LOSS MINIMISATION AND IMPROVED VOLTAGE PROFILE IN RADIAL DISTRIBUTION SYSTEMS USING PSO VARIANTS

NARGIS CHAUHAN
M.Tech student Scholar
Department of Electrical and Electronics Engineering,
Visakha Institute of Engineering & Technology,
Narava, Visakhapatnam, A.P, India.
nargischauhan@gmail.com

PYDISETTY MAHESWARA RAO
Assistant Professor
Department of Electrical and Electronics Engineering,
Visakha Institute of Engineering & Technology,
Narava, Visakhapatnam,A.P, India
mahesh.pydisetty@gmail.com

Dr. B. SRINIVASA RAO
Professor & HoD
Department of Electrical and Electronics Engineering,
Visakha Institute of Engineering & Technology,
Narava, Visakhapatnam, A.P, India.
vieteeehod0915@gmail.com

Abstract

In this project network reconfiguration which is constrained non linear optimization problem has been solved for loss minimization, load balancing, etc. for last two decades using various heuristic search evolutionary algorithms like binary particle swarm optimization, neuro-fuzzy techniques, etc. The contribution of this paper lies in considering distributed generation which are smaller power sources like solar photovoltaic cells or wind turbines connected in the customer roof top. This new connection in the radial network has made unidirectional current flow to become bidirectional there by increasing the efficiency but sometimes reducing stability of the system. Artificial Bee Colony algorithm has been applied here successfully to minimize real power loss because it does not require barrier factors or cross over rates because the objectives and constraints are dealt separately. The main advantage of this algorithm is continuous guiding search along with changing objective function because power from distributed generation is continuously varying so this can be applied for real time applications with required modifications. This algorithm here is tested for a standard 33 bus radial distribution system for loss minimization and test results here shows that this algorithm is efficient and suitable for real time applications.

INTRODUCTION

The per capita Electrical energy consumption of any country is an indication of its growth and the quality of life of the people, it is used widely in buildings for Heating, Ventilation and ac (HVAC) in countries like USA (for heating) and in Gulf countries (for cooling). The electrical energy is also used in industries for manufacturing and in traction for transporting. .

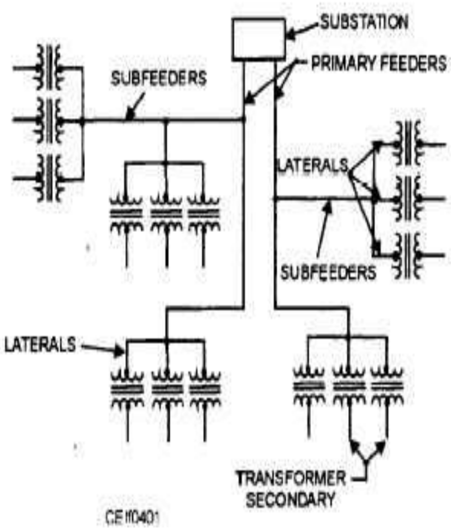

Fig.1.Radial distribution system

Major source for power generation is still coal which is burned to produce power and carbon dioxide which is the main reason for global warming because it obstructs the reflection of sunlight back from Earth. The Thermal power plant is located either near coalmines or near ports and energy travels long distance to consumers with higher voltages in steps to reduce losses. Radial type of distribution is used because it is easy to operate and set protection devices in a unidirectional power flow. A distribution generation (DG) uses distributed generation units (DGU) which generates electrical power from a nearby energy sources on the type of availability like the solar cells or concentrators, wind turbine, etc. which reduces strain on the main transmission line, increases reliability, reduces cost of power generation and saves non-renewable power resources.

Distribution network reconfiguration (DNR) has been dealt for last two decades with an objective to reduce power loss, to balance loads and to improve voltage profile, etc. by using different algorithms which can give faster convergence for deciding the switches in DNR, to decide the value of power that can be drawn from DGU in DG.

The network reconfiguration which itself is a complex combinatorial problem has been further complexed by addition of DG as it has many advantages. Merlin and Back (1975) first proposed this reconfiguration using branch technique the problem was 'n' line section switches will have 2n possible system configurations which will consume more calculation time. Shirmohammadi and Hong (1989) suggested a heuristic algorithm based on Merlin and Back (1975) but without simultaneous switching of feeder reconfiguration. Civalnar et al. (1988) suggested a heuristic algorithm where a simple formula for branch exchanged power loss calculation was developed considering only one pair of switching operation at a time. Das (2006) used an algorithm based on fuzzy logic. The genetic algorithm was used by Nara et al. (1992) later Zhu refined the genetic algorithm by introducing competition in cross over and mutations (Zhu, 2002). Sathishkumar and Jayabarathi (2012) used chemo taxis on bacterial growth in bacterial foraging optimization algorithm, Imran and Kowsalya (2014) found good fire works in fireworks algorithm, all the above methods used only reconfiguration which is opening or closing the sectionalizing or tie switches in a distribution system without considering DG.

THE NEED OF RECONFIGURATION

Reconfiguration, by exchanging the functional links between the elements of the system, represents one of the most important measures which can improve the operational performance of a distribution system. The problem of optimization through the reconfiguration of a power distribution system, in terms of its definition, is a historical single objective problem with constraints. Since 1975, when Merlin and Back introduced the idea of distribution system reconfiguration for active power loss reduction, until nowadays, a lot of researchers have proposed diverse methods and algorithms to solve the reconfiguration problem as a single objective problem. Some authors have proposed Pareto optimality based approaches (including active power losses and reliability indices as objectives.

For this purpose, different artificial intelligence based methods have been used: micro genetic, branch exchange, particle swarm optimization and non-dominated sorting genetic algorithm.

DISTRIBUTION NETWORK RECONFIGURATION TECHNIQUES

DNR technique consists of traditional network reconfiguration and heuristic reconstruction method. In order to solve DNR, there are few categories of algorithm that can be applied which are switch exchange method, mathematical optimization theory, artificial intelligence algorithm and optimal flow pattern .Initially, the traditional network reconfiguration is implemented to reduce power losses, balance the load and stabilize voltage in normal operating conditions where it does not include the impact of network reconfiguration to the system reliability.

There are many ways to reconfigure the distribution network are introduced such as the developing of algorithms like Particle Swarm optimization (PSO), Simulated Annealing (SA), Tabu Search (TS) and Genetic Algorithm (GA). Particle swarm optimization (PSO) algorithm proposed in used population-based approach. Modification was done by linearly decrease the inertia weight during simulation. It is capable of finding optimal or near-optimal solution to the test system and it operating time is acceptable for practical applications.

Electric power begins at a generating station, where the potential difference can be as high as 13,800 volts.[6] AC is usually used. Users of large amounts of DC power such as some railway electrification systems, telephone exchanges and industrial processes such as aluminium smelting usually either operate their own or have adjacent dedicated generating equipment, or use rectifiers to derive DC from the public AC supply. However, High-voltage DC can be advantageous for isolating alternating-current systems or controlling the quantity of electricity transmitted.. Once in the transmission system, electricity from each generating station is combined with electricity produced elsewhere. Electricity is consumed as soon as it is produced. It is transmitted at a very high speed, close to the speed of light.

Reconfiguration, by exchanging the functional links between the elements of the system, represents one of the most important measures which can improve the operational performance of a distribution system. The problem of optimization through the reconfiguration of a power distribution system, in terms of its definition, is a historical single objective problem with constraints. Since 1975, when Merlin and Back introduced the idea of distribution system reconfiguration for active power loss reduction, until nowadays, a lot of researchers have proposed diverse methods and algorithms to solve the reconfiguration problem as a single objective problem. Some authors have proposed Pareto optimality based approaches (including active power losses and reliability indices as objectives). For this purpose, different artificial intelligence based methods have been used: micro genetic, branch exchange, particle swarm optimization and non-dominated sorting genetic algorithm.

GENETIC ALGORITHM

In a genetic algorithm, a population of candidate solutions (called individuals, creatures,or phenotypes) to an optimization problem is evolved toward better solutions. Each candidate solution has a set of properties (its chromosomes or genotype) which can be mutated and altered; traditionally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible. The evolution usually starts from a population of randomly generated individuals, and is an iterative process, with the population in each iteration called a generation. In each generation, the fitness of every individual in the population is evaluated; the fitness is usually the value of the objective function in the optimization problem being solved. The more fit individuals are stochastically selected from the current population, and each individual's genome is modified (recombined and possibly randomly mutated) to form a new generation. The new generation of candidate solutions is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population.

In a genetic algorithm, a population of candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem is evolved toward better solutions. Each candidate solution has a set of properties (its chromosomes or genotype) which can be mutated and altered; traditionally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible.The evolution usually starts from a population of randomly generated individuals, and is an iterative process, with the population in each iteration called a generation.

3.3.2. ARTIFICIAL BEE COLONY ALGORITHM

In the ABC model, the colony consists of three groups of bees: employed bees, onlookers and scouts. It is assumed that there is only one artificial employed bee for each food source. In other words, the number of employed bees in the colony is equal to the number of food sources around the hive. Employed bees go to their food source and come back to hive and dance on this area. The employed bee whose food source has been abandoned becomes a scout and starts to search for finding a new food source. Onlookers watch the dances of employed bees and choose food sources depending on dances. The main steps of the algorithm are given below:

- Initial food sources are produced for all employed bees
- REPEAT
- Each employed bee goes to a food source in her memory and determines a neighbour source, then evaluates its nectar amount and dances in the hive
- Each onlooker watches the dance of employed bees and chooses one of their sources depending on the dances, and then goes to that source. After choosing a neighbour around that, she evaluates its nectar amount.
- Abandoned food sources are determined and are replaced with the new food sources discovered by scouts.
- The best food source found so far is registered.
- UNTIL (requirements are met)

In ABC, a population based algorithm, the position of a food source represents a possible solution to the optimization problem and the nectar amount of a food source corresponds to the quality (fitness) of the associated solution. The number of the employed bees is equal to the number of solutions in the population. At the first step, a randomly distributed initial population (food source positions) is generated. After initialization, the population is subjected to repeat the cycles of the search processes of the employed, onlooker, and scout bees, respectively.

An employed bee produces a modification on the source position in her memory and discovers a new food source position. Provided that the nectar amount of the new one is higher than that of the previous source, the bee memorizes the new source position and forgets the old one. Otherwise she keeps the position of the one in her memory. After all employed bees complete the search process; they share the position information of the sources with the onlookers on the dance area. Each onlooker evaluates the nectar information taken from all employed bees and then chooses a food source depending on the nectar amounts of sources. As in the case of the employed bee, she produces a modification on the source position in her memory and checks its nectar amount. Providing that its nectar is higher than that of the previous one, the bee memorizes the new position and forgets the old one. The sources abandoned are determined and new sources are randomly produced to be replaced with the abandoned ones by artificial scouts.

ABC is a swarm intelligence algorithm proposed by Karaboga in 2005, which is inspired by the behavior of honey bees. Since the development of ABC, it has been applied to solve different kinds of problems. Artificial bee colony (ABC) algorithm is a recently proposed optimization technique which simulates the intelligent foraging behavior of honey bees. A set of honey bees is called swarm which can successfully accomplish tasks through social cooperation.

In the ABC algorithm, the first half of the swarm consists of employed bees, and the second half constitutes the onlooker bees.The number of employed bees or the onlooker bees is equal to the number of solutions in the swarm. The ABC generates a randomly distributed initial population of SN solutions (food sources), where SN denotes the swarm size.

Let $X_i = \{x_1, 1, x_2, 2, \dots, x_n, n\}$ represent the i^{th} solution in the swarm, Where n is the dimension size. Each employed bee X_i generates a new candidate solution V_i in the neighborhood of its present position as equation below:

$$V_{i_k} = X_{i_k} + \Phi_{i_k} \times (X_{i_k} - X_{j_k})$$

Where X_j is a randomly selected candidate solution ($i \neq j$), k is a random dimension index selected from the set $\{1, 2, \dots, n\}$, and Φ_{ik} is a random number within $[-1, 1]$. Once the new candidate solution V_i is generated, a greedy selection is used. If the fitness value of V_i is better than that of its parent X_i, then update X_i with V_i; otherwise keep X_i unchangeable. After all employed bees complete the search process; they share the information of their food sources with the onlooker bees through waggle dances. An onlooker bee evaluates the nectar information taken from all employed bees and chooses a food source with a probability related to its nectar amount. This probabilistic selection is really a roulette wheel selection mechanism which is described as equation below:

$$P_i = \frac{fit_i}{\sum_j fit_j}$$

Where fit_i is the fitness value of the i^{th} solution in the swarm. As seen, the better the solution i, the higher the probability of the i^{th} food source selected. If a position cannot be improved over a predefined number (called limit) of cycles, then the food source is abandoned. Assume that the abandoned source is X_i, and then the scout bee discovers a new food source to be replaced with i^{th} as equation below:

$$X_{i_k} = lb_j + rand(0,1) \times (ub_j - lb_j)$$

Where $rand(0,1)$ a random number within is $[0,1]$ based on a normal distribution and lb, ub, are lower and upper boundaries of the i^{th} dimension, respectively.

Artificial Bee Colony (ABC) algorithm has been used for nano electronic based phase-locked loop (PLL) optimization by O. Garitselov, S. P. Mohanty, and E. Kougianos to speedup physical design optimization.

To apply ABC, the considered optimization problem is first converted to the problem of finding the best parameter vector which minimizes an objective function. Then, the artificial bees randomly discover a population of initial solution vectors and then iteratively improve them by employing the strategies: moving towards better solutions by means of a neighbor search mechanism while abandoning poor solutions.

LOSS REDUCTION DUE TO RECONFIGURATION

The objective function of the problem is formulated so as to get maximum power loss reduction in distributed system which is the sum of power loss reduction due to reconfiguration as well as connection of DGU, which is subject to the voltage, current and power flow constraints as shown below:

$$Maximize f = \max \cdot (\Delta P_{Loss}^{R} + \Delta P_{Loss}^{DG})$$

$$\text{Subjected to } V_{\min} \le |V_k| \le V_{\max}$$
$$\text{and } |I_{k,k+1}| \le |I_{k,k+1,\max}|$$
$$\sum_{k=1}^{n} P_{GK} \le \sum_{k=1}^{n} (P_k + P_{Loss,k}) .$$

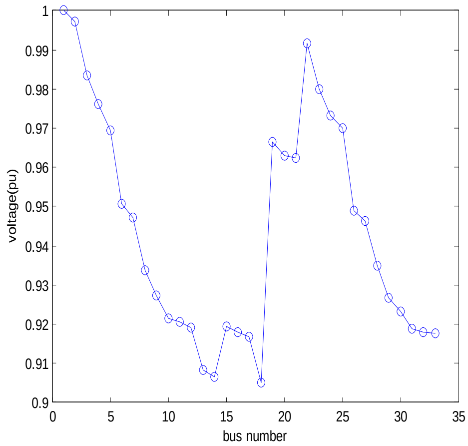

Fig 2 Simulation waveforms without doing any reconfiguration of feeders and without connections of distributed generators using MPGSA(Case 1)

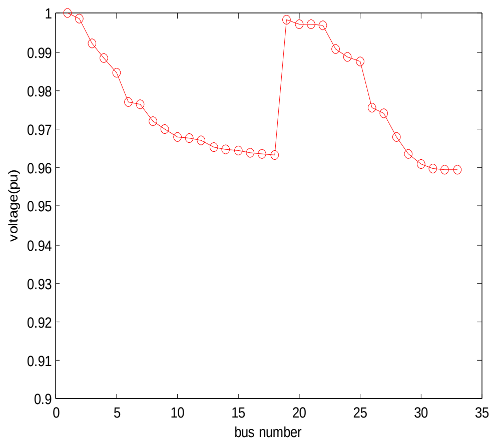

Fig 3 Simulation wave forms when system is reconfigured by opening/closing the sectionalizing and tie switches using MPGSA(Case 2)

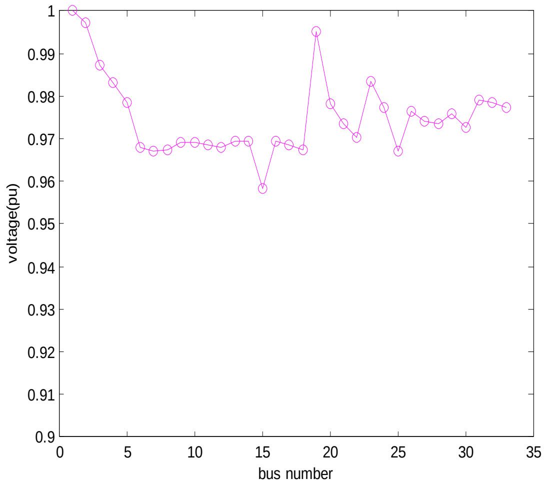

Fig 4 Simulation wave forms for no reconfiguration but only DG connection using MPGSA(case 3)

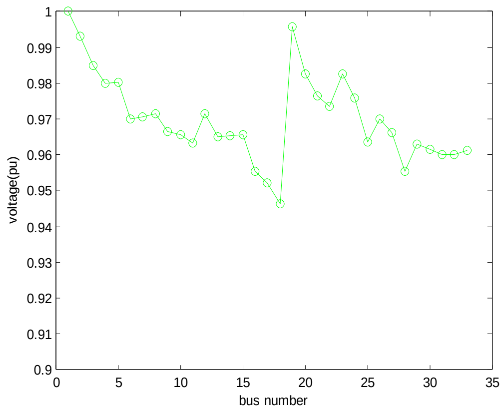

Fig 5 Simulation wave forms for two step operation of first reconfiguration of feeders, next connecting DG units using MPGSA(case 4)

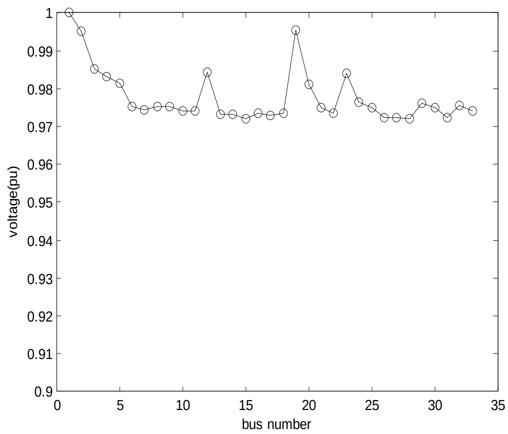

Fig 6 Simulation wave forms for simultananeous operation of reconfiguration and connection of DG units using MPGSA(case 5)

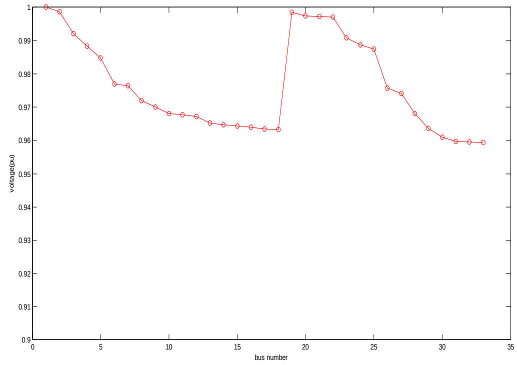

Fig 7 Simulation wave forms when system is reconfigured by opening/closing the sectionalizing and tie switches using ABCA(case 2)

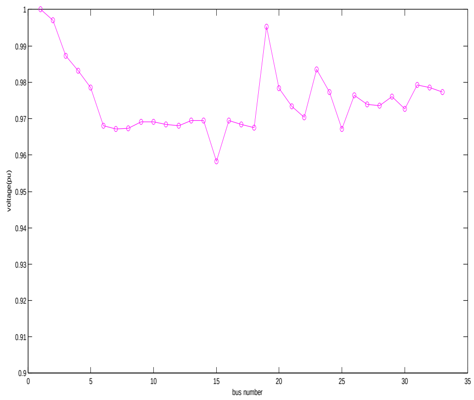

Fig 8 Simulation wave forms for no reconfiguration but only DG connection using ABCA (case 3)

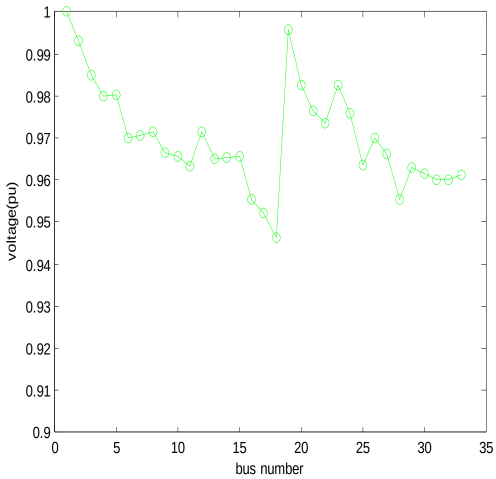

Fig 9 Simulation wave forms for two step operation of first reconfiguration of feeders ,next connecting DG units using ABCA(case 4)

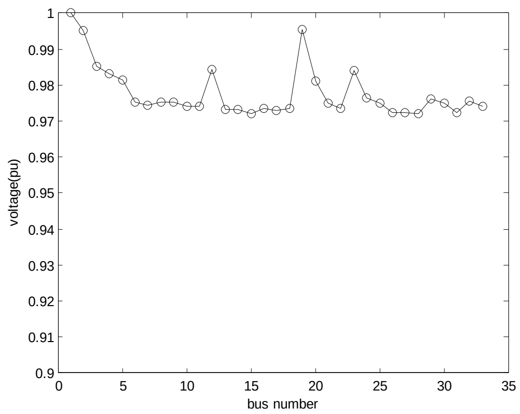

Fig 10 Simulation wave forms for simultananeous operation of reconfiguration and connection of DG units using ABCA(case 5)

CONCLUSION

In this paper simultaneous reconfiguration and DG allocation for a 33 bus radial distribution system is proposed with a ABCA algorithm. The results proves that the simultaneous reconfiguration with DG allocation give better results out of all other combinations. For this application of simultaneous reconfiguration and DG The results obtained with other evolutionary algorithms like genetic algorithm (GA), refined genetic algorithm (RGA), ant colony optimization algorithm in hypercube system (HC-ACO), harmony search algorithm (HSA) are compared with the proposed method and the results show that performance of proposed Artificial bee colony (ABCA) is better and is more suitable for practical applications because the objectives and constraints are dealt separately.

.

REFERENCES

[1] Agalgaonkar, P., Kulkarni, S.V., Khanparde, S.A., Soman, S.A., 2004. Placement and penetration of distributed generation under standard market design. Int. J. Emerg. Electr. Power Syst. 1 (1)..

[2] Celli, G., Ghiani, E., Mocci, S., Pilo, F., 2005. A multi objective evolutionary algorithm for the sizing and sitting of distributed generation. IEEE Trans. Power Syst. 20 (2), 750–757."

[3] Civalnar, S., Grainger, J., Yin, H., Lee, S., 1988. Distribution feeder reconfiguration for loss reduction. IEEE Trans. Power Deliv. 3 (3), 1217–1223

[4] Das, D., 2006. A fuzzy multi objective approach for network reconfiguration of distribution systems. IEEE Trans. Power Deliv. 21 (1), 202–209

[5] Imran, A. Mohammed, Kowsalya, M., 2014. A new power system reconfiguration scheme for power loss minimization and voltage profile enhancement using fire works algorithm. Int. J. Electr. Power Energy Syst. 62, 312–322.

[6] Rao, R.Srinivasa, Ravindra, K., Satish, K., Narasimham, S.V.L., 2013. Power loss minimization distribution system using network reconfiguration in the presence of distributed generation. IEEE Trans. Power Syst. 28 (1), 317–325.