the branch & voltages of bus be related as follows:

$$V_2 = V_1 - C_1 Z_{12} \tag{10}$$

$$V_3 = V_2 - C_2 z_{23} \tag{11}$$

$$V_4 = V_3 - C_3 z_{34} \tag{12}$$

$$V_5 = V_2 - C_4 z_{25} \tag{13}$$

$$V_6 = V_5 - C_5 z_{56} \tag{14}$$

On Substitution of (9) & (10) in (11), the voltage at bus 4 is given by

$$V_3 = V_1 - C_1 z_{12} - C_2 z_{23} \tag{15}$$

$$V_5 = V_1 - C_1 z_{12} - C_4 z_{25} \tag{16}$$

$$V_6 = V_1 - C_1 z_{12} - C_4 z_{25} - C_5 z_{56} \tag{17}$$

Equations (9), (14), (15), (16), (17) can be rearranged as below

$$\begin{bmatrix} V_1 \\ V_1 \\ V_1 \\ V_1 \\ V_1 \end{bmatrix} - \begin{bmatrix} V_2 \\ V_3 \\ V_4 \\ V_5 \\ V_6 \end{bmatrix} = \begin{bmatrix} z_{12} & 0 & 0 & 0 & 0 \\ z_{12} & z_{23} & 0 & 0 & 0 \\ z_{12} & z_{23} & z_{34} & 0 & 0 \\ z_{12} & 0 & 0 & z_{25} & 0 \\ z_{12} & 0 & 0 & z_{25} & z_{56} \end{bmatrix} \begin{bmatrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{bmatrix}$$

$$[\Delta v] = [BCBV][C] \tag{18}$$

Where $[\Delta v]$ = represents a matrix that gives change in bus voltage with respect to the substation voltage.
Now, substitute (2.8) in (2.18) and the subsequent equation is written as

$$[\Delta V] = [\text{PLF}][\text{I}] \tag{19}$$

Where, [PLF] denotes primitive impedance load flow matrix given as

$$[\text{PLF}] = \begin{bmatrix} Z_{12} & Z_{12} & Z_{12} & Z_{12} & Z_{12} \\ Z_{12} & Z_{12}+Z_{23} & Z_{12}+Z_{23} & Z_{12} & Z_{12} \\ Z_{12} & Z_{12}+Z_{23} & Z_{12}+Z_{23}+Z_{34} & Z_{12} & Z_{12} \\ Z_{12} & Z_{12} & Z_{12} & Z_{12}+Z_{25} & Z_{12}+Z_{25} \\ Z_{12} & Z_{12} & Z_{12} & Z_{12}+Z_{25} & Z_{12}+Z_{25}+Z_{56} \end{bmatrix} \tag{20}$$

The following important observations are derived from the given PLF matrix and used to create the suggested topological & primitive based distribution load flow approach.

1. Every element of the (n -1) × (n-1) PLF matrix is non-zero complex and symmetric.
2. The total of the impedances of primitive matrix of every lines in the path linking the bus at substation as well as every selected bus yields diagonal elements.
3. Each network bus-p might have only single path starting of the substation bus.
4. The total of the impedances of primitive matrix of such lines that look similar to the pathways of substation p and q buses gives of p-q off-diagonal elements.

These insights are effectively employed in proposing the approach using the branch path (k) matrix, which takes advantage of the network's topological structure.

The branch path matrix gives information about branches and their respective primitive impedance of the radial network. The rows of the K matrix represent branch numbering and K matrix columns represent primitive impedance of the branches in the radial distribution network. The proposed method saves a lot of time and effort by avoiding the formation of BIBC and BCBV matrices.

II.3 ELEMENTS OF PLF MATRIX FORMATION BY BRANCH PATH (K) MATRIX:

Figure: 2.1 depicts the basic 6-bus radial distribution network which is used to describe the formation of elements of PLF matrix by the Branch path matrix (K). Reduced incidence matrix can be used to create the K matrix (A).

$$\text{K=Transpose of A-1} \tag{21}$$

For the specified distribution network of radial with 6-Bus, the K-matrix is provided as

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 & 1 \end{bmatrix} \tag{22}$$

II.4 DIAGONAL ELEMENTS FORMATION:

The K matrix is formed of 0s and 1s. The representation of node-1 in a Branch path matrix's row provides information regarding the interconnecting path among node-1 &whichever selected node. As a result, the PLF matrix diagonal elements is obtained.
For instance, the 4th row in the earlier mentioned K matrix will have 1's in both the first & fourth columns, so the fourth row's diagonal element is the sum ofZ_{12} and Z_{25} given as

$$Z_{44} = Z_{12} + Z_{25} \tag{23}$$

In this way all the diagonal elements are determined in PLF impedance matrix based on topological structure.

II.5 DIAGONAL ELEMENTS FORMATION:

When the K matrix rows are analysed, if common 1's are there in the relevant columns, the sum of that primitive impedances will give the particular elements of off diagonal for the matrix PLF.

For an instance, a PLF matrix is constructed by correlating the second & third rows, yielding the sum of Z_{12} and Z_{32} given as

$$Z_{23} = Z_{12} + Z_{23} \tag{24}$$

Due to symmetrical nature of the PLF impedance matrix, the value of Z_{32} will also carry the same value of Z_{23}.In this way all the off diagonal elements are determined in PLF impedance matrix based on topological structure.

II.6 ALGORITHM FOR DISTRIBUTION LOAD FLOW:

Step 1: Examine the data from the distributed system & set 1+j0 p.u to the bus voltages.
Step 2: Using equation 2.20., create the Branch path matrix
Step 3: By comparing 1s in the K matrix directly, sum the all primitive impedances of those lines.
Step 4: Determine the Current Injections I[i] & Power Injections at each bus. In this case, I is a variable that represents nodes.
Step 5: All of the buses $I[i]^{old} = I[i]$ should be assigned.
Step 6: Measure the elements of PLF by the equation 2.21
Step 7: set iteration value k=1. Using equation 2.22, keep updating the bus voltages on all buses
Step 8: With the revised bus voltages, compute the current injections I[i].
Step 9: Only when the maximum [| $I\left[i\right]^{k+1} - I\left[i\right]^{k}$ |] exceeds tolerance, increase the number of iteration and proceed to 7th step.
Step 10: Stop after printing the converged load flow solution.

III. CLASSIFICATION OF LOADS:

The classic model of constant power load is commonly utilised in studies of distribution systems with static load flow. Although, the actual load of a distribution system requires the utilisation of constant impedance, exponential, constant current, or a combination of all of these loads models, it cannot be modelled using constant power models alone.

III.1 CONSTANT POWER LOAD MODEL:

It's a model with a static load, meaning the power is independent of the changes in voltage magnitude, also called as constant MVA load model. Therefore, the exponent value should be 0.

$$PL = PL_0\left(\frac{V}{V_0}\right)^0 \tag{25}$$

$$QL = QL_0\left(\frac{V}{V_0}\right)^0 \tag{26}$$

Where, V_0 = load nominal voltage. V = load bus voltage. PL = active power @ load bus voltage. PL_0 = active power @ nominal load voltage. QL = Reactive power @ load bus voltage. QL_0 =Reactive power @ nominal load voltage.

III.2 CONSTANT CURRENT LOAD MODEL:

It's a model with a static load, meaning the power is constant. in which the level of magnitude of voltage is directly proportional to the power. Therefore, the exponent value should be 1.

$$PL = PL_0\left(\frac{V}{V_0}\right)^1 \tag{27}$$

$$QL = QL_0\left(\frac{V}{V_0}\right)^1 \tag{28}$$

III.3 MODEL OF CONSTANT IMPEDANCE LOAD:

It's a model with a static load, meaning the power is constant in which power is proportional of the voltage magnitude, also known as a model with constant admittance load. As a result, the exponent value should be 2.

$$PL = PL_0\left(\frac{V}{V_0}\right)^2 \tag{29}$$

$$QL = QL_0\left(\frac{V}{V_0}\right)^2 \tag{30}$$

III.4 MODEL OF EXPONENTIAL LOAD:

It's a model with static load in which the power is defined as an exponential voltage equation, as given below:

$$PL=PL_0\left(\frac{V}{V_0}\right)^{np} \tag{31}$$

$$QL=QL_0\left(\frac{V}{V_0}\right)^{nq} \tag{32}$$

Where load exponents are 'np' and 'nq'. By adjusting the exponents to 0, 1, 2 the load is modelled as a constant current, constant impedance, constant power model. Erstwhile exponents can be represented by the cumulative effect of various types of components of load. Table 1 illustrates the typical values for the different static loads exponents as represented by Ulas Eminoglu and M. Hakan Hocaoglu in [25]

Table 1: Common exponent values for various static loads:

S No	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Components of load	**Constant Power**	**Constant current**	**Constant impedance**	**Incandescent light**	**Fluorescent light**	**Air conditioner**	**Dryer**	**Freezer**	**Heater**	**Pumps, fans etc**	**Computer. etc.**
np	0	1	2	1.55	0.96	0.2	2.04	0.77	2	0.08	2
nq	0	1	2	0	7.38	2.3	3.27	2.5	0	1.6	5.2

Source: Authors, (2025).

IV. RESULTS AND DISCUSSIONS:

The proposed method's effectiveness is ascertained on varied standard IEEE test systems for various load models. The suggested approach is used to perform analysis of Load flow for various composite and static loads.

IV. 1 LOAD FLOW RESULTS WITH DIFFERENT COMPOSITE LOAD MODELS:

Case A: For load flow analysis, a mixed load of (a constant Z (impedance) load of 30%+ a load of constant current of 30%+ a load of constant power of 40%) is used. Table 2 displays the results of load flow various for test systems of composite (mixed) load.

Table 2: Results of Load flow for a mixed load from various test systems.

Item. No	**1**	**2**	**3**	**4**	**5**
Test system	15 bus	33bus	34 bus	69 bus	85 bus
TPL (kW)	56.74	185.85	204.36	195.16	260.26
TQL (kVAR)	52.6	125.67	60.10	89.4	163.76
Iterations	2	2	2	3	2

Source: Authors, (2025).

Case B: To conduct analysis of load flow for various test systems, an industrial load of (air conditioner load of 21% + fluorescent light of 49% + incandescent light of 30%) is considered. Table 3 shows the results of load flow for the industrial load of various test systems

Table 3: Results of Load flow for Industrial load from various test systems.

Item. No.	**1**	**2**	**3**	**4**	**5**
Test System(bus)	15	33	34	69	85
TPL (kW)	50.17	164.606	189.69	170.23	206.23
TQL (kVAR)	46.52	111.142	55.09	78.7	129.95
Iterations	4	5	4	5	6

Source: Authors, (2025).

Case C: To do analysis of load flow for various systems, a commercial load of (air conditioner of 40 %+ fluorescent light of 39 % + pumps of 8 % & fans load +incandescent light of 13 %) is considered. Table 4 displays results of the load flow of various test systems for the load of commercial.

Table 4: Load flow results of commercial load for various test systems.

S.No	***1***	***2***	***3***	***4***	***5***
System (bus)	*15*	*33*	*34*	*69*	*85*
TPL(kW)	*51.12*	*169.35*	*190.57*	*175.49*	*211.71*
TQL(kVAR)	*47.39*	*114.42*	*56.11*	*81.09*	*133.39*
Iterations	*4*	*5*	*4*	*5*	*6*

Source: Authors, (2025).

Case D: To do analysis of load flow for various test systems, a residential load of (heater load of 25 %+air conditioner load of 31 % + incandescent light of 8 % + freezer load of 13 % +dryer load of 23 %) is considered. Table 5 displays the results of load flow of residential load for various test systems.

Table 5: Results of Load flow from various test systems for residential load.

Item. No.	1	2	3	4	5
System(bus)	15	33	34	69	85
TPL (kW)	53.97	173.7337	193.63	180.92	228.77
TQL (kVAR)	49.5	117.3357	57.00	82.25	144.08
Iterations	3	5	3	4	5

Source: Authors, (2025).

IV. 2 LOAD FLOW RESULTS USING VARIOUS LOAD MODELS:

The suggested load flow technique is applied on the standard 15 bus IEEE test system. The base voltage and base MVA are considered to 11KV and 100MVA with a convergence value of 0.00001p.u.Table 6 shows load flow results of 15 bus sytem with different static loads.

Similarly, the method of load flow was tested on a variety of IEEE standard test systems like 15 bus, 33 bus, 34 bus, 69 bus, 89 bus systems for convergence of 0.0001 p.u. The real and reactive power loss are calculated and tabulated with number of iterations required for each load models.

Table 6: Results of Load Flow for 15 bus system with various static Loads.

Bus /Load type	Constant power	Constant current	Constant Impedance	Incandescent light	Fluorescent light	Air conditioner	Dryer	Freezer	Heater	Pumps, Fans etc	Computer & T.V.load
1	1	1	1	1	1	1	1	1	1	1	1
2	0.9713	0.9726	0.9737	0.9722	0.9754	0.9729	0.9744	0.9733	0.9725	0.9724	0.9753
3	0.9567	0.9587	0.9605	0.9581	0.963	0.9591	0.9615	0.9599	0.9585	0.9584	0.9629
4	0.9509	0.9532	0.9553	0.9526	0.9582	0.9537	0.9565	0.9545	0.953	0.9529	0.958
5	0.9499	0.9523	0.9544	0.9516	0.9573	0.9528	0.9556	0.9536	0.9521	0.9519	0.9571
6	0.9582	0.9601	0.9617	0.9596	0.9639	0.9604	0.9627	0.9611	0.96	0.9597	0.9638
7	0.956	0.958	0.9597	0.9575	0.962	0.9583	0.9607	0.959	0.9579	0.9576	0.9619
8	0.957	0.9589	0.9606	0.9584	0.963	0.9592	0.9615	0.9599	0.9588	0.9585	0.9627
9	0.968	0.9694	0.9706	0.969	0.9728	0.9697	0.9713	0.9702	0.9693	0.9691	0.9723
10	0.9669	0.9684	0.9696	0.968	0.9714	0.9686	0.9704	0.9691	0.9682	0.9681	0.9713
11	0.95	0.9524	0.9544	0.9517	0.9572	0.9528	0.9556	0.9536	0.9522	0.9519	0.9571
12	0..9458	0.9485	0.9507	0.9478	0.9537	0.9489	0.952	0.9498	0.9483	0.948	0.9536
13	0.9445	0.9472	0.9496	0.9465	0.9529	0.9477	0.9509	0.9486	0.9471	0.9467	0.9525
14	0.9486	0.9511	0.9532	0.9504	0.9562	0.9516	0.9544	0.9524	0.9508	0.9507	0.956
15	0.9484	0.9509	0.9531	0.9502	0.956	0.9514	0.9543	0.9523	0.9507	0.9505	0.9559
TPL(kW)	61.794	56.1418	51.4517	57.2218	43.9899	55.0338	48.8414	53.1745	56.0307	57.0845	45.5511
TQL(kVAR)	57.2975	52.0498	47.6962	53.0566	40.7621	51.0161	45.2712	49.2914	51.9519	52.9209	42.215
Iterations	3	1	3	3	5	3	4	3	3	3	4

Source: Authors, (2025).

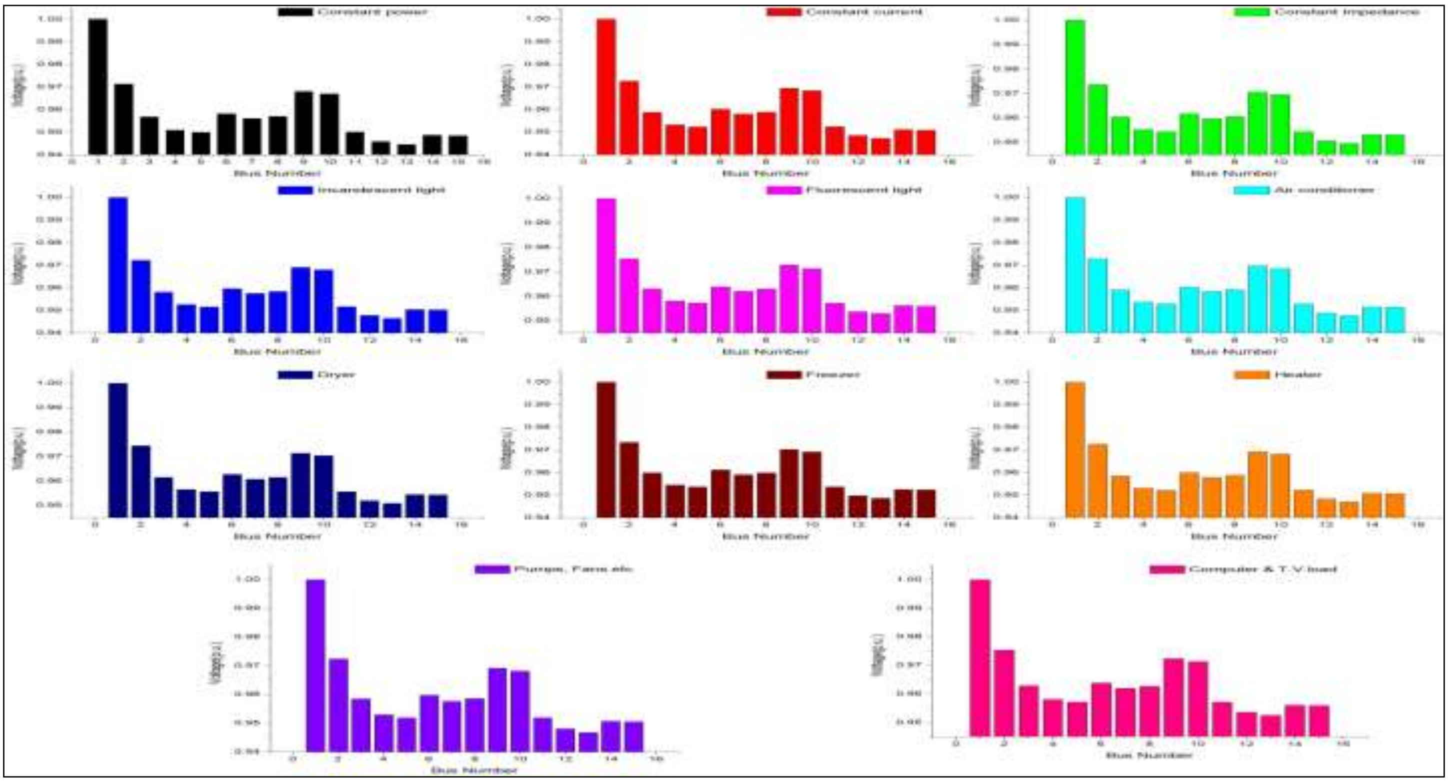

Figure 1: Voltage profile of different loads.

Source: Authors, (2025).

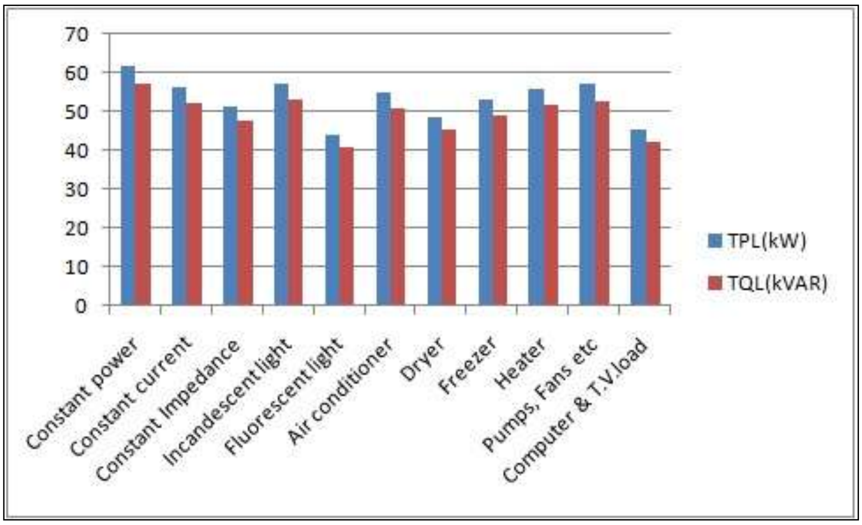

Figure 2: Results of Load flow for a 15-bus system with various static loads.
Source: Authors, (2025).

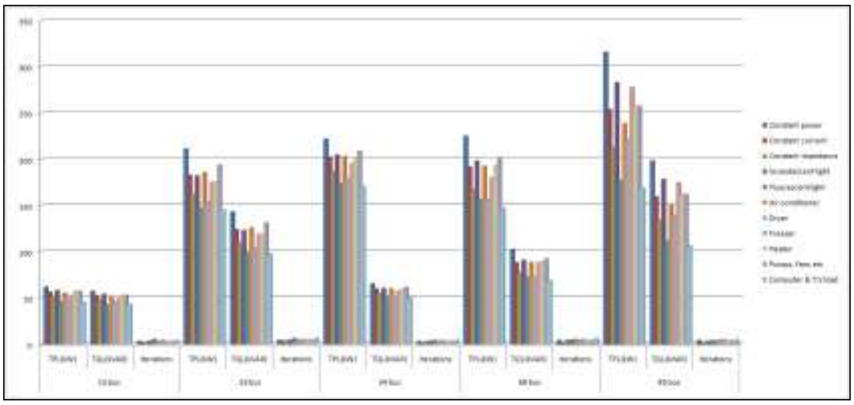

Figure 3: Power loss results of 15, 33,34,69,85 bus test systems with different static loads.
Source: Authors, (2025).

Table 7: Comparsion table.

Test system	Type of load	No of iterations For tolerance of 0.00001 p.u.	
		Methods in[9,26,27,28]	**Proposed algorithm**
15 bus[26]	Constant power	4	**3**
	Constant current	3	**1**
	Constant impedance	4	**3**
	Composite	-	**2**
33 bus[27]	Constant power	6	**4**
	Constant current	-	**3**
	Constant impedance	-	**4**
	Composite	-	**2**
34 bus[9]	Constant power	7	**3**
	Constant current	5	**1**
	Constant impedance	7	**3**
	Composite	6	**2**
69 bus[27]	Constant power	6	**4**
	Constant current	-	**2**
	Constant impedance	-	**4**
	Composite	-	**3**
85 bus[28]	Constant power	4	**4**
	Constant current	3	**1**
	Constant impedance	4	**3**
	Composite	3	**2**

Source: Authors, (2025).

V.CONCLUSIONS:

The conclusions derived are

- Based on the topological nature of radial distribution systems, the PLF impedance matrix was formed without the need of matrices BIBC, BCBV.
- The radial distribution systems topological structure was realized by using branch path (K) matrix which makes proposed algorithm so robust in nature.
- Due to this it can be applicable to larger distribution systems also for distribution automation.
- The proposed algorithm significantly reduces computational burden by avoiding the BIBC, BCBV matrices for the formation of the PLF impedance matrix.
- Since, the PLF impedance matrix is constructed based on the radial distribution systems topological structure, the need of complex algebraic expressions for the analysis of load flow can be avoided.
- The proposed algorithm has faster convergence, error free compilation and also requires less memory.

Finally, the proposed load flow is tested for different load models of distribution systems and further load growth on different IEEE test systems is also being analysed

VI. ACKNOWLEDGMENTS

Dr.C.Hari Prasad carried out literature survey and participated in load flow study.Mrs.T.Srinivasa Padmaja,Dr.B.Rajasekhar Reddy participated in assessment study and performed the analysis. All three participated in sequence alignment and drafted the manuscript and approved the final manuscript. Owing to to 1's comparisons directly in the Branch's path of matrix, the suggested algorithm requires fewer iterations, resulting in faster convergence. The proposed algorithm achieves convergence in fewer iterations for different load models when compared with branch current load flow algorithm as shown in Table 8.

VII. AUTHOR'S CONTRIBUTION

Conceptualization: Dr.Chella Hari Prasad, Mrs.T.Srinivasa Padmaja and Dr.B.Rajasekhar Reddy.
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