A Novel Improved Particle Swarm Optimization Frame Work for Reconfiguration of Radial Distribution System

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Abstract—**Electrical feeder reconfiguration performs a crucial task in operating the topological formation of distribution feeders by varying the open/close condition of the switches in each normal and abnormal working environments. In the present paper an Improved Particle Swarm Optimization (IPSO) strategy are developed for distribution reconfiguration problem. The network reconfiguration has been carried out by employing a 33 bus radial distribution system for normal standard situations and condition in the occurrence of the fault. The Improved Particle Swarm Optimization (IPSO) approach has conveyed considerable minimization of real power losses in the time of normal situation of operation. During occurrence of fault the reconfiguration process could enhance the quantity of load centers provided and thus the whole load. It could be clearly determined that the proposed approach conveys an enhanced performance.**

Keywords— IPSO, 33 Bus Radial Distribution Systems, Reconfiguration

I. INTRODUCTION

The present power distribution systems because of the developing difficulties it is turning into vital to automate the tasks that are done physically or need some kind of human intercession. Automation of distribution system is one among the preference areas for electrical utility companies. It is accepted proven fact that a major amount of energy originated by the power plants is vanished because of transmission and distribution losses and the particular losses occurring in the distribution network add up to pretty much 40% of the overall losses[1].Network reconfiguration area is one among the critical region during which distribution automation is being connected. In primary distribution system there are two categories of switches utilized; sectionalizing switches (usually closed) and tie switches (regularly open). Generally it is expressed that in the strategy for system reconfiguration the topological setup of the distribution system is changed with the help of tie and sectionalizing switches. The power transmitted by the substation is provided to the loads progressively influences the effectiveness of the system configuration. In order to supply power to the target centers at minimum deficiency power utility companies venture to search out the better optimum configuration.

In the course of normal operation there are two important reasons why the network may have to be reconfigured:(i) load balancing and (ii) loss reduction. To determine the load balancing reconfiguration is adapted depending on the contemporary loading circumstances to get rid of overburdens on line segments or particular segment of the distribution systems and on the condition of loss reduction the reconfiguration is performed to cut down the real power losses within the system. However supporting effective state of fault the system reconfiguration is done to separate the fault and reestablish the service to the unaffected region within a very short time. In the same approach on account of cataclysmic events like surge, the fault identification system recognizes the feeders that are influenced and after that system reconfiguration is made by detaching the influenced feeders and reestablishes the supply to the unaffected systems. In this paper Improved Particle Swarm Optimization (IPSO) algorithm is anticipated to be utilized to automatically reconfigure the feeder for loss reduction within the network and restoration of supply throughout faulted situation. Owing to that total vary of candidate- switching connection, finding the operating network reconfiguration turns into a difficult combinatorial, non-differentiable awkward optimization problem. The feasible connections of switching range during a typical configuration network are often given as 3^m; here '*m*' is the overall range of tie switches inside the network. However all the exchanging switches do not appear to be plausible because of operational requirements and it would like an extended time for calculation of line losses. Normally the radial requirement and discrete nature of the switches inhibits the usage of established strategies to tackle the reconfiguration issue.

Reconfiguration of distribution network for loss decrement was initially projected by Merlin and Back [2]. In this the negligible-loss operational configuration for the distribution network describing a spanning tree structure at a selected load circumstance is determined by using a mix of optimization and heuristic methods. A heuristic algorithm with branch and bound form has been indicated by [3] where a basic formula was formed for purpose of amendment in power loss as a result of a branch exchange. Shirmohammdi and Hong [4] utilized ideal power flow approach for reducing the losses by the assist of system reconfiguration. Baran and Wu [5] utilized

heuristic way to deal with diminish the search for choosing the switching choices and anticipated an algorithm to recognize the branches to be changed. Goswami and Basu [6] introduced a minimum loss configuration methodology by deploying a heuristic algorithm rule that is based on optimum flow pattern and this is achieved by opening a closed switch and additionally by closing a usually opened switch in iterative process. McDermott, Drezga, and Broadwater [7] utilized a target function that characterized as the ratio of incremental losses to incremental load supplied and proposed a heuristic constructive algorithm in which switches is opened at every progression and therefore the switch that created least increment within the function was closed. Researchers have developed Genetic Algorithms (GA) [8], fuzzy-GA [9], Particle Swarm Optimization (PSO) [10], Hybrid Evolutionary algorithm [11], Harmony Search Algorithm [12], and Bacterial Foraging Algorithm [13] to solve reconfiguring distribution system complications for the reduction of losses.

In this paper reconfiguration of distribution system have been formulated by utilizing Improved Particle Swarm Optimization (IPSO) with associate objective to decrease losses and improving the loads supplied. At first the utilizations of improved particle swarm optimization is employed in hydro dynamic designs, Android medical care IoT, solving traveling salesman issue and in unit dedication problem. The standard PSO has a conduct to get caught in local minima and maxima, so as to avoid this anew advance for updating the velocity and the position of the particles are formulated during this work. The network reconfiguration has been implemented with a 33 bus radial distribution system and also the outcomes are correlated among those applicable within the literature. This paper is organized into four sections, the primary of that is introduction. Section II discussed on proposed algorithm for reconfiguration. Section III present results of 33- bus system for both normal case and fault condition. Finally, we tend to provide our conclusion in section IV.

II. IMPROVED PARTICLE SWARM OPTIMIZATION ALGORITHM

In the field of swarm intelligence, Particle Swarm Optimization (PSO) is one of the spearheading methods. PSO was formulated beneath the stimulation of performance laws of human associations, bird flocks and fish schools, it was first to be employed in 1995 by Eberhart and Kennedy [14]. PSO don't utilizes operators has mutation, cross over and selection, like Genetic Algorithm (GA) which is one of the population based approach. The population optimization is done during data interchange along with individual elements of the population. It begins its approach by arbitrarily choosing from a bunch of arrangement and after that searching it iteratively. PSO could be a meta-heuristic algorithm and have minor or no suppositions concerning the issue being enhanced and is competent of searching very massive spaces of candidate solutions.

In its fundamental variant PSO algorithm characterizes a population specified by swarm of candidate solutions specified as particles. These particles travel around the search space and the own best identified position inside the search-space in addition to the whole swarm's best identified positions are influenced by the action of the particles inside the search space. The motion of the swarm is monitored by the better position. This strategy is replicated with a presumption that an acceptable solution can finally appear.

In PSO, clarification for each optimization issue is taken within account as a bird in the searching space and it is specified has "particle". Each particle has a fitness rate that is decided by target functions and it has additionally a velocity that concludes its destination and distance. In the solution space all particles will look for their optimum positions and furthermore the positions of the optimum particles in the swarm. PSO primarily arranges a bunch of random particles (random solutions), and next during repeated searching assets the optimum solution. In each repetition the best position recognized with a particle is termed p_{best}, in the same way the best position known with the entire swarm is called g_{best}. For each particle id, the velocity and its position are reorganized as

$$V_{id'} = \alpha V_{id} + \gamma_1 rand\,() \,(P_{idb} - X_{id)} + \gamma_2 rand\,() \,(P_{gdb} - X_{id}) \quad (1)$$

$$X_{id'} = X_{id} + V_{id'} \quad (2)$$

Where, ω is termed has inertia weight, it is a proportion factor so it is concerned with former velocity, $0 < \alpha < 1$, γ_1 and γ_2 are constants and are called accelerating factors, normally $\gamma_1 = \gamma_2 = 2$, $rand\,()$ are random numbers, X_{id} indicates the position of particle id; V_{id} indicates the velocity of particle id; P_{id}, P_{gd} indicates separately the best position particle id has found and the position of the best particles in the entire swarm.

The convergence speed of particles is vital in event of run of typical PSO; however there is a really high plausibility of the solutions being caught in local maxima or local minima. In vary by the access for velocity and position updating, if a specific particle is caught in local maxima or minima there is likely hood that the entire swarm could likewise be caught. So as to stay away being caught into a local optimum, the anticipated improved PSO follows a new data allocation method. It is often bound to raise the global searching space of particles and facilitate them to keep away from being caught into a local optimum too early. This will additionally develop the chance of searching g_{best} inside the search space. In this new approach, the particle velocity and position renewal formula are as follows:

$$V_{id'} = \alpha V_{id} + \gamma_1 rand()(X_{id} - P_{idw}) + \gamma_2 rand()(X_{id} - P_{gdw}) \quad (3)$$

$$X_{id'} = X_{id} + V_{id'} \quad (4)$$

Where the worst position particle id found is given by P_{idw} and the worst position of the whole swarm has found is given by P_{gdw}.

The flow of the IPSO is as follows:

Step 1: Random initialization of velocity and position of particles ;

Step 2: Evaluation of fitness of each particle;

Step 3: For each particle if the fitness value is lesser than the best fitness value P_{idb} then renewing the best position P_{idb} ; or else if its fitness value is larger than the worst fitness value P_{idw} , renewing the P_{idw} ;

Step 4: For each particle if the fitness value is lesser than the best whole swarm fitness value P_{gdb} , renewing the best fitness value P_{gdb} of particle id ; or else if larger than the worst whole swarm fitness value P_{gdw} , renewing P_{gdw} ;

Step 5: For each particle,

- Generating new particle t by updating the position and velocity mentioned in (1) and (2)

- Generating new particle t' by updating the position and velocity mentioned in (3) and (4)

- Making a comparison between t and t', then choosing the better one into the next generation;

Step 6: Producing next generation particles according to the above genetic selection strategy;

Step 7: Checking for stopping criteria if satisfied terminating the operation or else returning to step 3

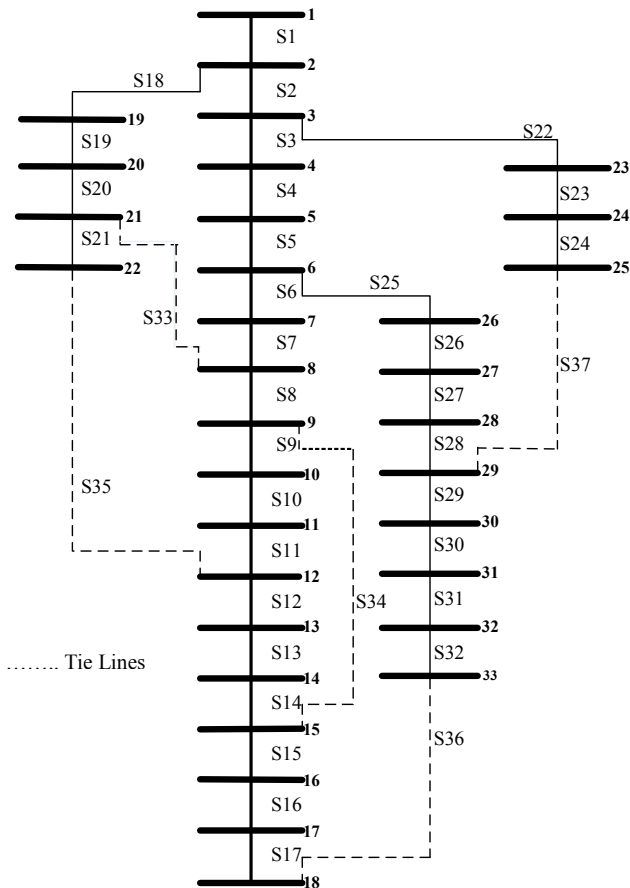*A. IEEE 33 Bus Distribution System*

Fig. 1. Single Line Diagram of IEEE33 Bus System

The base design of the framework has a single supply point with 33-buses, 3 laterals, 37 branches, 5 loops or tie switches which are kept generally open and is closed to vary circuit resistance for decrease of losses or can be closed just during fault condition to support uninterrupted supply. The line diagram of the system is illustrated within the Fig. 1.The entire real power for base configuration is 3715 kW, 2300 kvar with a real power loss of 202.67 kW [12]. The superior voltage limit is 1.0 p.u and inferior voltage limit is 0.9 p.u. The power flow is computed with Newtons-Raphson method. The load model is employed with an unvarying constant power for simulation and voltage of primary bus is 1.0 p.u. In the network sectionalize switches (usually closed) are represented from 1 to 32 and tie switches (regularly open) are represented from 33 to 37. The particulars of the 33 bus system are summarized in the Table I.

TABLE I.   DETAILS OF 33 BUS DISTRIBUTION SYSTEM

Number of Buses	33
Number of Branches	37
Number of Tie Lines	5
Tie Lines	S33,S34,S35,S36,S37
Total Real Power	3715 Kw
Total Reactive Power	2300 Kvar

III. RESULTS AND DISCUSSION

In order to express the proposed method IEEE 33 bus system is taken into consideration. The method is coded using Matlab Version R2011b is use to run the optimal power flow solver with Newton-Raphson method. The iteration settings for PSO embrace 100 maximum numbers of iterations, with acceleration constant of 2 and 2.5 and maximum and minimum inertia weights at 1 and 0.2 respectively. The maximum and minimum velocity of particles is fixed at 0.9 and 0.4 respectively. The simulations are implemented in a system having Intel i5 Core processor cloaking a speed of 2 .7GHz with a RAM of 6GB .IPSO is carried out and the best of the results of 20 trail runs are given in this section.

Case 1: Normal case

The original configuration represented in Fig. 1, for this one the usually open switches are S33, S34, S35, S36 and S37 with original real power loss is 202.6 kW. The proposed algorithm configures the network for the base case and recommended a new configuration, according to this configuration, the tie switches are S2, S13, S16, S33, and S37. For this configuration the real power loss accomplished by the system falls to 112.68kW adding up to a diminishment of 44.40 %. The outcome of the reconfiguration is represented in the Table II.

It is additionally noted that minimum voltage profile enhanced to 0.9234 after reconfiguration condition while at

before reconfiguration it is 0.9107. The change is seen at node 18 as represented in the Fig. 2.

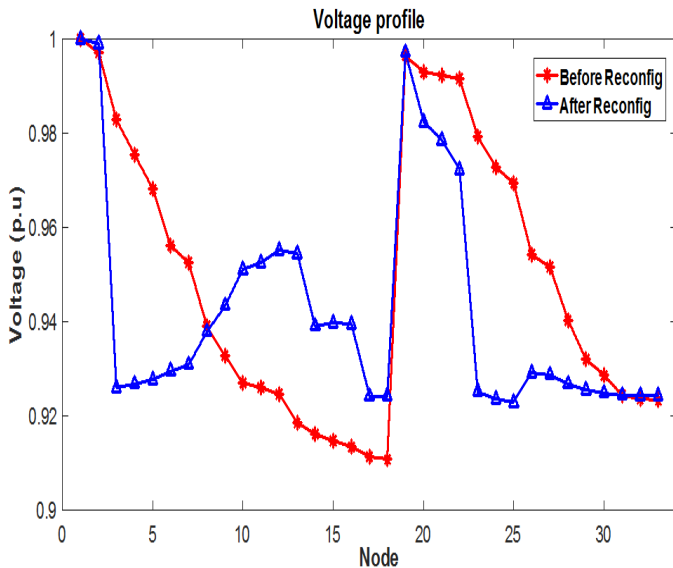| Base Case	Tie Switches	Real Power Loss (Kw)
Before Reconfiguration	S33, S34, S35,S36,S37	202.67
After Reconfiguration	S2, S13, S16, S33, S37	112.68

Fig. 2.   Voltage profile plot before and after reconfiguration

The proposed method is examined among the methods projected by Goswami [6], Mcdermott [7], R. Srinivasa Rao [12] and Tamer M. Khalil [15] for the similar 33-bus test system. The results of the proposed method along with other methods for the efficient assessment it is specified in Table III. The decrease of real power loss by reconfiguration has indicated significant reduction and marked change when assessed to the alternate methods.

TABLE III.   COMPARISON WITH OTHER METHODS

Method	Tie Switches	Loss After Reconfiguration (KW)	% Reduction in Loss
Proposed	*S2, S13, S16, S33, S37*	*112.68*	*44.40*
Goswami [6]	S7,S9,S14,S32,S37	136.59	32.6
Mcdermott [7]	S7,S9,S14,S32,S37	136.59	32.6
R. Srinivasa Rao [12]	S33,S14,S8,S32,S28	135.78	33.1
Tamer M. Khalil [15]	S7,S9,S14,S32,S37	136.59	32.6

This proposed method consolidated the power loss by 44.40 % when contrasted with the original network. The change in loss reduction is more than 11.8 % what is accounted in the literature reviewed.

Case 2: Fault case

In order to verify the execution of the proposed algorithm under the state of fault, a fault is assumed at Node 5 (showed in red in the Fig. 3.). To disconnect the fault and to manage the continuous supply to the other nodes without violating the system conditions, the network needs to be reconfigured. The faulty node is detached by opening the switches that associate with the node. During this case S4 and S5 are opened to isolate Node 5. Indeed, even under this condition it is prerogative to supply power to the other nodes at minimum loss. The proposed algorithm configures the network for fault case and advised another configuration, as per this configuration, the tie switches are S7, S9, S14, S32, and S37. It can observed that beside from S37   all alternative ties switches within the initial configuration like S33, S34, S35 and S36 are closed to assign power to other nodes   in accordance with the changed topology. For this changed configuration the real power loss remains at 138.9275 KW.
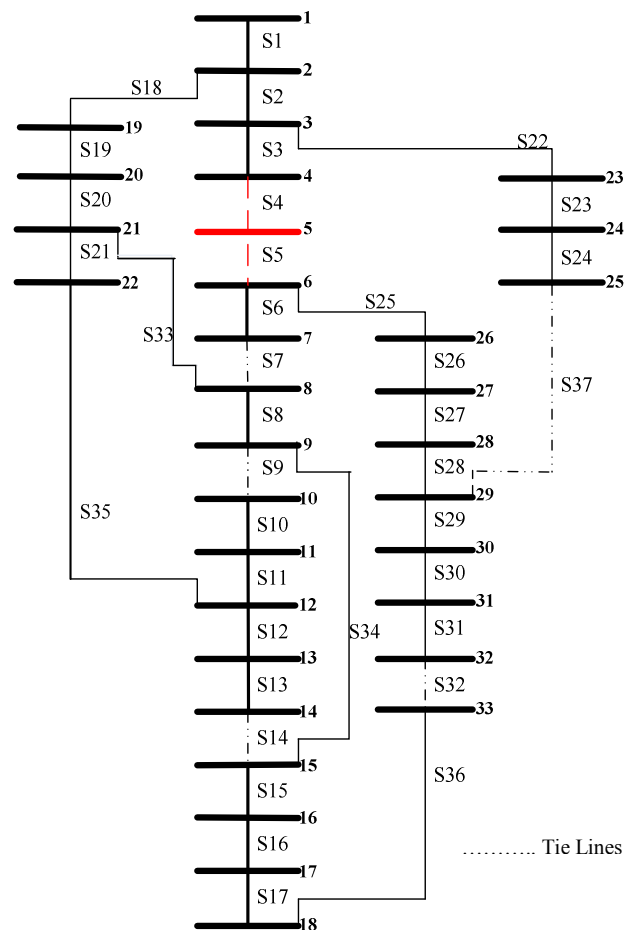

Fig. 3.   Reconfigured network in the presence of fault

During view of the fault and isolation of the fault there is bound to have some load loss. It is observed in the case of

fault, the original system will able to supply a load of only 1570 KW. This is against the available load of 3715 KW after accounting for the real power losses. On the other hand when the system is reconfigured using the proposed approach the total load supplied increases to 2605 KW. The improvement in view of reconfiguration is represented in the Table-IV.

TABLE IV. TIE SWITCHES AND LOAD SUPPLIED IN THE PRESENCE OF A FAULT

Fault Case	Tie Switches	Total Load Supplied (KW)
Before Reconfiguration	S33, S34, S35,S36,S37	1570
After Reconfiguration	S7, S9, S14, S32, S37	2605

The reconfiguration of the network able to supply nearly 70 % of the total load which is 26% more than what the original network will supply in the case of a fault.

IV. CONCLUSION

In this paper an Improved Particle Swarm Optimization Algorithm has been developed for network reconfiguration of distribution system. The performance of the IPSO algorithm is justified under both normal operational conditions and through the occurrence of the fault .It may be clearly determined from the results that the proposed method delivers better than the other approaches available in the literature. The reduction of real power loss by reconfiguration has shown considerable reduction and marked improvement in comparison to other methods. The reconfiguration of the network has improved the ability of the system to supply power to an increase number of load centers during fault condition. The proposed approach has the capability to automate the reconfiguration and has the potential to be connected with GIS based platforms as well.

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