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Impact of Electric Vehicle Charging Stations on Distribution System Voltage Stability

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ABSTRACT

The electrical vehicle (EV) brings a sustainable future for next generation of automobiles. When an electric vehicle (EV) battery runs out of power, it has to be recharged. In order to serve a lot of electric vehicles, charging stations must be widely established, especially in residential areas. As electric charging stations will be used simultaneously by many EV's they should be optimally placed in the areas of dense traffic for minimum total cost of the charging station and minimum total loss of distribution network. Eventually, the influence of EV load on power system voltage stability is related in proportion of three different types of loads-individual loads, equivalent impedance, and the total load. This work studies the impact of fast charging stations on the voltage stability as it is considered as one of the main threats to secure the operation of power system. To this end, this work studies the impact of fast charging stations on the voltage stability and device a methodology to mitigate it. Moreover, an optimization algorithm is used to find the optimal location for EV charging stations. Some of the optimization algorithms will be studied and the efficient optimization algorithm will be chosen by comparing its performance in terms of optimal value and convergence time. The objective function is to maximize the voltage stability of the system with some operational constraints. The stability analysis will be performed by using the results from load flow studies. The forward- backward sweep method of load flow study is used in this work.

The proposed methodology will be applied IEEE 33 bus test system by placing the EV charging stations at some random locations. Then, the optimization results will be applied to place the charging stations at strategic locations. The voltage stability of the system will be improved along with improvement in load margin.

Keywords: Load flow analysis; optimization techniques; Genetic algorithm; Particle swarm optimization

1. Introduction

According to definitions given by the IEEE, voltage stability refers to the power system capable to maintain all bus voltages within acceptable range both under normal conditions and in the subsequent of disturbances. Voltage stability is crucial for maintaining the stability of the electrical system and cannot be ignored. Voltage instability is a problem that occurs in systems which are overloaded. The majority of devices used on a daily basis, including equipment and appliances, will be powered by electricity under the power system concept which is exactly same as true for electric cars. Petrol and diesel pumps will soon be replaced with intelligent electric car charging stations. The availability of charging stations is really essential to the success of electric automobiles. However, the change in load is exactly proportional to the change in voltage magnitude, it will also an additional load to the distribution system, which may also cause instability in the system.

The necessity for the development needed in the growth of EVs were explored in [1] by the authors. PEVs and BEVs charge their batteries using electricity from the electric power grid. Numerous studies have examined the financial costs and benefits of PEVs on utility and distribution networks. Governments are concentrating on building EV charging stations in metropolitan areas and along certain highways[2],[3],[4]. Multiple researches have shown that even minimal penetration of EV charging may have an effect the power system, including harmonic distortion, load management, voltage profile and various losses [5]. There have been several actions made up to this moment to reduce the effects of the problems mentioned. [6] analyses the potential for increasing system stability by using various charge control mechanisms. Several researchers have investigated how EVs would affect the power system. In the literature, the majority of study is focused on smart charging methodologies[7],[8],[9] and load profiles[10], but there has been work done to evaluate the effect of EVs on the distribution system itself. Through simulation analysis, the primary objective of this study is to determine how EVs would affect the voltage profile of the distribution grid[11]. To that end, a bus voltage stability index called IEEE 33 bus has been modified to identify weak buses in the distribution system. The best placement of EV is chosen among the identified weak buses.[12] As a consequence, the voltage profile of every bus has improved, resulting in the stability of the whole distribution system.

2. VOLTAGE STABILITY

2.1 Power system voltage stability:

A power system should always be in a stable functioning condition that satisfies a number of operational requirements and is secure in the event of an emergency. Due to economic and environmental constraints, modern power systems are being operated closer to any feasible limits for stability. In light of this, maintaining a power system's dependable and secure operation is a matter of extreme importance and difficulty. Power system scholars and planners have focused a lot of emphasis recently on voltage instability, which is one of the major factors contributing to power system vulnerability. The term "voltage instability phenomena" refers to situations in which the receiving end voltage significantly deviates from its normal value and either does not return even after the setting of restoring devices like VAR compensators, or oscillates in the absence of damping against the disturbances. Voltage collapse is a series of events that occur before voltage instability and cause the voltage to drop to an un-favourable level. Voltage issues, traditionally linked to flimsy systems and long lines, are increasingly being worried about in well-developed networks due to increased loading. Today, the main causes of voltage instability in a power system have been fully studied and identified. This chapter provides a brief overview of voltage stability's fundamental concepts as well as some of its established analytical techniques. The challenge of voltage stability and common approaches to investigating the issue are demonstrated via simulation results on test power systems. The extent of the use of Artificial Neural Networks as a superior alternative is studied in light of the drawbacks of traditional methodologies for voltage stability analysis.

2.2 Classification of voltage stability:

Voltage stability refers to a power system's capacity to maintain constant voltages at all of its buses both during routine operation and in the event of a disruption. The potential for instability manifests as a gradual decrease or increase in voltage on particular buses. Voltage instability may result in either a loss of load in the region where voltages drop to unacceptable levels or in the integrity of the power system. Rotor angles varying out of phase can also be related to a progressive decline in bus voltages. For instance, very low voltages would be experienced at intermediate locations in the network near to the electrical center when rotor angles between two groups of machines approached or exceeded 180°, causing a progressive loss of synchronism of the machines. In contrast, if rotor angle stability is not a concern, a prolonged voltage decline associated with voltage instability takes place. The voltage drop that happens when active and reactive power flow through inductive reactance connected to the transmission network, which limits the capacity of the transmission network for power transfer, is typically the main cause of voltage instability. When some of the generators reach the limitations of their reactive power capabilities, the power transfer limit is further constrained. Loads are what cause voltage instability, but in response to a disturbance, distribution voltage regulators, tap-changing transformers, and thermostats have a tendency to restore power that the loads have used. Restored loads put extra strain on the high voltage network, which lowers voltage even further. When load dynamics seeks to recover power demand beyond the capacity of the transmission system and the attached generation, a rundown condition that causes voltage instability results.

Voltage stability of system are mainly classified into 2 types followed by:

i. Large Disturbance voltage stability

ii. Small Disturbance voltage stability

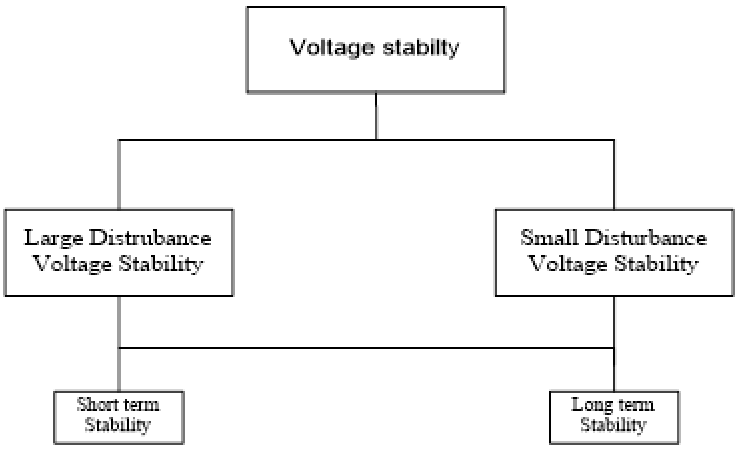


Fig 2.1: Classification of voltage stability

2.2.1. Large Disturbance voltage stability:

It is concerned with a system's capacity to manage voltages in the wake of significant disturbances such system failures, loss of generation, or circuit contingencies. The nature of the system load as well as the interplay between continuous and discrete controls and safeguards influence this capability. The analysis of a system's nonlinear dynamic performance over a period of time long enough to capture the interactions of components like under-load transformer tap changers and generator field-current limiters is necessary to determine the stability of a system under major disturbances. A few seconds to tens of minutes may be included in the relevant research time. As a result, analysis calls for long-term dynamic simulations.

2.2.2. Small Disturbance voltage stability:

It is concerned with a system's capacity to manage voltages in the face of minor disturbances, such as gradual changes in system load. The features of loads, continuous controls, and discrete controls at a particular instant of time define this type of stability. This notion is important in determining how the system voltage will respond to tiny system changes at any given time. The fundamental mechanisms that contribute to minor disturbance voltage instability are fundamentally steady-state in nature. As a result, static analysis may be utilized efficiently to calculate stability margins, identify factors impacting stability, and investigate a wide range of system states and post-contingency scenarios. A requirement for minor disturbance voltage stability is that the bus voltage magnitude grows as the reactive power injection at the same bus increases at a certain operating state for every bus in the system. A system is voltage unstable if the magnitude of the bus voltage (V) declines as the reactive power injection (Q) at the same bus increases. In other words, a system is voltage stable if the V-Q sensitivity for all buses is positive, and unstable if the V-Q sensitivity for at least one bus is negative

3. POWER FLOW STUDIES IN DISTRIBUTION SYSTEM

3.1 Classification of distribution system

The three components of the power system network are generation, transmission, and distribution. Transmission and distribution systems provide the power produced by the power plant to the load. In this essay, we will describe the different forms of distribution network. According to the structure of the system, the distribution network is categorized into three categories:

- Radial Distribution System
- Ring Distribution System
- Interconnected Distribution System

3.1.1 Radial Distribution System

In this scheme, different feeders are connected to the distributor at just one end and radiate from a single substation. Only one path connects each customer to the substation in a radial system. From the substation to the customer, electrical power travels only one way. Therefore, if a system failure arises, the customer will experience a total loss of power. When compared to other systems, this system has a cheap initial cost. Simple in terms of conception, creation, and use. The radial distribution system has lower dependability. The distributor is highly loaded closer to the feeding end. With changes in load, consumers at the other end would experience voltage swings.

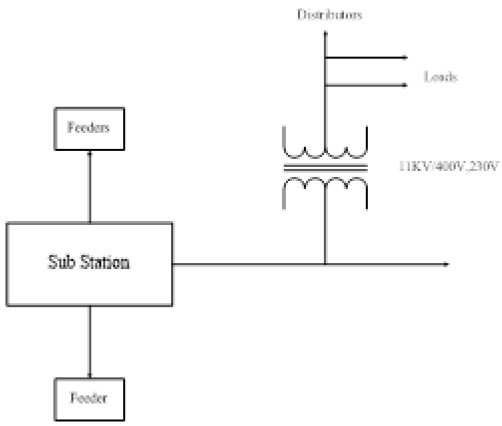


Fig 3.1: Radial distribution system

Advantages:

- Simplest as supplied at only one end
- The initial cost is low
- Favourable if the station is situated in the middle of the load.
- More value in some places with low load requirements
- Requires fewer wires and requires little

3.1.2 Ring distribution System

In this network design, a ring network of distributors is supplied by more than one feeder. If one feeder fails or requires maintenance, the ring distributor is still powered by other feeders linked to it. As a result, even if one of the feeders fails, the supply to the consumers remains uninterrupted. Furthermore, the ring main system is outfitted with various section isolates at various suitable spots. If a failure arises on any portion of the ring, it is simple to isolate that section by immediately opening the relevant section isolators on both sides of the faulty region transformer.

In this way, even when one section of the ring is shut down, supply to the customers linked to the safe zone of the ring may be safely maintained. The following variables affect how many feeders are connected to the ring main electrical power distribution system.

- Maximum Demand: If it is higher, additional feeders will be used to feed the ring.
- Total Length of Main Distributors of the Ring: Since it is longer, additional feeders must be linked to the ring system in order to make up for the voltage drop in the line.
- Required Voltage Regulation: The number of feeders connected to the ring is also based on the maximum voltage drop that the line can bear.

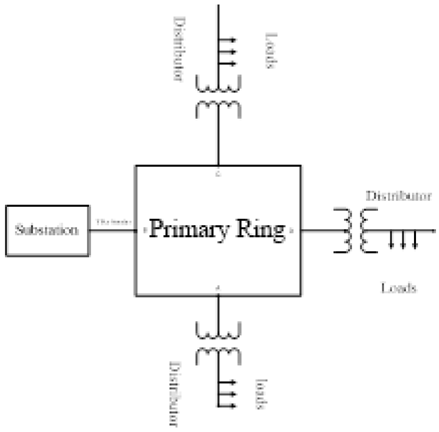


Fig 3.2: Ring distribution system

Advantages:

- Power is supplied from both ends
- if one end develops a fault, the other end continues to supply power
- The voltage drop along the distribution line is lower in ring systems
- Many users may be added to the system compared to a radial system

3.1.3 Interconnected distribution system

An interconnected distribution system is one where a ring main feeder is fed by two or more generation stations or substations. In the case of transmission breakdown, this system guarantees reliability. In order to fulfil increasing power demands from increased load, any region served from one producing station during peak load hours may be fed from the other generating station or substation.

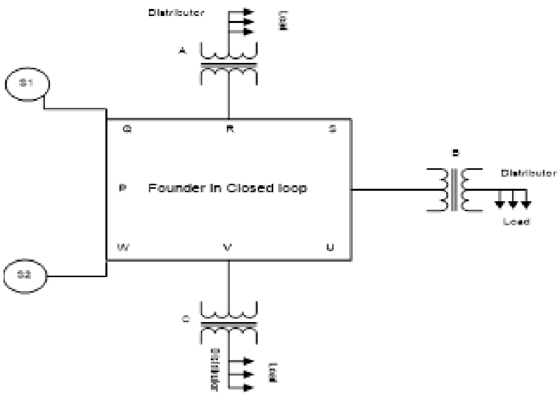


Fig 3.3: Interconnected distribution system

3.2 Load flow analysis in radial distribution system

A load flow analysis provides active and reactive power losses in each branch as well as voltage phasors. The planning, operation, and optimization of the power distribution system are all improved by load flow analysis for radial distribution systems. The distribution networks fall under the category of poor condition as a result of some of the following particular traits:

- High R/X ratios
- Multi-phase, unbalanced operation
- Unbalanced distributed load
- Distributed generation

The distribution network fails Newton Raphson and other transmission system algorithms as a result of the current problems. For this reason, the backward-forward sweeping approach is used to study the distribution network. In comparison with NR techniques, this method doesn't require a Jacobian matrix.

3.2.1 Formulation of the problem

The power flow analysis can be used to obtain the voltage magnitude, power losses of the 33bus system. The following simple recursive equations are used to calculate power flows in a distribution system.

$$P_{k+1} = P_k - P_{Loss,k} - P_{LK+1}$$
$$Q_{k+1} = Q_k - Q_{Loss,k} - Q_{LK+1} \quad (1)$$

Where P_k - Real power flowing out of bus;

Q_k - Reactive power flowing out of bus;

P_{LK+1} - Real load power at bus k+1;

Q_{LK+1} - Reactive load power at bus k+1;

The power loss in the line section connecting buses k and k+1 may be computed as:

$$P_{loss}(k, k+1) = R_k \frac{P_k^2 + Q_k^2}{V_k^2} \quad (2)$$

$$Q_{loss}(k, k+1) = X_k \frac{P_k^2 + Q_k^2}{V_k^2} \quad (3)$$

$P_{loss}(k, k+1)$ - Real power loss in the line section connecting buses k and k+1;

$Q_{loss}(k, k+1)$ - Reactive power loss in the line section connecting buses k and k+1;

The overall power loss of the feeder, $P_{T,loss}$ may then be calculated by adding the losses of all feeder line sections, which is given as

$$P_{T,loss}(k, k+1) = \sum_{k=1}^{n} P_{loss}(k, k+1) \quad (4)$$

$$Q_{T,loss}(k, k+1) = \sum_{k=1}^{n} Q_{loss}(k, k+1) \quad (5)$$

3.3 Backward/Forward Sweep methods:

Consider a radial network; the backward/forward sweep technique for load-flow calculation is an iterative approach that performs two recursive equations at each iteration. Two sets of recursive equations may be used to iteratively solve the load flow of a single source network. The first set of equations for calculating the power flow through branches begins at the last branch and moves backwards toward the root node. The second set of equations determines the voltage magnitude and angle at each node, beginning at the root node and moving forward to the final node.

3.3.1 Forward Sweep method:

A voltage drop estimate with optional updates to the current or power flow provides by the forward sweep. Nodal voltages are updated in a forward sweep begins from first-layer of the branches and moving down to last-layer of the branches. The purpose of the forward propagation is to calculate the voltages at each node starting from the feeder source node. The effective power in each branch is maintained constant to the value attained in the backward walk throughout the forward propagation.

3.3.2 Backward Sweep method:

In general, the backward sweep is a solution for current or power flow with potential voltage modifications. It begins with the branches on the bottom layer and gradually moves to the branches connected to the root node. The backward propagation calculates the node voltages from the previous iteration to determine the updated effective power flows in each branch. It implies that updated power flows in each branch are transferred backward through the feeder using the backward propagation while the voltage values obtained in the forward path are maintained constant. This shows that the backward propagation moves from the source node to the final end node.

3.4 Calculation of Backward/Forward Sweep method

The three basic variations of the forward/backward sweep technique are widely known and may be distinguished from one another by the types of electric values that are computed at each iteration, beginning at the terminal nodes and moving up to the source node (backward sweep).

1. The current summation method, in which the branch currents are evaluated;
2. The power summation method, in which the power flows in the branches are evaluated;
3. The admittance summation method, in which, node by node, the driving point admittances are evaluated.

In other words, the three variants of the B/F method use constant admittance, constant power, and constant current models to simulate the loads throughout each cycle. Since the bus voltages are calculated starting at the source node and moving towards the ending nodes in the forward phase based on values derived in the backward phase. In order to continue with iteration, voltages are then applied to update the quantities used in the backward sweep based on the dependence of loads on the voltage. When a convergence condition is confirmed, the procedure comes to an end.

By comparing the calculated voltages in previous and present iterations, the successive iteration is obtained If the voltage differences is smaller than the given tolerance, or 0.0001, the convergence may be reached. Otherwise, the current computed voltages are used to calculate additional actual power flows in each branch using a backward walk, and the process is repeated until the solution is reached. The backward/forward sweep approach has now been modified such that it may be used to evaluate how the iterative process converges. The effective active and reactive powers of a branch flowing from node 'k' to node 'k+1' are being measured backwards from the previous node and are given as:

$$P_k = P'_{k+1} + r_k \frac{P'^2_{k+1} + Q'^2_{k+1}}{V^2_{k+1}} \tag{6}$$

$$Q_k = Q'_{k+1} + X_k \frac{P'^2_{k+1} + Q'^2_{k+1}}{V^2_{k+1}} \tag{7}$$

Where $P'_{k+1} = P_{k+1} + P_{LK+1}$

$Q'_{k+1} = Q_{k+1} + Q_{LK+1}$

P_{LK+1} and Q_{LK+1} are the load that are connected at the 'k+1' node

P_{K+1} and Q_{K+1} are the effective active and reactive power flows from the node 'k+1'

The voltage magnitude and angle at each node are calculated in forward direction. Consider a voltage $V_k\angle\delta_k$ at node 'k' and $V_{k+1}\angle\delta_{k+1}$ at node 'k+1' then the current flowing through the branch having an impedance, $z_k = \sqrt{r_k^2 + x_k^2}$ connected between 'k' and 'k+1' is given as,

$$I_k = \frac{V_k\angle\delta_k - V_{k+1}\angle\delta_{k+1}}{r_k + jx_k} \tag{8}$$

The magnitude and phase angle equations may both be applied to finding the voltage and angle by iteratively moving forward according to each node in the radial distribution system. Initially, all nodes are considered to have a flat voltage profile, i.e.,1.0 pu. The updated voltages at each node are used to progressively calculate the branch powers. The suggested load flow approach calculates voltages in the forward walk while total power is completed in the backward walk.

3.4.1 Algorithm of Backward/Forward Sweep method

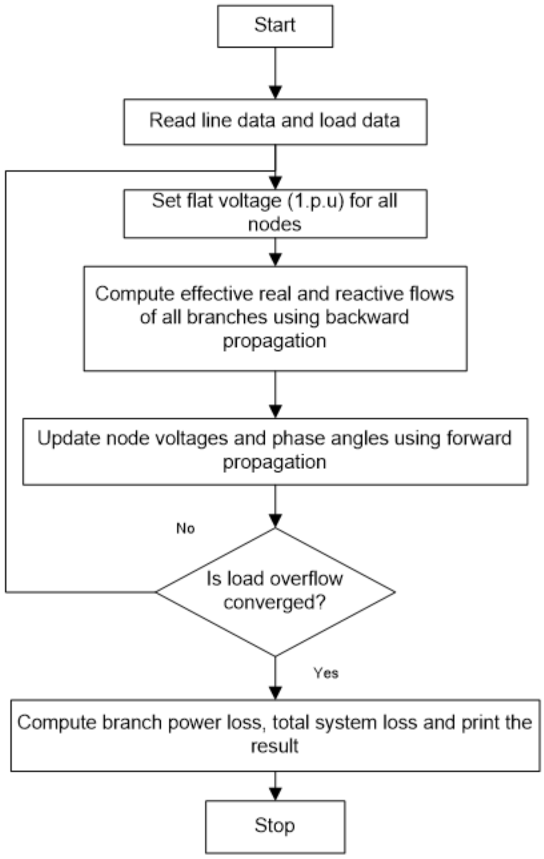


Fig 3.1: Flow Chart of Backward/Forward Sweep Method

4. GENETIC ALGORITHM

The optimization method proposed is based on a Genetic Algorithm (GA) which is a stochastic algorithm based on the principles of genetics, natural selection, and Darwinian evolution that allows the survival of the person with the help us make that is best placed to survive in the environment in which he lives, allowing regeneration and transmission of the best outcomes to the next generation. By minimising cost functions, it is possible to determine the best sites for EV charging stations by using genetic algorithm. The chromosomes of the genetic material involved in the process in this situation, the environmental conditions to which they will have to adapt will be a fitness function that will enable a careful review of several factors to improve the various objectives specified. To adapt a GA to the problem constraints, the objective function to be optimised, the idea of chromosome, and the equivalent of genetic must be specified. Moreover, dynamics of crossover and mutation must be determined. A simple overview of genetic algorithm helps in understanding how it is applied to the specific matter of optimum charging station location in a region. Before to having a discussion about the algorithm, the problem must be defined as a mathematical equation known as the "Objective Function" or "Fitness" function.

4.1 Steps involve in Genetic Algorithm:

1. GA begins by creating an initial population of randomly selected responses (Initialization).
2. The objective function is used to determine the quality of these random solutions in the second stage (Evaluation).
3. Thirdly, these answers are sorted by their goodness.
4. The choice of pairings from these responses is the fourth stage. This is a fitness-proportionate selection that is affected by the quality of the responses and probability (Parent Selection)
5. The fifth stage involves using the crossover process to combine these pairs of responses to produce a new generation of answers (Crossover). The crossover process is defined as merging two results and producing two additional solutions, similarly to the fusion of two chromosomes,

which produces two new chromosomes.

6. This new generation of responses undergoes mutation in the sixth step (Mutation). The term "mutation" refers to the alteration of one or more genetic material.
7. The evaluation, parent selection, crossover, and mutation processes will be repeatedly applied to this population of mutated answers until their goodness in comparison to previous generations.

4.2 Optimization Performance by Genetic Algorithm

Let C_1 is the cost of the costumer to travel to the to the charging.

C_2 is the cost of the power used while traveling to the destination charging station.

C_3 is the price of people control brought on by obtaining the desired power.

$$C_1 = A \times \sum_{i=1}^{n}\left[(x-a_i)^2+(y-b_i)^2\right]^{1/2} \tag{9}$$

$$C_2 = G \times P \times \sum_{i=1}^{n}\left[(x-a_i)^2+(y-b_i)^2\right]^{1/2} \tag{10}$$

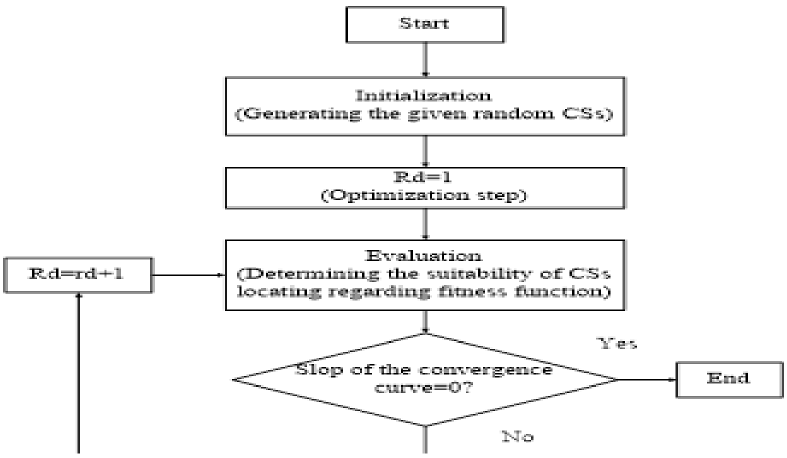
$$C_3 = R \times P \times \sum_{i=1}^{n}\left[(x-a_i)^2+(y-b_i)^2\right]^{1/2} \tag{11}$$

So, the total expense C consists of the sum of costs:

$$C = \left[A+(G+R)P\right]\sum_{i=1}^{n}\left[(x-a_i)^2+(y-b_i)^2\right]^{1/2} = C_1 + C_2 + C_3 \tag{12}$$

Where A is the average cost per km for costumer, G is the cost of electricity generated per kwh, R is the cost of the contamination controlling for production of kwh, P is the power utilization of an EV for every km, x and y are the charging stations coordinates and a_i and b_i are the settlement coordinate

4.3 Flow chart of Genetic algorithm:



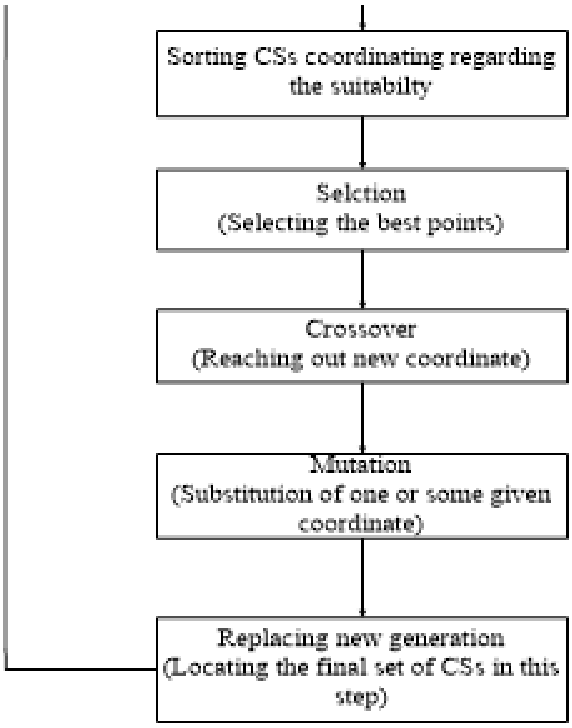


Fig 4.1: Flow Chart of GA

5. Particle swarm optimization

PSO is an analytical algorithm based on a stochastic optimization of swarm intelligence. It has been widely used in vehicle scheduling, energy management and other fields. PSO has some problems in practical applications, such as premature convergence and dimension disaster. As a result, the method has to be modified and enhanced in accordance with the particular optimization task.

A researching person in an N-dimensional real space may be thought of as each particle in PSO. The flight speed and direction of particles are dynamically adjusted according to the optimal historical position of particles and the optimal historical position of the population. The optimal solution of individual search for each particle is called individual extreme and later. The particles will update their velocity and location iteration by iteration until the termination condition is satisfied.

The conventional PSO's formulae for updating location and velocity are presented as follows:

$$V_{id+1} = \varpi * V_{id} + c_1 * rand * (P_{id} - X_{id}) + c_2 * rand * (P_{gd} - X_{id}) \qquad (13)$$
$$X_{id+1} = X_{id} + V_{id+1}$$

where V_{id} refers to the i^{th} particle velocity for d^{th} iteration in the N-dimensional search space, X_{id} indicates i^{th} particle position for the d^{th} iteration, and similarly, P_{id} is the best position of an individual particle, P_{gd} is the optimal global solution in the same iteration and dimension. ϖ is called the inertia weight and by adjusting it, the global and local optimization performance of PSO can be adjusted accordingly. A random parameter called rand has a value range of [0, 1]. c_1 and c_2 denote learning factors, of which the former is the individual learning factor while the latter is the social learning factor, and they usually are set as a constant. The position of the particle at the next moment is determined by the current position and velocity, while the current velocity is determined by the original velocity, local particles and global particles.

5.1 Basic particle swarm optimization algorithm:

Particle swarm optimization algorithm is a self-adapting. Revolution computation technology based on the population search put forward by Kennedy and Eberhart in 1995. This algorithm through the individual cooperation between the populations realizes to search the optimal solution of the problems.

Suppose that *m* particles constitute a swarm in *D* dimensional space. The information of particle i can be expressed as a *D* -dimensional vector. The position of the i^{th} particle is $X_i = (x_{i_1}, x_{i_2}, ..., x_{i_n})^T$, the speed is $V_i = (v_{i_1}, v_{i_2}, ..., v_{i_n})^T$, The optimal position of self-search is $P_i = (p_{i_1}, p_{i_2}, ..., p_{i_n})^T$,the whole particle swarm search the optimal position is $P_i = (p_{g_1}, p_{g_2}, ..., p_{g_n})^T$. The speed and the optimal position update equations of the particles respectively:

$$v_{id}^{k+1} = \omega v_{id}^{k} + c_1 rand_1^k (p_{id}^k - x_{id}^k) + c_2 rand_2^k (p_{gd}^k - x_{id}^k) \qquad (14)$$
$$x_{id}^{k+1} = x_{id}^k + v_{id}^{k+1}$$

Here: v_{id}^{k} is the speed of the particle i^{th} in the j^{th} dimension, the k_{th}^{th} iteration; x_{id}^{k} is the current position of the particle i in the j^{th} dimension, the k^{th} iteration; p_{id}^{k} is the individual extreme point position of the particle i in the j^{th} dimension, the k^{th} iteration; p_{gd}^{k} is the global extreme point position of the whole population in the j^{th} dimension, the j^{th} iteration; w is the inertia factor; 1c, 2 c is the study factor; 1 rand, 2 rand is the random number of [0,1]; i =1, 2…., m j =1, 2……., D. When the flight speed of the particle is small enough or reaches the presupposed iterations, the iteration will stop, and then output the optimal solution.

5.2 Adaptive particle swarm optimization algorithm:

The choice of inertia factor influences the convergence of the algorithm directly, which is the shoe pinches of PSO algorithm behaviors and properties. In order to avoid the example in the late of the algorithm appear "oscillation" near the global optimal solution easily, the inertial factor is made to change with adaptive value automatically, and its calculation expression is:

$$\omega = \begin{cases} \omega_{\max} - \dfrac{(\omega_{\max} - \omega_{\min})(f - f_{avg})}{f_{\max} - f_{avg}} & f > f_{avg} \\ \omega_{\max} & f < f_{avg} \end{cases} \tag{15}$$

$\omega_{\max}$, $\omega_{\min}$ is the maximum and the minimum of the inertial factor; f is the adaptive value of the particle; f_{avg} is the average adaptive value of every generation; $f_{\max}$ is the maximal adaptive value of the particle swarm.

5.3 Algorithm of PSO:

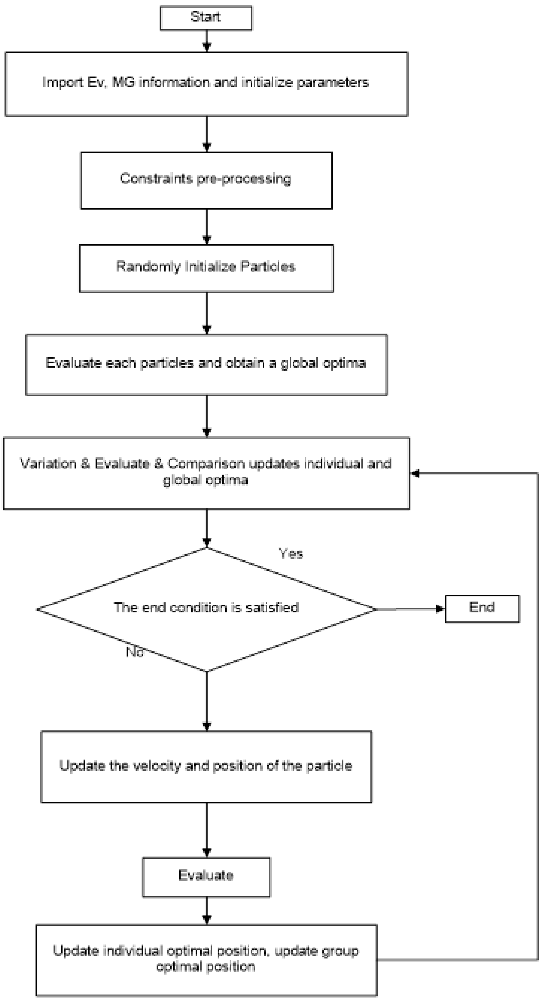


Fig 5.1: Flow chart of PSO

6. RESULTS

The following table represents base case profiles, only electrical vehicle placement and electrical vehicle placement after reconfiguration

Parameters	Base case	Only EV placement	EV placement after reconfiguration
Total Active losses	202.6771	221.9021	147.986
Total Reactive losses	135.141	148.7173	135.2833
EV placement	-	4 7 19 29 20	-
Optimal EV placement	-	-	24 27 18 2 9
Real power EV kw	-	117 117 169 201.5 78	110.5 143 299 110.5 78
Reactive power EV kvar	-	56.66 56.66 81.85 97.5909 37.77	53.517 69.258 144.812 53.517 37.77
Minimum voltage	0.91306	0.9063	0.97654

Fig.7.1: Base Case voltage profile.

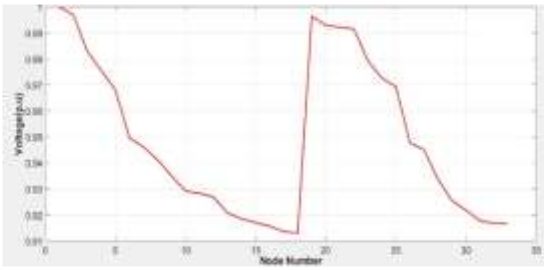


Fig.7.2: Only EV placement

Fig.7.3: Convergence graph.

Fig.7.4: EV Placement After reconfiguration

Fig.7.5: Convergence Graph After reconfiguration

As per results shown in the table when the EV's are connected simultaneously to the IEEE 33kv bus system it's observed that the total active losses and reactive losses are increased and also regarding in this condition the placement of EV's obtained with low losses and stable voltage is occurred. After the optimization techniques are applied such as genetic and pso optimization techniques when EV's connected to the bus system, the total active and reactive losses are reduced by these techniques and also obtaining the optimal EV placement of the IEEE 33kv bus system.

7. CONCLUSION

The position of the electric vehicle charging station may impact the properties of the distribution network, as well as the consumer's attitude because of investment and profit. Additionally, the placement of EVCS affects the choice of the EV user to charge. As a result, three perspectives are taken into consideration while examining research papers on the best places for charging stations: distribution network operator, charging station owner, and electric vehicle user. To identify the optimal placement for the charging stations, several studies published from the literature review have analysed and evaluated the formulation of the issue, techniques, objective functions, and limitations. This article also discusses the load flow process in distribution system and optimal placement of EV by optimization techniques. It also covers objective functions and constraints for problem formulation, EV load modelling, treatment of uncertainties and solution strategies. The authors also discussed optimization techniques for solving the problem, and they improved upon previous results by using the genetic and pso algorithms. Finally, this review article also analyses the effect of charging station load on the distribution network.

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