DISTRIBUTION SYSTEM RECONFIGURATION FOR IMPROVEMENT IN LOAD BALANCE AND SERVICE RESTORATION USING ARTIFICIAL ANT COLONY OPTIMIZATION

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Abstract

Electrical distribution companies are attempting to make strides load balance and service restoration. These three are the most and major components faced by electrical engineers in electrical distribution system. To achieve these objectives, distribution system reconfiguration (DSR) is one of the most intelligent key to progress these two components. In this paper artificial ant colony optimization (AACO) is used for tackling the distribution system reconfiguration with the goals of these two components within the nearness of limitations. The viability of the proposed strategy is illustrated on IEEE three feeder load balance and IEEE four feeder service restoration from this strategy ideal solutions have been obtained.

Keywords*—Electrical Distribution System (EDS), Distribution System Reconfiguration, Artificial Ant Colony Optimization (AACO), Load Balancing Index (LBI), Probabilistic Transition Rule (PTR).*

I. INTRODUCTION

The distribution system is electrically associated between the utility and the customers, where sectionalizing and tie switches are utilized in order to achieve both protection and make changes within the configuration of electrical distribution system. These are the two types of switches that made more productive by reconfiguring distribution system with regard to the variation in load demand. The sectionalizing switches are ordinarily closed condition and tie switches are in the open condition.

In electrical distribution system load should be in balanced condition something else it may create overburden issue, because of overloading the voltage within the system will drop, this lead to more loading on feeder compared with feeder loading capability restrain (i.e. Warm Limits). At last, the overburden feeder (or) over current carried conductor harmed (i.e. open circuited)[1].The service restoration is major view point of reliability, this can be considered in as it were unusual conditions. This may give way better persistent power supply to loads but may not fulfill the 100% power supply. Change in load balance and service restoration are given superior investment utilization as well as progressed service quality (i.e. reliability, continuity of power supply to the loads[2].

In this paper, reconfiguration of distribution system has been defined by utilizing Artificial Ant Colony Optimization method [3]. This strategy provides the solution to nonlinear issues, diminishes time utilization and gives precise results. This method is co-related with EDS as current matches with ant's movement, pheromone intensity matches with power stream and length of the line with resistance or time utilization. Two destinations are met, to begin with one is load balance and moment one is service restoration. The proposed work is organized into six areas, to begin with area 1 is introduction, area 2 on problem formulation, area 3 talks about proposed strategy calculation for reconfiguration, and area 4 discusses proposed method applications on test systems. Area 5 on results and finally conclusions are in the area 6. The design of the vast majority of the electrical distribution system of all the related defensive gears is spiral in nature. As load balancing index is diminished other than any confinement restriction diminished other than any confinement, ideal working condition can be acquired [4]. The normal for every single burden fluctuates as the loads are a blend of local, business and the industrial loads and their separate pinnacle esteems won't be the equivalent. This is because of certain pieces of the system are exceedingly stacked at specific terms and softly stacked at some other point intervals [5]. Along these lines, the loads can be adjusted by moving them so that the spiral structure of the system can be changed effectively to lessen the load unbalancing [6]. Numerous endeavours have been made to take care of the issues of the distribution network. These preliminaries of research can be fundamentally separated into standard and Artificial intelligence based methods. The customary strategies are the experimentation techniques and the traditional optimization techniques. Merlin *et al [*7] presented a technique where they have defined the issue for distribution network reconfiguration as blended whole number nonlinear optimization issues. It was understood through a different and unmistakable branch and bound technique. Further, extraordinary branch trading type experimentation techniques were advanced by [8-12]. As the new distribution systems are increasing in size, the trouble of the reconfiguration is additionally improving. In this way, the experimentation strategies are unfit to give great arrangements. Subsequently, the redirection towards different stochastic-based methods, for example, usage of Genetic Algorithm for reconfiguration occurred [13]. Later on, a few comparative techniques came into training for the system reconfiguration. Another system used to be figured the use of Genetic algorithm nearby with fundamental circles. Be that as it may, this limited the inquiry space of Genetic algorithm via changing the genetic operators. Enacheanu etal. [14] displayed a technique which was once fundamentally dependent on Genetic evaluation with graph theory.

II. PROBLEM FORMULATION

2.1 Load Balance

First, distinguish the over burden feeder, then distinguish the capacities of neighboring feeder and then calculate the meager load at that point reconfigure the system, in the event that any feeder overburden after reconfiguration go for load shutdown otherwise do calculation of LBI subjected to over limitations.

Least LBI infers to kept up great load balance with in the system (i.e LBI is zero then 100% load balance within the system.

$$LBI = \frac{1}{n}(\sqrt{\sum(Y-Yi)^2} \quad \text{-------------} (1)$$

n = no. of primary feeders

Y = average of the normalized loadings Yi

$$Yi = \frac{\text{ith}-\text{feederactualloading}}{\text{ith}-\text{feederbaseloading}}$$

Subjected to following constraints:

$S_i<S_{Ri}$

$P_i<P_{Ri}$

$Q_i<Q_{Ri}$

Where: i=1, 2, 3….n; n= no. of primary feeders

S_i =MVA loading on feeder - i

S_{Ri}=Rated MVA on feeder - i

P_i=MW loading on feeder - i
P_{Ri} =Rated MW loading on feeder - i
Q_i =MVAR loading on feeder – i
Q_{Ri} =Rated MVAR on feeder

2.2 Service Restoration

First identify faulted feeder, isolate the fault identify the affected zones due to fault, which are out of service (healthy zones).Reconfigure system and do calculation of LBI subjected to above constraints.

In each and every reconfiguration load should be maintained in balance condition, critical parameters and radiality with in permissible limits. Among all possible combinations which one gives least LBI value and satisfies all critical parameters that is the optimal solution for both A and B cases.

III. ARTIFICIAL ANT COLONY OPTIMIZATION (AACO)

This method gives solution to nonlinear issues related to any field of work. Natural living behavior of ants gives ideal solution either a negligible or a maximal of primary objective of issue is called Ant Colony Optimization.

When an ant moves to explore for food from home to food source it deposits chemical substance on ground called as pheromone. This substance could be a clue for other ants from the same domestic to gather the nourishment. Ants take after the pheromone trails cleared out by the primary ant. From home to food source the ants have a few ways with variable pheromone trails. Among those trails ants select higher pheromone concentric way. This way is also attracted by remaining ants. Continuously ants favor most brief way (i.e. higher pheromone intensity).

Below figures.2 and 3 represent ant colony system without and with obstacle. Thicker line demonstrates higher pheromone escalated as a shortest way, more slender line shows less pheromone escalator as a longer path.

The ACO is described as the probabilistic method which is used for the solving of the combinatorial troubles and it is typically referred as very populated Meta-heuristic method. In the above method each solving way is entitled via an ant operation in the area. The supply of the creativity for ant colony optimization is performance of the ants in recognising the most feasible way from it food to nest and vice- versa. That made feasible by the means of their performance of placing chemical substances regarded as the pheromones.

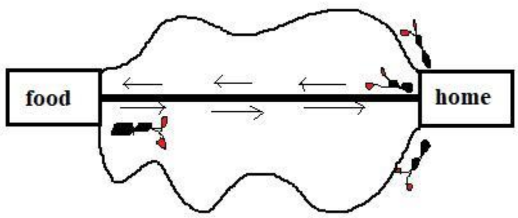
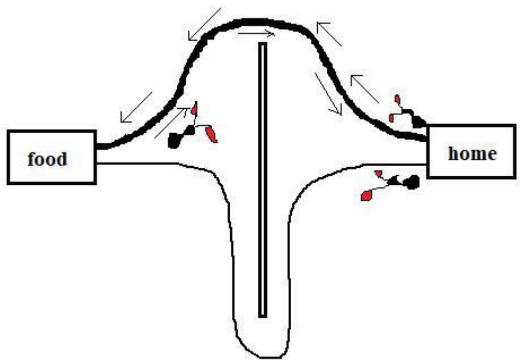


Figure 1: Natural Behavior of Ant without Obstacle

Figure 2: Natural Behavior of Ant with Obstacle



In electrical distribution system, n= number of switches and the total possible number of combinations for reconfiguration are 2^n. In order to reduce the time of consumption for all the possible reconfigurations ant colony optimization itself has probabilistic transition rule (PTR).PTR measures the probability of an ant for choosing a path among all possible paths. For example when a system has some ten switches then total number of possible combinations for distribution system reconfiguration are

$$2^{10} = 1024$$

By using PTR this can be reduce to ten possible combinations for reconfiguration and gives the most optimal solution.PTR is formulated as below equation

$$P_{i,j}{}^{k}(t) = \frac{[\tau_{i,j}(t)]^{\alpha}[\eta_{i,j}(t)]^{\beta}}{\sum[\tau_{i,j}]^{\alpha}\,[\eta_{i,j}]^{\beta}}$$

Which will be visited to avoid stagnations .i, j is the travel path of ants.
$t_{i,j}$=pheromone trail deposited between the nodes i, j.
$h_{i,j}$=represents the heuristic information.
$d_{i,j}$= distance between city i and j.
α, β =Are two parameters that influence the relative weight of pheromone trail and heuristic guide function respectively?
After each tour is completed a local pheromone is updated.
It isthe sum of old pheromone intensity ($\rho\tau_{i,j}(t)$) and new pheromone intensity ($\Delta\tau_{i,j}{}^{k}$)

$$\tau_{i,j}(t+1) = \rho\tau_{i,j}(t) + \Delta\tau_{i,j}$$

$$\Delta\tau_{i,j} = \sum \Delta\tau^{k}{}_{i,j}$$

Where:
t =iteration counter;
k= 1, 2….l ants ;
Q=constant;
L_k =length of tour.

Figure 3: Flow chart for Service Restoration

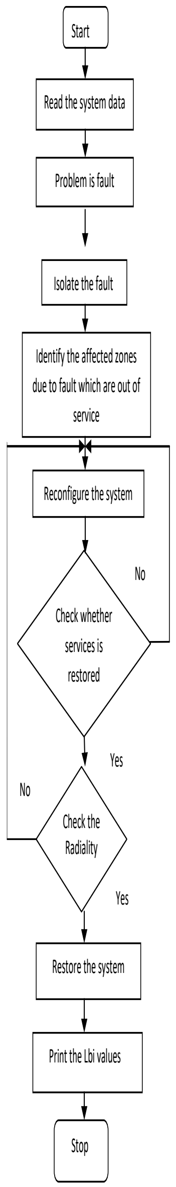
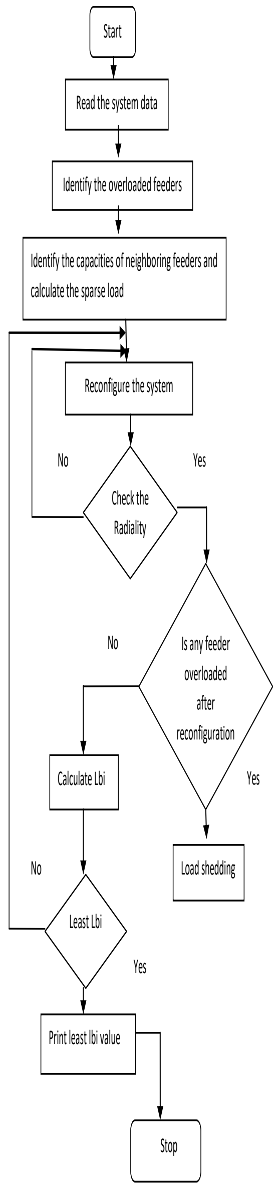


Figure 4: Flow chart for Load Balance



VI. PROPOSED METHOD

Three feeder load balancing the planned AACO methodology is tested on IEEE 3 feeder load balance and IEEE four feeder service restoration. The results are as follows.

4.1 IEEE THREE FEEDER SYSTEM

A)Test System-1:

The planned technique was applied to IEEE 3 feeder system , during this distribution system has totally sixteen branches
among, thirteen switches are sectionalizing switches(i.e. straight lines) remaining three

are tie switches(i.e. dotted lines).Each feeder loading capability is 15MVA.

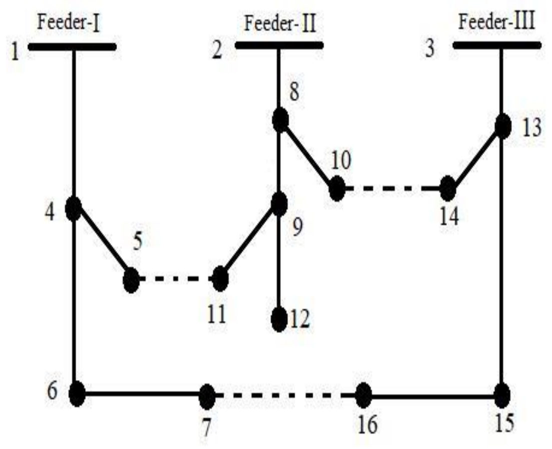


Figure 5: IEEE three feeder test system

Before reconfiguration: The feeder-I loading is 9.912618MVA, feeder-II loading is 17.426990 MVA and feeder-III loading is 6.185466. Feeder-II is overloaded by 2.426990 MVA, Tie switches are 5-11, 7-16 and 10-14.

After reconfiguration: The feeder-I loading is 10.5973 MVA, feeder-II loading is 11.0947 MVA and feeder-III loading is 12.068 MVA. Among all possible combinations, all feeders are in balanced condition, least LBI value 0.027953 achieved by Optimal Tie switches 8-10, 11-9 and 7-16.

TABLE.1: IEEE three feeder load data

From bus to bus	R(ohm)	X (ohm)	End bus load (MW)	End bus load (MVar)
1-4	0.075	0.10	2.0	1.6
4-5	0.08	0.11	3.0	1.5
4-6	0.09	0.18	2.0	0.8
6-7	0.04	0.04	1.5	1.2
2-8	0.11	0.11	4.0	2.7
8-10	0.08	0.11	5.0	3.0
8-9	0.11	0.11	1.0	0.9
9-11	0.11	0.11	0.6	0.1
9-12	0.08	0.11	4.5	2.0
3-13	0.11	0.11	1.0	0.9
13-14	0.09	0.12	1.0	0.7
13-15	0.08	0.11	1.0	0.9
15-16	0.04	0.04	2.1	1.0
7-16	0.04	0.04		
5-11	0.04	0.04		
10-14	0.09	0.11		

4.2 IEEE FOUR FEEDER SYSTEM

B)Test System-2: The recommended AACO procedure is tried on IEEE four feeder test framework (figure.6), in this 16 sectionalized switches are by and large in closed condition(between zone loads example-switches 2,3,4…) and 15 tie switches are for the most part open condition(between zone loads of distinctive feeders example-switches 6,7,8…). Each feeder loading capability is 10,000 kVA.1, 11, 21, 31 are the circuit breakers of four feeders within the framework. TABLE 2 appears the zone loads. Service restoration is like one among the most vital for Distribution system..Whenever the fault happens in the allotted distribution networks, the strained section of the system to be minimal. During the present direction of work, the portion of healthy part of the present system gets de stimulated. Service restoration is utilized to resupply the ability to those de-invigorated burdens. Prior, because of the little size of distribution system, i.e. no uniform strategies to fix the system were shaped. As estimation of the system expanded, the inconvenience put through via operators expanded, re-establishing the system in less time used to be the fundamental endeavour.

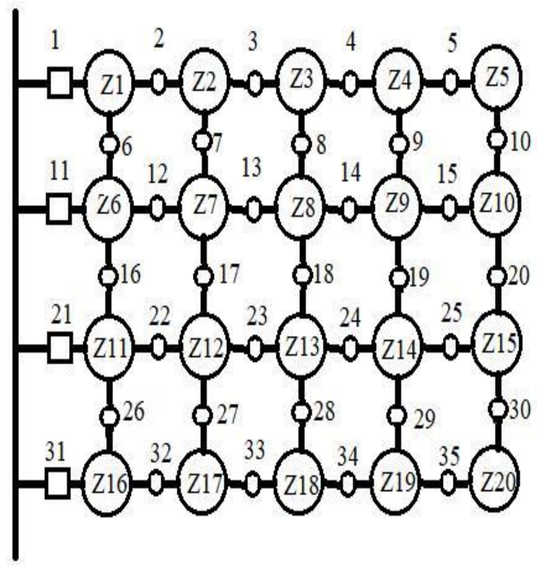


Figure 6: IEEE Four Feeder Test System

From fig.6, each feeder capacity is 10000 kVA and actual load on feeder A, B, C and D are 6500 kVA, 4300 kVA, 8800 kVA, 7300 kVA respectively.

Fault on feeder B at position Z8 Because of fault, faulted section is separated by opening switches 13 and 14.discarded load on feeder B is 2300 kVA.

Before reconfiguration: Load on feeder A is 6500 kVA, feeder B is 2000 KVA, feeder C is 8800 kVA, feeder D is 7300 kVA.

After reconfiguration: Switch 10, 20 are in closed condition (sectionalized switch) and switch 15, 25 are in open condition. Load on feeder A is 7900 kVA, feeder B is 2000 kVA, feeder C is 8200 kVA, feeder D is 7300 kVA.

V. RESULTS

Three feeder load balancing:

The results of the distribution system reconfiguration using artificial ant colony optimization for load balancing for IEEE three feeder system using c programming is listed in the table 3 and comparison values are listed in table 4.

Four feeder service restoration:

The results of simulation for reconfiguration of distribution system based on AACO for IEEE four feeder test system service restoration for a fault is done at zone8and the consequences are shown in the table 5.

Table.2: IEEE four feeder load data

ZONE NUMBER	ZONE LOAD(KVA)
1	1600
2	700
3	1800
4	500
5	1900
6	500
7	1500
8	1000
9	500
10	800
11	3000
12	3500
13	700
14	1000
15	600
16	1500
17	2000
18	1800
19	1500
20	500

TABLE.3: Switches and LBI values

SNO	TIE SWITCHES	LBI VALUE
1	5-11,7-16,10-14	0.1799
2	9-11,8-10,15-16	0.0499
3	9-11,8-14,7-16	0.1697
4	9-11,8-10,7-16	0.0235
5	4-6,8-10,10-14	0.0584

TABLE. 4: Comparison of results with other methods

Method	LBI value of 3 feeder system
Proposed system	0.0235
S. Civanlar	0.2416
P. Ravi Babu et al[17]	0.1583
P. Ravi Babu et al[18]	0.112

FAULT	ZONES ADDED TO OTHER FEEDERS	LBI VALUES
AT Z8	Z9- FI,Z10-FIII	0.1386
	Z9,Z10-FI	0.1319
	Z11,Z12,Z13,Z14,Z9-FIII Z15,Z10-FIV	0.13676
	Z10-FI, Z9-FIII	0.13547
	Z10,Z15-FI,Z11,Z12,Z13,Z14-FIII , FII,FIV are same	**0.1266**

Table. 5: Results of four feeder system under faulty Conditions at ZONE 8

CONCLUSION

Load balance and Service restoration are the main objectives in distribution system in this paper. IEEE three feeder system is balanced by the proposed technique and the LBI values are compared with other techniques and the least value is obtained.

Service restoration on the IEEE four feeder system is done for the fault at zone 8 and optimal value of LBI is obtained. The reconfiguration of electrical distribution system is obtaining a very reasonable value in phase of the modern distribution systems (DS). In this situation electrical distribution system reconfiguration has attained a significant importance very fastly. In suggested method, Ant Colony Optimization, the modern method in the meta-heuristic procedure, is a procedure based on population, is suggested for balancing the load through reconfiguration. To avoid obtaining results which are not appropriate for our problems, some rules are to be followed which are proposed by artificial ant colony optimization (AACO). Test outcomes are showing that obtained results by following this method are optimal values compared to the other methods. LBI value is minimized to a value of 0.0235 for a 3 feeder, 16 bus test system and the LBI value for the service restoration on IEEE 4 feeder test system is reduced to 0.126614. The results thus obtained shows an optimistic algorithm for distribution system reconfiguration. It can be used to reduce the load unbalance in the system and the restoration of service is done for the system where the system has no faulty conditions.

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