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Impact of Plug-in Electric Vehicles Integrated into Power Distribution System based on Voltage Dependent Power Flow

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Abstract: This paper proposes the impact of plug-in electric vehicles integrated into power distribution system based on voltage dependent control. The plug-in electric vehicles was modeled as the static load model in power distribution systems under balanced load condition. The power flow analysis is determined by using the basic parameters of the electrical network. The main point of this study are compare with voltage magnitude profiles, load voltage deviation, and total power losses of the electrical power system. There are investigating the affected from constant power load, constant current load, constant impedance load and plug-in electric vehicles load, respectively. The IEEE 33 bus test system is used to test the proposed method by assigning each load type to a balanced load in steady state and applied the solving methodology based on the bus injection to branch injection matric, branch current to bus voltage matrix, and current injection matrix to solve the power flow problem. The simulation results showed that the plug-in electric vehicles load had the lowest impact compared to other loads. The lowest plug-in values for the electric vehicle loads were 0.062, 119.67 kW and 79.31 kVar for the load voltage deviation, total active power loss and total reactive power loss, respectively. Therefore, this study can be verified that the plug-in electric vehicles load were affected to the lowest of the electrical power system in condition to same sizing and position. So that, in condition to the plug-in electric vehicles load added into the electrical power system with the conventional load type or complex load type could be considered that the affected from the plug-in electric vehicles load in next study.

Keywords: load flow analysis; load voltage deviation; plug-in electric vehicles load; power-flow analysis; static load models.

1. Introduction

The complexity of different load types has affected the advancement of power electronic technology and devices in daily life. There are also studies on the features of modern loads to solve problems in the electrical system. The plug-in electric vehicles (PEVs) are a growing burden in the area of power systems. The use of PEVs is likely to increase. It can reduce the emission of carbon dioxide that is harmful to the environment and affects the global warming. Including the public sector, promotion and privileges such as taxation or privilege in special areas.The advantage of PEVs arises from its use of fuel cells as well as battery energy storage, and it converts and combines power to traction drive systems. The electrical power system was connected with an electric wiring cable to the AC-DC power converters that called the battery charger used for charging the battery packs of PEVs when a low level state of charge(SOC). Generally, the PEVs is defined in slow charging mode for consuming the energy from the electrical power system [1]. As Figure 1 shows, the high penetration

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of PEVs connected to the each household and consumed energy from the grid. Interestingly, in condition to recharge of the battery for instantaneous time on same time of the every PEVs may be more effected to the electrical power system.

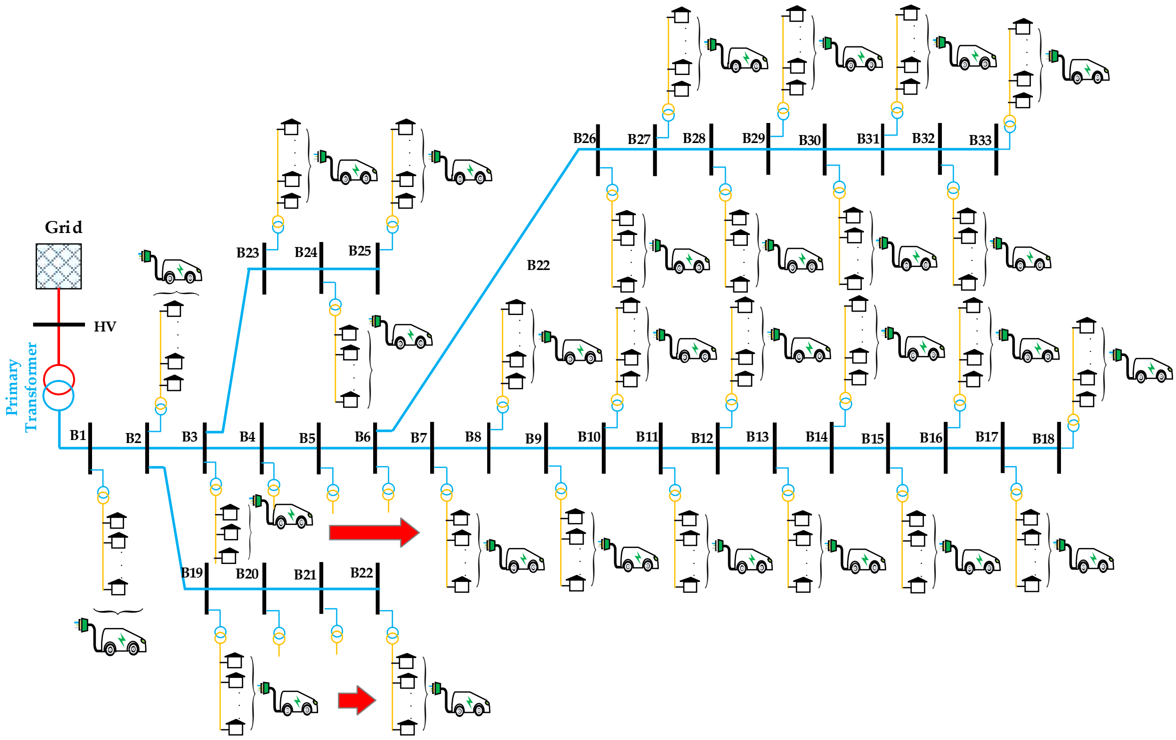

Figure 1. PEVs connected in the radial distribution system

Meanwhile, the impact of electric vehicles on fast charging is to reduce system voltage stability. Charging of the battery depends on the charging type of the EVs battery installed in each charging station[2]. Energy sources are needed to support the expansion and power requirements of electrical equipment in the installed system. Generally, the energy source comes from the conventional source of energy and combine with renewable energy. Therefore, the risk assessment of the electrical system of the distribution system. By analyzing the charging behavior of electric vehicles during charging and convert the power of the electric vehicle into the electrical system randomly. It can prevent and reduce the risk of controlling on the power distribution system[3]. Electric vehicle batteries (BEVs) and electric vehicle loads (EVs) have been presented by considering the effect on V2G and G2V power curves; In terms of power demand from the electrical system. The level of penetration of BEVs and EVs at different levels of the electrical power system. The effect of these loads on the electrical system was presented in [4]. The uncertainly propagate of charging from PEVs load were effected to reduce aging of transformer in condition to loss increase, insulation lift, the hot spot temperature which is using daily load profiles to simulate the impact of PEVs. Meanwhile, the effect from unbalance load not considered [5]. Therefore, Smart charging need to manage for increasing long lift time of the transformer [6] and improved suitable condition for energizing of transformer by using smart transformer type [7].The one type of methodology from smart charging is coordinated charging of PHEVs that can be reduced distribution system losses [8]. The objective function from triangle equivalence of losses, load factor and load variance are used to find the optimal condition on PHEVs demand load profiles [9]. Furthermore, in the electrical power system networks are connecting thought transmission lines. Therefore, distribution feeder reconfiguration can be adapted for managing the energy consumption from the PHEVs that method can reducing expected cost and total power loss reduction from variance of penetration level of PEVs in the electrical power system [10].

Additionally, the user' benefits are become key issue to manage in term of reduce the cost of battery capacity degradation, electricity cost and waiting time for charging battery. So that, the charging management should be controlled in optimal scheduling and pay back the most benefits to EV car owners[11].The aggregated EV charging demand need to determine and investigate in term of uncertain any pattern of EV load in the electrical power system, which are relevant an agent based approach. The agent-based approach consists EV type, battery and charging process, charging infrastructure, mobility and social, respectively. Monte Carlo techniques were used to define charging demand and charging scenarios, which are revealed voltage profiles reduced during on peak demand charging and should be controlled in condition balance and unbalance load[12-14]. The reliability evaluation of a distribution network by combined with distribution generator(DG), battery storage(BS) and electric vehicles(EVs) revealed EVs in discharging mode or V2G technology can be supply the power to grids and the EVs should be controlled in limits on recharging mode for increasing high reliability from the evaluation[15]. Consequently, the PEVs can be reduced the impact from charging mode in same time or in same power transmission line by using the V2G technology and combined with smart grids control [1, 16-21]. The smart grids control concept are need to manage in optimal condition all relevance; such as power sources, transmission system, distribution system, user benefits and economics [22-24]. Therefore, optimization techniques are applying to find the optimal solution any problems that effected from PEVs increasing and high consume the energy power from the electrical power system networks [11, 25-27].

In power flow studies, the generally practice is to present the composite load characteristics at the point common coupling of electrical power system. The load models consist of static load models and dynamic load models, which the static load model is selected for the proposed study. The static load models consists of voltage dependency and frequency dependency of the load characteristics [28-30]. The purposed of paper considered the voltage dependency of load characteristics by using the exponential model to solve the difference type of load models. The battery charger in normal mode charging or slow charging was represented the characteristics of PEVs, which described in an exponential load by testing in the laboratory [31]. Many researchers were studied and showed from proposed in impact from PEVs for the electrical power system network as in above, but not considerate in the actual behavior of the PEVs under voltage dependent power flow. So that, this study is interesting to investigate the PEVs load model based on exponential load characteristics by considering in the static load. With numerical investigations, the voltage dependent power flow is used to solve by comparison with the conventional load type (Z, I, P) found in the IEEE 33 bus radial distribution test system. This means that is also defined in a balanced load system to find the total power losses and the load voltage deviation of the electrical power system.

The structure of the paper is as follows: the load flow study (LF) for power flow analysis is presented in Section 2, and the proposed conventional load (Z, I, P), PEVs based on static load models is presented in Section3. Section 4, presents the total power losses in the electrical power system. The test radial distribution system is provided in Section5. Section6 proposes the simulation results and explanation. Finally, the conclusion and discussion are given in Section 7.

2. Proposed Load Flow Study and Formulation

The Load flow study (LF) is very important in the planning of modern power system or in condition to improve the existing system, to considerate the some issues that may be effect to planning design part, operation part and control part. The key point of LF the power system network is using to solve the steady state solution which are provides the information on voltage magnitude and phase angle, active power reactive power flow and total power loss, respectively. To understand the impacts of PEVs on LV networks considering the amount of PEVs and behavioral uncertainties, a static framework is proposed which can be applied to any type of conventional loads of the electrical load system and PEVs load. In order to investigate the impact of PEVs load effected on the electrical

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power system under slow charging mode of the battery charger. The solving methodology is using relevant based on three delivered metrics, the bus injection to branch injection matric(BIBC), branch current to bus voltage matrix (BCBV) and current injection matrix (I), respectively. In this section, will be applying the PEVs load and analyzed the effected into the electrical power system as follows. The BIBC, BCBV and I are simplify to analyze the radial distribution network(RDN) and can be adapt the PEVs load into algorithm[32]. Basically, the component of complex power load $\left(S_k\right)$ and injection current $\left(I_k^t\right)$ on the bus k can be showing as (1) and (2), respectively.

$$S_k = P_k + jQ_k \quad k = 1 \ldots N \tag{1}$$

Where N is total number of bus in the radial distribution network. P_k and Q_k are active power and reactive power of load at bus k.

Therefore, can be rearranged the equivalent injection current at the t iteration of solution from any bus to I matrix is.

$$I_k^t = I_k^r\left(V_k^t\right) + jI_k^i\left(V_k^t\right) = \left(\frac{P_k + JQ_k}{V_k^t}\right)^* \tag{2}$$

Where V_k^t are bus voltage and I_k^t equivalent injection current, respectively. Meanwhile, the equivalent injection current consists of real part $\left(I_k^r\right)$ and imaginary part $\left(I_k^i\right)$. Both of bus voltage and equivalent injection current are considerate at the t iteration of solution.

Kirchhoff's Current Law (KCL) is applied to solve the power flow of RDN from relationship between bus current injections and branch currents by formulating the branch currents from current any branch to the equivalent current injections can be showed as

$$\left[\mathbf{B}\right] = \left[\mathbf{BIBC}\right]\left[\mathbf{I}\right] \tag{3}$$

Where $\mathbf{I}$ is represented the current injection matrix, $\mathbf{BIBC}$ is represented the branch injection to branch current matrix and $\mathbf{B}$ represented the current each branches, respectively. Generally, the $\mathbf{BIBC}$ was obtained number 1 or 0 only and upper triangular matrix.

Meanwhile, relationship between branch currents to bus voltages can be showing a function of branch current, line parameters and the substation voltages as

$$\left[\Delta\mathbf{V}\right] = \left[\mathbf{BCBV}\right]\left[\mathbf{B}\right] \tag{4}$$

Where $\mathbf{BCBV}$ is represented the branch currents to bus voltages matrix and $\Delta\mathbf{V}$ represented the voltage difference from root node to each branch current.

The **BCVB** and **BIBC** are combined with relation between current injections and bus voltages of the RDN can be expressed as.

$$\left.\begin{aligned}\left[\Delta\mathbf{V}\right] &= \left[\mathbf{BCBV}\right]\left[\mathbf{BIBC}\right]\left[\mathbf{I}\right] \\ &= \left[\mathbf{DLF}\right]\left[\mathbf{I}\right]\end{aligned}\right\} \tag{5}$$

So that, voltage solution of the RDN each t iteration can be expressed as

$$\left[\Delta\mathbf{V}^{t+1}\right] = \left[\mathbf{DLF}\right]\left[\mathbf{I}^t\right] \tag{6}$$

3. Static Load Models and Load Voltage Deviation

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3.1 Static load model

A load model of the electrical power system is defined by expressing the character instantaneous of time and then represented as an algebraic function based on the frequency or the bus voltage magnitude at that instant. Basically, the apparent load power (kVA) can be considered separately to the active power component and the reactive power component, respectively. Generally, the voltage dependent of the load behavior at each bus is represented by the exponential model as [28].

$$P_{Lk} = P_{Lk0}\left(\frac{V_k}{V_{ko}}\right)^{n_{pi}} \tag{7}$$

$$Q_{Lk} = Q_{Lk0}\left(\frac{V_k}{V_{ko}}\right)^{n_{qi}} \tag{8}$$

$$S_{Lk} = P_{Lk} + jQ_{Lk} \tag{9}$$

where n indicates amount of the PQ bus in the electrical power system, S_{Lk}, P_{Lk} and Q_{Lk} indicates represented the nominal apparent power, active power and reactive power, respectively. Meanwhile, V_{i0} is represented the magnitude of the bus nominal voltage, n_{pi} and n_{qi} are represented the load indices from each load type.

The PEVs is a hybrid automobile by combining with the combustion engine and the electric motor for traction drive. Meanwhile, energy source to feed the electric motor control with battery that can be recharged by connecting to the electrical network. Therefore, the PEVs in the electrical network was represented by using the battery charger which is also to convert the AC-DC converter for charging the battery. In order to considerate in slow charging mode of charger can be represented the character instant of time as an algebraic function by using the exponential model, as in [31]. So that, from (10) and (11) is concerned the load power factor value of the battery charger, which considerate when installed.

$$P_{PEVs} = S_0 \times kp \times \left(\frac{V_i}{V_{io}}\right)^{n_{pi}} \tag{10}$$

$$Q_{PEVs} = S_0 \times kq \times \left(\frac{V_i}{V_{io}}\right)^{n_{qi}} \tag{11}$$

$$S_{PEVs} = P_{PEV} - jQ_{PEV} \tag{12}$$

where S_0 indicates the apparent load power (kVA) at nominal voltage V_{i0}, kp is represented the load power factor pf and can be found $k_q = \sqrt{\left(1 - pf^2\right)}$.

Table 1. Exponential indices value of load type

Load Type	n_{pi}	n_{qi}
Constant impedance (Z)	2	2
Constant current (I)	1	1
Constant power (P)	0	0
PEVs[31]	2.59	4.06

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Table 1, shows the constant indices of load types used to solve the power flow problem on the electrical power system. The indices consist of a constant impedance load, constant current load, constant impedance load and PEVs, respectively. The PEVs are specified on the slow charging model of the battery charger used in this study.

3.2. Load Voltage Deviation (LVD)

The increasing load on the power system will affect the voltage level in each bus. Therefore, the LVD is used to analyze the deviation of the bus voltage that is affected by the load. In general, the LVD value must be minimal. It shows that the system still has a good level of voltage. Therefore, the change in load on each bus must be appropriate, as described in (13), [33-34].

$$LVD = \sum_{k}^{n} \left(\frac{V_k^{ref} - V_k}{V_k^{ref}} \right)^2 \tag{13}$$

where V_k is represented bus load voltage of each load. Meanwhile, V_k^{ref} is represented voltage reference under normal conditions that is also defined at 1 p.u..

4. Total Power Loss of Electrical Power System

Generally, all electric appliance or loads of the electrical power system will be variance from behavioral of the loads characteristic. Therefore, the total real and reactive power loss in the system used to evaluate in the level of impact when loads increasing in the electrical power system can be calculated using (19) and (20) as follows[35].

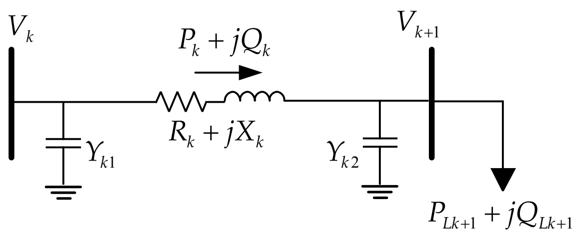

Figure 2. Electrical equivalent circuit of a typical branch *k*

$$P_{k+1} = P_k - P_{Loss,k} - P_{LK+1} \tag{14}$$

$$= P_k - \frac{R_k}{|V_k|^2} \left\{ P_k^2 + \left(Q_k + Y_k |V_k|^2 \right)^2 \right\} - P_{Lk+1} \tag{15}$$

$$Q_{k+1} = Q_k - Q_{Loss,k} - Q_{Lk+1} \tag{16}$$

$$= Q_k - \frac{X_k}{|V_k|^2} \left\{ P_k^2 + \left(Q_k + Y_{k1} |V_k|^2 \right)^2 \right\} - Y_{k1} |V_k|^2 - Y_{k2} |V_{k+1}|^2 - Q_{Lk+1} \tag{17}$$

$$|V_{k+1}|^2 = |V_k|^2 + \frac{R_k^2 + X_k^2}{|V_k|^2} \left(P_k^2 + Q_k^2 \right) - 2 \left(R_k P_k + X_k Q_k \right) \tag{18}$$

$$= |V_k|^2 + \frac{R_k^2 + X_k^2}{|V_k|^2} \left(P_k^2 + \left(Q_k + Y_k |V_k|^2 \right)^2 \right) - 2 \left(R_k P_k + X_k \left(Q_k + Y_k |V_k|^2 \right) \right) \tag{19}$$

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The active and reactive power in the transmission line section are connecting buses k and $k+1$ can be calculating as

$$P_{Loss}(k,k+1) = R_k \bullet \frac{(P_k^2 + Q_k^2)}{|V_k|^2} \tag{20}$$

$$Q_{Loss}(k,k+1) = X_k \bullet \frac{(P_k^2 + Q_k^2)}{|V_k|^2} \tag{21}$$

The power loss from a transmission line consists of active and reactive. Therefore, the total active power loss $(P_{T,loss})$ and the total reactive power loss $(Q_{T,loss})$ of the electrical power system are using summarize the losses of all transmission line in the system, which are given as

$$P_{T,Loss} = \sum_{k=1}^{n} P_{Loss}(k,k+1) \tag{22}$$

$$Q_{T,Loss} = \sum_{k=1}^{n} Q_{Loss}(k,k+1) \tag{23}$$

Using this efficient voltage dependent power flow technique, the total losses and voltage at each bus of the electrical power system were assessed.

5. Radial Distribution System(RDS) for testing from purpose

The propose in this study selects a primary distribution system to evaluate the impact of each load type on the power system network. The IEEE 33 bus test system has been used to obtain results and to evaluate the efficiency of each type of load test. By determining base MVA = 100, base voltage = 11 kV. Generally, the IEEE 33 bus test system is defined by consisting of 32 line sections with a total power constant load of 3.72 MW and 2.3 MVar in the balanced load system shown as in[36].Generally, the RDS was interested and used to solve many problem from the system for proving and comparing each based case. Therefore, this paper was considered the IEEE33 bus test system for solving the impact of PEVs integrated into power distribution system based on voltage dependent power flow. The IEEE33 bus test system was modified the traditionally load models to voltage dependent load models. The LF methodology was applied to analyze and compare each load type by using voltage profiles, total power loss and LVD. This paper was supposed in condition of balance load for any load to install each bus of the power system and trying change load type by changing the exponential indices for each loads by using data in Table1.

6. Simulation Results

The proposed each load type and LF algorithm were implemented in a MATLAB m-file. The LF was solved based on the balance load of constant impedance load (Z), constant current load (I), constant power load (P) and PEVs obtained using the static analysis of the electrical power system. In this paper, we assume that each type of load installed in the electrical system is the same load for each cycle analysis and the load type change is complete. Therefore, the number of conventional load (Z,I,P) and PEVs will distribute each at the RDS buses. The results show the bus voltage, total power loss and LVD for each type of load, as given in Table 2, Figure 3, Table3, Figure 4 and Table 4, respectively.

The basic steps of load flow analysis for RDS are as follows.

Step 1: Read data for using in calculation, which consists of buses data, lines data and exponential indices value of load type.

Step 2: Initial voltage profiles (V_0) and (V_k) for all bus at $1\angle 0°$.

Step 3: Form the BIBC matrix by using data in step 1.

Step 4: Form the BCBV matrix by using data in step 1.

Step 5: Form the DLF matrix by using data in step 1.

Step 6: Set the exponential indices of each load types j

j=1 (Z load; P=2 and Q=2)

j=2 (I load; P=1 and Q=1)

j=3 (P load; P=0 and Q=0)

j=4 (PEVs; P=2.59 and Q=4.06)

Step 7: Define iteration count $t = 0$ and tolerance convergence (ε) =0.0001.

Step 8: Iteration $t = t+1$.

Step 9: Compute the equivalent current injection (I_k^t) from (2) based on individual type of each load on (7)-(12) for finding complex power (S_k^t) and using the exponential indices from Table 1., for applying voltage dependent power flow.

Step 10: Calculate the bus voltage using Equation (6) as $[\Delta \mathbf{V}^{t+1}] = [\mathbf{DLF}][\mathbf{I}^t]$.

Step 11: Check the mismatches. If $\max(abs(V_{new} - V_{old})) \le \varepsilon$, go to Step 8 else go to step 12.

Step 12: Calculate the final voltage at each bus, LVD and the total power loss from (13), (22), and (23).

Step 13: Print the bus voltage magnitude, LVD and total power loss

Step 14: $j = j+1$

Step 15: Check the exponential indices. If $j \le 4$, go to Step 7, else go to step 16.

Step 16: Stop

Table 2. Comparison voltage profiles of IEEE 33 bus test system load-flow results

Bus No.	Z(p.u.)	I(p.u.)	P(p.u.)	PEVs(p.u.)
1	1.0000	1.0000	1.0000	1.0000
2	0.9973	0.9972	0.9970	0.9977
3	0.9847	0.9839	0.9829	0.9873
4	0.9782	0.9769	0.9755	0.9820
5	0.9717	0.9701	0.9681	0.9768
6	0.9558	0.9530	0.9497	0.9631
7	0.9527	0.9498	0.9462	0.9602
8	0.9485	0.9453	0.9413	0.9572
9	0.9432	0.9395	0.9351	0.9532
10	0.9382	0.9342	0.9292	0.9494
11	0.9374	0.9334	0.9284	0.9489
12	0.9362	0.9320	0.9269	0.9480
13	0.9310	0.9264	0.9208	0.9441
14	0.9290	0.9243	0.9185	0.9426
15	0.9278	0.9230	0.9171	0.9418
16	0.9267	0.9218	0.9157	0.9410
17	0.9250	0.9199	0.9137	0.9396
18	**0.9245**	**0.9194**	**0.9131**	**0.9392**
19	0.9968	0.9967	0.9965	0.9972
20	0.9933	0.9931	0.9929	0.9939

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21	0.9926	0.9924	0.9922	0.9932
22	0.9919	0.9918	0.9916	0.9926
23	0.9813	0.9804	0.9794	0.9843
24	0.9750	0.9739	0.9727	0.9788
25	0.9719	0.9707	0.9694	0.9760
26	0.9541	0.9512	0.9477	0.9617
27	0.9519	0.9489	0.9452	0.9598
28	0.9421	0.9383	0.9337	0.9507
29	0.9350	0.9308	0.9255	0.9441
30	0.9320	0.9275	0.9220	0.9414
31	0.9285	0.9237	0.9178	0.9385
32	0.9277	0.9229	0.9169	0.9378
33	0.9274	0.9226	0.9166	0.9376

In Table 2, it is possible to see the voltage magnitude profiles by arranging from bus No.1 to bus No.33 under difference load types and voltage level are reduce from the root node to the end of node. Therefore, the effect of load and transmission line are reducing level of the voltage profile and increasing the total power loss. The results are the voltage magnitude profiles by using the voltage dependent power flow to solve the effect from difference load types. The simulation results show the lowest voltage each load types on bus No.18 (the bold text number). There are arrange from high to low of the voltage profiles; 0.9392 p.u., 0.9245 p.u., 0.9194 p.u. and 0.9131 p.u., by represented PEVs load, Z load, I load and P load, respectively. Therefore, in this case the weak point found that effected from power constant by comparing but same as tending point from contour static voltage magnitude profiles each load types in the weak point. Additionally, the simulation results are show in a static power analysis by using on average peak value of power demand from each load and enough for representing the characteristic to the RDN.

Figure 3 shown the contour of static voltage magnitude profiles are comparing with Z load, I load, P load and PEVs, respectively. The graphic show the lowest contour voltages profiles remain about 0.9130 p.u. (red color field) and the highest contour voltages profiles remain about 1 p.u. (violets color field). Interestingly, the static voltage analysis by applying contour color can show some details of the characteristic from each any load. Especially, the PEVs load of the contour of static voltage magnitude profiles are reveal that affect in the lowest level in the RDN when compared with any load types. In order to arrange the level from the highest to the lowest impact of the RDN are constant power load, constant current load, constant impedance load and PEVs, respectively. Therefore, the Z load, I load, P load and PEVs affected by considering to static voltage stability based on the voltage profiles obtained from the electrical power system. In decreasing order, the factors that affect the static voltage stability were P load, I load, Z load, and PEVs, respectively.

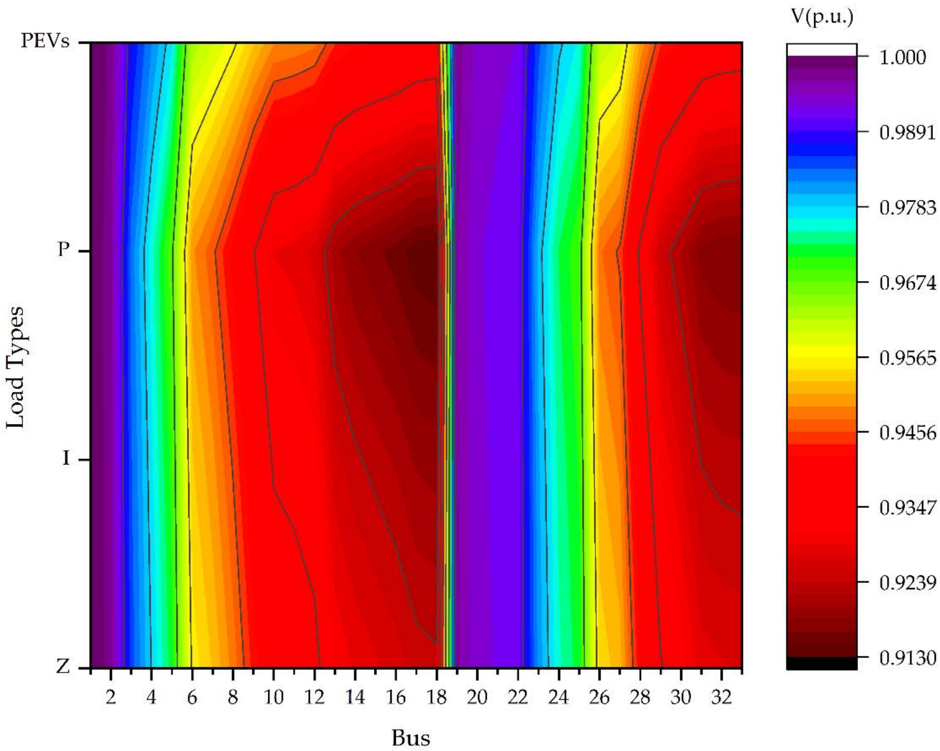

Figure 3. Contour of static voltage profiles from difference load type

Table 3, demonstrate that all effects from each load model types to the transmission line losses from transmission line No.1 to transmission line No.32. The total power losses are derive from the current flow thought a transmission line between two buses that affected from load are installed on any the buses. The sizing and location of the transmission line loss were effected to voltage drop in the power system and in condition to install near the root node that should be carry burden from current thought to the end of node. However, in the realistic many factor and details to effect the loss from cable such as temperature, installation method, type of cable etc., The simulation results from Table 3, showed in condition to transmission line loss in Kilowatt unit(kW) of each transmission line in the RDN. In this case, the transmission line No.2 was effected more transmission line loading than another of each transmission line. In this case compare with each load types from the highest to the lowest(the bold text number) are 51.791 kW, 45.975 kW, 41.469 kW, and 30.940 kW which rearrange load types from P load, I load, Z load and PEVs, respectively. In condition, if compare on the second order from the highest to the lowest found that (the italic text number) on the transmission line number No.5 are 38.249 kW, kW, kW, and kW, that derived same as, from P load, I load, Z load and PEVs , respectively. So that, the total power loss in the transmission lines can reducing and improving from this weak point but that out of scope in this work.

Table 3. Comparison of IEEE 33 bus test system from lines active power loss results

Br. No	Z(kW)	I(kW)	P(kW)	PEVs(kW)
1	10.031	10.999	12.240	7.613
2	**41.469**	**45.975**	**51.791**	**30.940**
3	15.190	17.217	19.900	11.499
4	14.134	16.095	18.699	10.615
5	28.793	32.849	38.249	21.652
6	1.457	1.654	1.915	0.868
7	3.625	4.145	4.838	2.094
8	3.075	3.546	4.181	1.693

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9	2.606	3.012	3.561	1.471
10	0.404	0.467	0.554	0.235
11	0.640	0.742	0.881	0.359
12	1.927	2.240	2.666	1.033
13	0.526	0.612	0.729	0.265
14	0.256	0.299	0.357	0.094
15	0.201	0.235	0.281	0.091
16	0.179	0.210	0.252	0.086
17	0.038	0.044	0.053	0.021
18	0.157	0.159	0.161	0.140
19	0.807	0.819	0.832	0.707
20	0.098	0.099	0.101	0.085
21	0.042	0.043	0.044	0.037
22	2.852	3.005	3.182	2.144
23	4.596	4.850	5.144	3.402
24	1.143	1.210	1.287	0.835
25	1.931	2.217	2.601	1.789
26	2.460	2.831	3.329	2.328
27	8.315	9.588	11.301	8.052
28	5.751	6.638	7.833	5.746
29	2.853	3.297	3.896	2.955
30	1.154	1.341	1.594	0.711
31	0.154	0.179	0.213	0.098
32	0.010	0.011	0.013	0.008

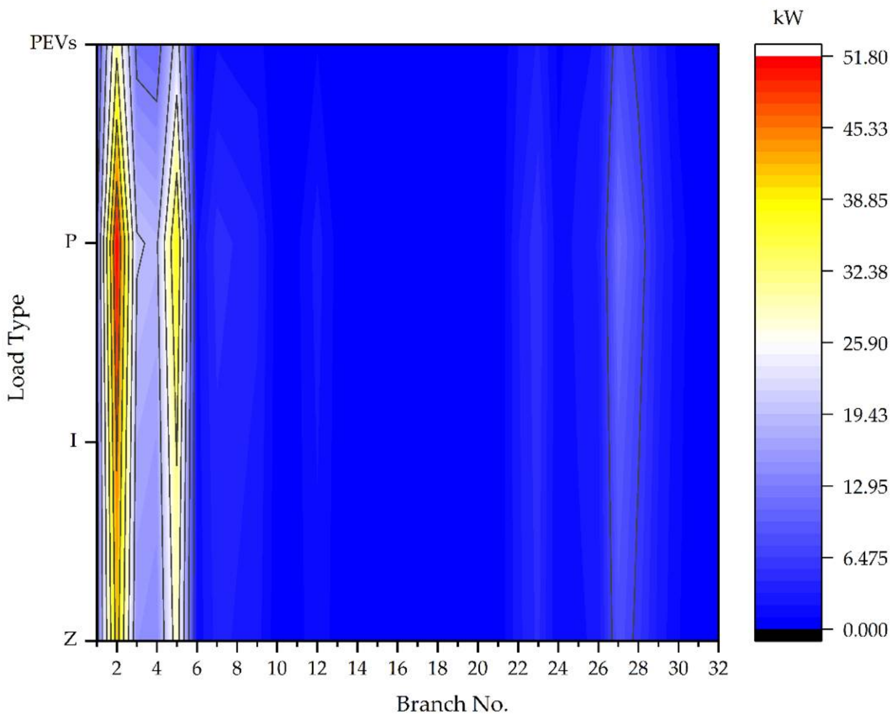

Figure 4. Contour of lines active power losses when difference load type

The results from Figure 4, were compared with the contour of lines active power loss magnitude profiles obtained for each load type in the IEEE 33 bus test system. All the simulation results shown the effect of the different lines active power loss profiles from the each load type. The Figure 4 ,shows that the highest active power loss each the load type of red color contour at the transmission line number No.2., and the second order of highest active power loss each the load type on yellow color contour in the transmission line number No.5.,respectively. The simulation results from the contour of line active power losses when difference load type are reveal the weak point of highest active power loss on the transmission lines. Meanwhile, the rest of all the transmission line showed in same as the contour color and in for the future need to analyze in deep details on line loading factor each transmission line.

From the resulting above, it can be observed that those all voltage profiles and all transmission line loss are vary from the exponential indices of load each types by using voltage dependent load power flow from purposed. Therefore, optimal model of load type clouded be selected and defined nearly about the behavioral of each load.

Table 4. Comparison of LVD, Total active power loss, and total reactive power loss.

Load Type	LVD	Active power loss (kW)	Reactive power loss (kVar)	Apparent Power Loss(KVA)	%LVD	%P	%Q
PEVs	**0.062**	**119.67**	**79.31**	**143.56**	**-40.96%**	**-41.31%**	**-41.07%**
Z	0.089	156.87	104.18	188.31	-22.60%	-22.91%	-22.70%
I	0.101	176.63	117.51	212.15	-12.85%	-13.04%	-12.91%
P[35, 37]	0.117	202.68	135.14	243.60	0.00%	0.00%	0.00%

Table 4, shows results of LF algorithm based on voltage dependent power flow by comparing the values of the total real power loss (P_{loss}), the total reactive power loss (Q_{loss}) and LVD, that values are different from the each load type. The total active power loss and the total reactive power loss of the PEVs shown are less than those of the Z, I, and P load. Meanwhile, it was the same as the LVD. Additionally, in condition to compare with the percentage by using based on the power constant load that revealed the variance of the PEVs more affected than Z, I, and P load. Interestingly, the PEVs show that it is not significantly by the voltage-magnitude profile and total power loss of the electrical power system. Generally, PEVs connected with another load into the network and should be considered at this point when large-scale of PEVs penetration and the conventional load of the power network combined. It is majorly impact of the electrical power system.

It is important to highlight that the effected to the LVD, total active power, and total reactive power are dependent on the type of load model installed in the RDS. Furthermore, the PEVs model are affect less than the Z, I, P load, in order to compare with one by one. Therefore, the PEVs may be effected to the electrical power system when plugs into the power system network thought the outlets by combining with the traditional load and high penetration of PEVs cloud be noted.

7. Conclusion

The proposed a simple algorithm with LF methodology has been applied using the m-files, MATLAB program environment for the IEEE33 bus test system simulation. In addition, the each load models are also defined to solve the problem by using on a balanced load in a radial distribution system (RDS). Different simulations have been performed on the each load models. There are consist a constant power load, constant current load, constant impedance load and PEVs, respectively. The simulation of each load on peak load value have been discussed with the RDS in detail. Therefore, the simulation results shown impact of each load type to the RDS and compared with the bus system which are total power loss and LVD. Among the results for the four proposed load models, the differences in the exponential indices value of load type reflect the behavior of each load on the voltage dependent power flow. Consequently, the PEVs from the simulation results showed the affected to the RDS by less than a constant power load, constant current load, constant impedance load. The PEVs in the test case revealed the lowest LVD and lowest total power loss values of 0.062, 119.67 kW and 79.31 kVar, respectively. Although, in daily life, the PEVs will be included or combined to another load in peak or off peak demand, its same charging time or same power transmission line of the electrical system and while simultaneously being charged. So that, large-scale of PEVs penetration will be affected to the electrical power system and cloud be managed in the optimal condition. Furthermore, proper management of PEVs in the each area of the battery charger can be beneficial of the reduced impact to the electrical power system. Moreover, it can also be implemented in other condition with PEVs charging clustered by coordinating the each charger with power grid for increasing the static voltage stability of the electrical power system.

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