An Intelligent Algorithm an Approach for Distribution System Solution

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Abstract: The minimum loss reconfiguration trouble in radial distribution networks is one of the complex combination optimizations because it is difficult to accurately determine the open sectionalizing switches for the given network. The genetic algorithm serves best to achieve configurations with optimal actual losses in the test system. The proposed method can easily handle any complex system for an optimal reconfigured network. Through genetic algorithms, the paper primarily focuses on active losses and voltage drops. The test system calculations confirm the validity and productivity of the proposed methodology. The numerical results of the IEEE 33 bus test system are obtained through a MATLAB program

1 INTRODUCTION

India is a nation where people rely on power every now and then. In recent times de-regulated environmental extension of coal or resources used for resulting in increased demand is important to manage the electricity demand with various methods (G. Poorna Chandra Rao and P. Ravi Babu,2023)(Mulusew Ayalewet al.,2022). In other words, electricity is an important aspect of modern civilization. Usage of power in our homes, industries, etc. completes our daily life (Juan Wen et al.,2022),(Zhu et al.,2020),(Ravi Babu et al.,2017). The process of generating, transmitting, and utilizing that power is done in an actual way. This step-by-step process happens with some electrical losses to produce great efficiency in the power systems. In an aspect, these efficiencies will also get disturbed or reduced due to more electrical losses (S. Ganesh et al.,2016) (DusharlaVenkata Sunil et al.2017),(A.V Sudhakar Reddy et al.,2017) Due to that reduction, there will be a decrease in performance, an increase in maintenance, and other environmental consequences too. One of the optimal methods to reduce losses while distributing the power can be done by understanding and alleviating the power losses to attain sustainable energy conservation. In India, power losses are a significant factor, accounting for around 23% of distribution losses, which is why it is crucial to reduce them (Surender Reddy Salkuti,2019) (Zeba Khan et al,2017) (Sushma Pasunuru et al.,2017) (G. Poornachandra Rao et al.,2022). The purpose of this paper is to delve into the complexities of power losses, their causes, and their effects. Before getting into this topic, we aim to provide a comprehensive understanding of electrical losses and their objectives (S Arun kumar et al,2022) (G. Poornachandra Rao et al.,2021),(Kiran Mai B et al.,2018) We mainly focused on strategies for reducing distribution losses. The cause for these enormous is low network voltages that results in huge current and resistive losses (Ravi Baby P et al.,2020) (Duerr et al,2020).

Distribution channels in India are commonly radial distribution systems and in order to enhance but most effective way. Feeder reconfiguration is nothing manipulating the existing system using open switches credibility and wholesomeness, reconfiguration is the and closed switches to attain desired radial network.

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In this method of reconfiguration, the radiality of the system should be maintained for which mathematical formulas and several techniques are developed through which we can find out the amount of change in power loss. And some of the other techniques use Kirchhoff's laws to solve the distribution network loss calculations that requires closing all the open switches to form a mesh and then operating the closed switches to achieve radiality with minimum power losses(Neda et al &Guo et al.,2020).

Sushma Pasunuru et al, explained reconfiguration method under several real-time constraints and the reconfiguration strategy is modelled through a decision-making tree and tree search algorithm which increases the probability of finding the best switches to be operated for minimal losses. Ravi Babu has made an attempt by applying a genetic algorithm which is an artificial intelligence program where node population is initialized on the basis of natural selection.

The selection of a particular switch through this algorithm is done through operations; they are reproduction, crossover, and mutation. Using this algorithm, we can operate the switches efficiently and effectively. It is a great technique for searching for an optimum and global result for the problem respectively

2 GENETIC ALGORITHMS

The genetic algorithm (GA) is the process of natural selection and evaluation to discover the best response for a given problem respectively, and these groups of potential solutions can be called an individual which is represented as strings called Chromosomes or more likely genes. GA mainly depends on the natural selection theory which was founded by Charles Darwin. Natural selection gives us a deep explanation of how the genetic traits of any species change over a time period and that results in the formation of new distinct or unique species. GA is started randomly by initializing the population of individuals. As said before each individual is the potential solution, these will be evaluated on the basis of fitness which measures how well the individual performs for the optimization and those selected individuals will be sent for reproduction. These step-by-step iterations are called Generations. Three procedures/rules are primarily utilized in each generation to produce a new generation of the existing population. This involves selection, crossover, and mutation.

Selection: It is the process of selecting any two chromosomes from a given population.

Crossover: It is a mixing operation where any random two chromosomes are swapped with some crossover rate to form new individuals.

Mutation: It is introduced for small changes in the genetic algorithm for selected individuals respectively. It maintains diversity in the individuals and prevents premature convergence to sub-optimal and better solutions.

It is important to note that the above steps will be repeated iteratively until the termination criteria are satisfied and the final solutions can be extracted based on the fitness values. Fig. 1 shows the iterations of GA mainly in five steps i.e., calculating fitness, Selection, Mating, Crossover, and Mutation. At the final termination, a new population is created. These are the step-by-step processes for achieving a better solution for the previous population.

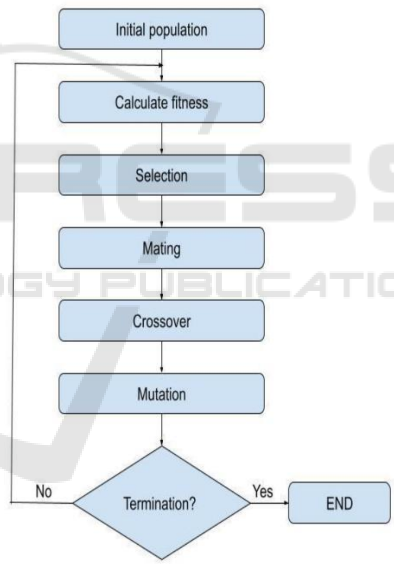

Figure.1. Basic Structure of GA

3 PROBLEM STATEMENT

The distribution system plays a significant role in the effectiveness and efficiency of electricity supply for Indian consumers. The main problem is the significant amount of power loss during the transmission and distribution process, which results in a loss of economy and efficiency of the power system, which is the primary problem. This work mainly focuses on proposed algorithms to enhance the performance of electric distribution systems(EDS) by reducing the present active power losses which are achieved through feeder reconfiguration.

The reconfiguration has to be made such that radiality in the existing system is not compromised and also voltages maintain certain distinctive levels.

The voltage in any given branch should be the level of:

$Vmin <= Vn <= Vmax$------ (1)

Where V_{min} and V_{max} are minimum and maximum permissible levels of voltages respectively, between which V_n is varying.

Across the next branch, the voltage can be calculated using eq.(1).

$V(n+1) = Vn - (i(b 〖n) * Zn)〗_$ ------ (2)

Where V(n+1)is the voltage found in the target branch, $i(b_n)$ is the current through the branch from sending end to target branch and Z_n is the impedance of the respective branch which is calculated with Resistance (R_n) and Reactance (X_n) at branch n of the network.

Equation(1) can be written in a generalized form as:

$|V(n+1)| = [B(j) - A(j)\ ]\hat{}(1/2)$ ------ (3)

Where,

$A(j) = P(n+1) * R(j) + Q(n+1) * X(j) - 0.5 * |V(n)\ |\hat{}2$ ------ (4)

$B(j) = \{ 〖A\hat{}2\ (j) - [R\hat{}2\ (j) + X\hat{}2\ (j)] * [P\hat{}2\ (n+1) + Q\hat{}2\ (n+1)]\}〗\ \hat{}(1/2)$ ------ (5)

It is very important to calculate load current which is given by the equation below:

$IL(n) = \sqrt{Pn^2 + Qn^2}$ ------- (6)

Where IL(n) is the load current of that branch, P_n is active load power and Q_n is reactive load power. Then the active power loss at a particular branch is given by:

$PL(n) = i(bn)\hat{}2 * R\_n$ ------ (7)

And,

$P(T) = \sum\_(n=0)\hat{}k\ p(n, n+1)$------ (8)

$P_{(T)}$ be the total active power loss.

4 TEST SYSTEM

Electricity network is a vital component of the electrical network, and the efficient distribution and transmission of electrical power is a crucial aspect of the network. The voltage regulation and stability of the power system are also a concern due to active power losses, which not only contribute to energy wastage but also impact its stability. These active power losses are caused by the resistive components in the distribution system. The test system aims to provide accurate results by evaluating different parameters and reconfiguration of lines for loss reduction. Fig. 2 provides us with the basic Radial 33 bus system/network which is a base case to us.

By applying the proposed technique on the given above standard 33 bus system, we get load current IL(n) using eq.(5) and the True power losses PL(n) at each branch respectively from eq.(6). The total active power losses at every branch of the system are calculated from eq(7) given above.

From the above-given figure.3 we can identify the process for working on the proposed method using GA. This process works in a loop of iterations until the desired results are obtained. By analyzing the given bus system in figure.2, the Tie switches available in the bus system enable us to reconfigure the distribution system in a way that is feasible. In the very first case, the system has to calculate the Active power losses for the base condition which helps to use as a reference to the next configured results. Taking the base case as a reference to check the optimal results, the system starts the iteration while it chooses the possible Tie switches for optimal reconfiguration of the distribution system and calculates the active power losses. Thus on comparing the obtained result with the base one, if it is within the range/limit from the base result then our method is satisfied for acquiring less active power loss. If not GA comes into the scene.

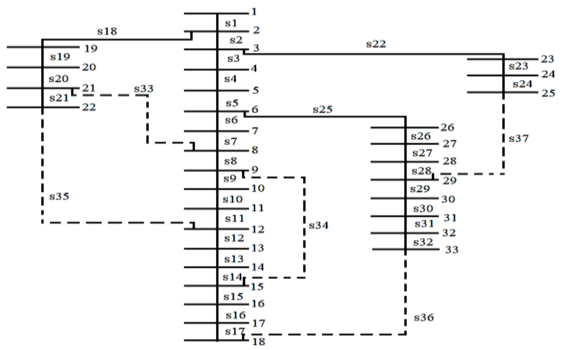

Figure.2. Basic 33 bus system

5 TEST SYSTEM RESULTS AND DISCUSSION

The IEEE 33 bus test system is considered a test system for real power minimization. The technique that was suggested was applied to this test system. This system consisting of five tie switches has a starting node voltage of 12.66 kV, base MVA-100, total true and reactive. 3715 kW and 2300 kVar respectively.

Before reconfiguration - The sectionalizing switches are S1 to S32 while the tie switches are S33 to S37. Both types of switches are used to section. For this combination, the power losses acquired are as follows 202.6771 kW- real power loss, 135.1510 kVar- reactive power loss, 243.6 kVA- apparent power loss.

After reconfiguration- S29, S33, S34, S35, and S37 are used to obtain the optimal configurations by using the rest of the sectionalizing switches (represented by dotted lines) shown in the figure.6 given below. For this configuration, the resulting losses are 109.6065kW- real power loss, and 78.031 kVar- reactive power loss, and 134.5495 kVA apparent power loss. The resultant power losses are 46% less than the previous network.

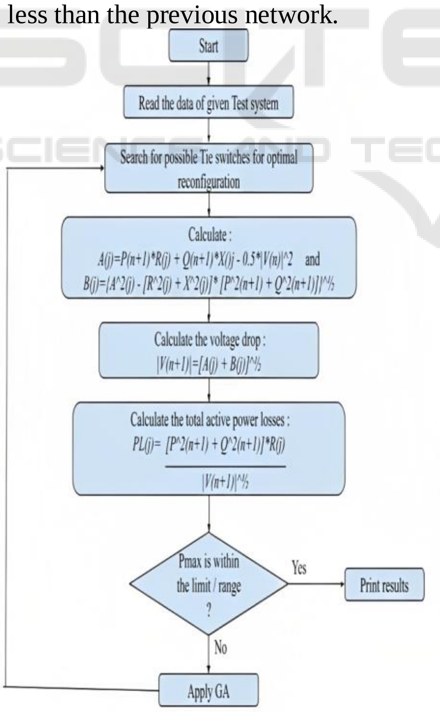

Figure.3. Flowchart of working of the proposed method

The proposed method is coded using MATLAB version R2017 for power flow calculations, GA is carried out with the best results as shown in Table 4.

Table 1: Results Validation for 33 Bus Test System

Method	**Tie Switch**	**True Loss (kW)**	**% of Loss reduction**
Proposed Method	S29,S33,S34,S35, S37	108.2062	46.5816
J.Z.Zhu [4]	S7,S9,S14,S32,S33	139.532	31.1555
MajidJamil et al. [6]	S2,S13,S16,S33,S37	112.68	44.4041
Firas M.F.Flaih et al. [7]	S7,S9,S14, S32,S37	139.55	31.1466
Poorna Chandra et al [19]	S29,S33,S34,S35, S37	109.6065	45.9206

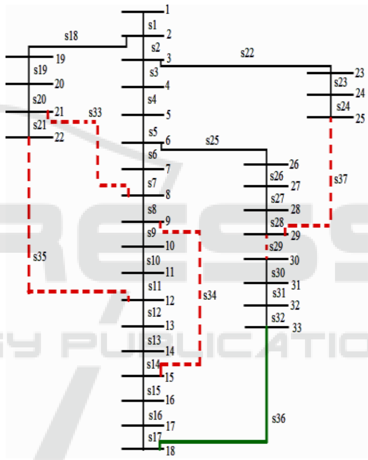

Figure.4: 33 Bus Optimal Reconfiguration system

6 CONCLUSIONS

The reinstatement and minimization of Ohmic losses in the electrical power distribution system are the two main objectives of this paper. A Genetic Algorithm techniques is applied on standard IEEE 33 bus test systems to achieve the optimal solution for Ohmic loss minimization minimizing the Ohmic losses and these Ohmic losses are reduced to 46.5816% and found good among when compared to other authors relevant work

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