Optimizing the Location of Distributed Generation using Different Optimization Algorithms: A Review

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ABSTRACT
Electrical Power Distributed Generations are used for improvement of the voltage level and minimization of the power line loss in electrical power distribution network. This paper presents a review on optimizing the location of distributed generation using different Optimization Techniques. Various meta-heuristic optimization techniques are discussed to reconfigure the distribution system, obtain the optimized location, sizing of Distributed Generations, minimization of the line losses and cost of the electrical network. The paper presents the review on the development of distributed generation model, problem formulation in distributed generation, different optimization techniques etc.

Keywords — Primary power distribution system, Teaching Learning Based Optimization Technique, Genetic Algorithm, butterfly particle swarm optimization, Distributed Generation

I INTRODUCTION

Electricity is one of the most important blessings of science to mankind. Today electricity plays an important role in all walks of life and life without electricity is difficult to imagine. Technology is advancing in various sectors including power sector. New concept is coming in Indian power sector such as smart grid .smart grid means make the grid smarter the main problem of current scenario in India is to supply quality power to the consumers. quality of power means minimum line loss, balanced power supply (active power and reactive power), uninterrupted power at lower cost. Power engineers are involved to develop new ideas in the field of smart grid. At present in India engineers are facing the challenges of load shedding problem for continuous power supply power constraint is generation should meet the load demand for this theory they are focused on renewable source of energy .renewable source of is used for generation and supply to the grid. The new concept is to make the grid smarter means new network relocation capacitor location and distribution generation. To find Distributed Generations suitable location and sizing, engineers use various optimization techniques. Heuristic methods like teaching Learning based Optimization (TLBO) which is based on nature [1], Genetic Algorithm (GA) is based on natural genetic [2], Butter fly Particle swarm Optimization (BPSO) based on nectar probability and sensibility [3], Simulated Annealing (SA) is not based on reconfiguration but it is modification to some other basic algorithm [4] etc. are used for solving the problem of electric power distribution network. For optimal location of DG in power system a conventional technique is presented [5]. Seeker Optimization Algorithm (SOA) based on weighted aggregation [6], The effect of DGs on voltage profile, reliability and losses to design an Electric Power Distribution System is presented [7] An Artificial Bee Colony (ABC) is meta heuristic method modified for Distributed Generation location with network relocation [8].A simultaneous relocation with DG location on different bus systems is done by harmony search method [9]. Optimal location and sizing of DGs to minimize the power loss is calculated by an analytical method [10]. DGs work like a capacitor but the only difference is capacitor supply reactive power only where as DGs supplies both active and reactive power. But DGs must be placed at an optimal location otherwise desired output will totally get changed (system loss will increase). This paper presents review on various optimization techniques including a new version of Teaching Learning Optimization algorithm (TLBO) to design Distributed Generations location with primary distribution relocation. The organization of the paper is as follows: Problem model for Distribution Generation location (section II), Problem formulation in Distribution Generation (section III), optimization technique for DG location (section IV), and the Conclusion (section V).

II MODELLING OF PROBLEM FOR D.G. LOCATION

In radial the network a relocation problem is for optimum location of power flow without violating the network constraints .power flow between the branches is different

In mesh distribution network as compare to radial network. Relocation always finds the best location of power flow in the branch. In optimization technique two switches are used one switch is for open and other switch is for closed .switch to present the total network as combination of one and zero.

For designing a suitable network the binary shifting of branches is considered to handle different parameter and solve the network relocation problem. Open switch and closed switch are used in the branch. If U number of sectionalize switch is available and V number of tie switch is available the

total number of switch is represented by S then it is represented by (S=U+V).In teaching learning based optimization technique a binary array is used for number of radial network. Fig1 shows the simple radial network in this network there are 10 sectionalizing switches and one tie switch. Sectionalizing switches are [1 2 3 4 5 7 8 9 10 11] which is represented by 1 in binary. Where 6 is tie switch is represented by 0.the whole network in binary is [1 1 1 1 1 0 1 1 1 1 1] Fig 2 shows a graphical presentation of Small Primary meshed distribution system consisting of 33 node and 1 substation.

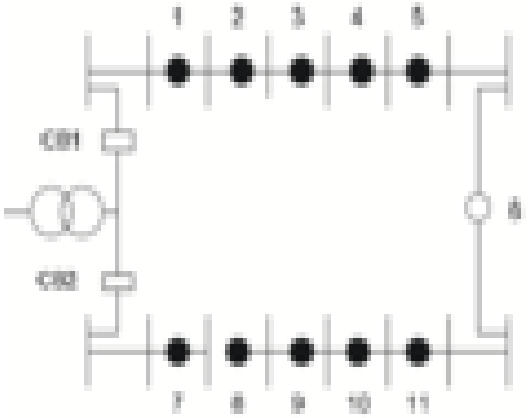

Fig.1 Simple Radial Distribution Network

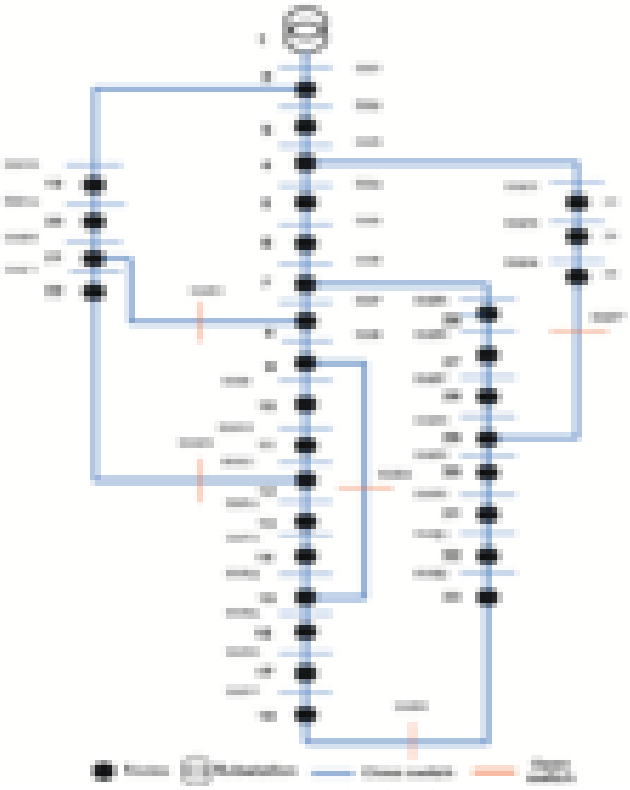

Fig.2: Simple Mesh Distribution Network

III PROBLEM FORMULATION IN DISTRIBUTED GENERATION LOCATION

In Distribution generation problem formulation a two bus system with D.G is considered as an example which is shown in Fig3.an objective function is also considered for optimization technique which minimizes the total power line loss while satisfying all type of equality and non equality constraints.

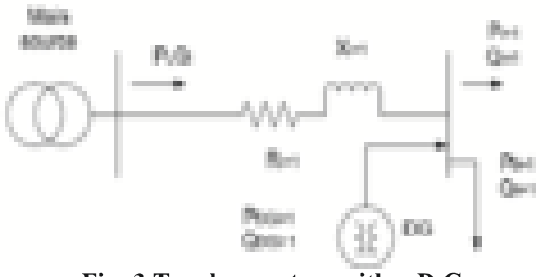

Fig. 3 Two bus system with a D.G.

The mathematical representation of the objective function is as follows:

$$F = \min \sum_{i=1}^{n-1} [\{\frac{P_i^2+Q_i^2}{V_i^2}\} X\ r_{i+1}] \quad (1)$$

The distribution generation problem is subjected to some equality and non-equality constraints such as:

$$P_i - [\{\frac{P_i^2+Q_i^2}{V_i^2}\} X\ r_{i+1}] - P_{Li+1} + \mu_p \alpha P_{i+1} - P_{i+1} = 0 \quad (2)$$

$$Q_i - [\{\frac{P_i^2+Q_i^2}{V_i^2}\} X\ X_{i+1}] - Q_{Li+1} + \mu_q \beta P_{i+1} - Q_{i+1} = 0 \quad (3)$$

$$V^2_{i+1} = V^2_i - 2(r_{i+1}P_i + X_{i+1}Q_i) + (r^2_{i+1} + X^2_{i+1})\{\frac{P_i^2+Q_i^2}{V_i^2}\} \quad (4)$$

where

μ_p multiplier of real power which indicates 1 when there is active source in the line, otherwise 0.

μ_q multiplier of reactive power which indicates 1 when there is a reactive source in the line, otherwise 0.

αP_{i+1} active power component.

βQ_{i+1} injected reactive power component.

In equality constraints

(a) Voltage Limit

limit of ± 5% of the nominal voltage value of the voltage system limit

$$|V^{spec}_{min}| \leq |V_i^{sys}| \leq |V_{max}^{spec}| \quad (5)$$

(b) Thermal capacity limit

$$|S_{Li+1}^{sys}| \leq |S_{Li+1}^{rated}| \geq |S_{i+1,1}^{sys}| \quad (6)$$

Distributed Generation unit size and power Factor Limit

(c) $|S_{iDG}^{min}| \leq |S_{iDG}| \leq |S_{iDG}^{max}|$ (7)

where,

S_i size of DG

The DG size and power factor are practically considered. DG unit sizes are from 30-40% of total system demand. The DG power factors are set to operate at 0.85, 0.9, 0.95 and unity and may be different from the bus load power factor where DG unit is placed.

IV OPTIMIZATION TECHNIQUES FOR DECIDING D.G. LOCATION

(a) Basic Teaching Learning Based Optimization algorithm

This method is global search algorithm. This is developed by Rao.et.al. TLBO algorithm is a nature-inspired Meta -heuristic population based optimization technique. it works on the philosophy of teaching and learning in the class room. The teacher and learner are two key component teacher teach the

students to improve their grades or result. Teacher efficiency is determined by learner result. Student also learns through interaction among themselves which also aid to improve learner result. In TLBO for initialization group of students are termed as population and marks obtained in different subjects are termed as design variable. Technique updates the present learner by comparing with best learner. The existing solution in terms of Teacher and students is updated in teacher phase as below:

$$X_{N\ i} = X_{o\ i} + D_M$$

where, D_M is the difference between the result of teacher and the mean result of whole class .

$$D_M = r_i\,(M_n - T_f * M_i)$$

$$X_{N\,i} = X_{0,i} + r_i(X_i - X_j)\ \ f(x_j) < f(x_j)$$

$$X_{N,i} = X_{0,i} + r_i(X_j - X_i)\ \ f(x_j) > f(x_j)$$

(b) Modified Teaching Learning based optimization

(i) Technique: In Problem model a bit Switch relocation of primary network is shown where optimal power flow location is found by closed switches. In modified TLBO some binary array is chosen. A bit shift operator name as bit shift locator is used to change the normally open switch location to update the population

(ii) Bit Relocate Operator- A Switch position of network is shifted by a bit relocate operator to relocate the new path of network. Switch position relocate from right to left and left to right. The direction of relocation is evaluated by basic equation of TLBO Fig 4 depicts the general bit shift relocation. Let M be an array containing 10 binary bits. if relocate operator is operated on M then each bit of M will relocate in right direction with relocation length of 2 and is represented as M. if relocate operator is applied on M the particular bit relocate in left direction by single bit length and is represented as M. two case is consider one all the switch relocate by two position in the right direction and other one when all switch relocate one position to left direction.

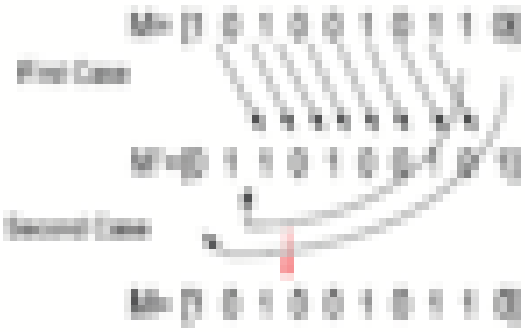

Fig. 4 Operation of basic Bit Shift Locator

Bit Shift operations relocate the problem with an example that electric distribution network is shown in Fig. 5(a) have 7 nodes and 10 connecting branch of power flow. Different technique make a radial network in Fig. 5(b) and change it in a binary array [1 1 11 0 0 1 0 0 1]

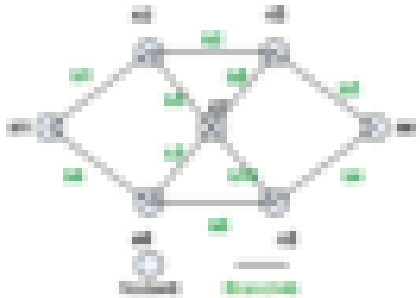

Fig. 5(a) Radial Topology for 7 node and 10 connecting path

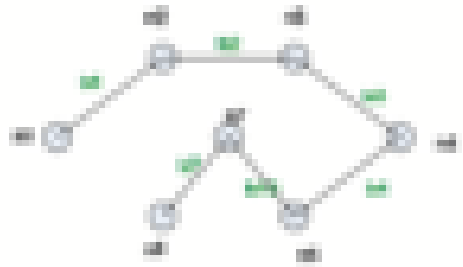

Fig. 5(b) Radial Topology for change in path

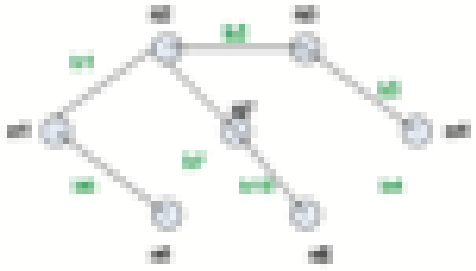

Fig. 6(a) Radial Topology for left shift

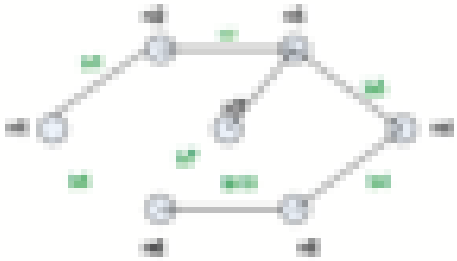

Fig. 6(b) Radial Topology for right shift

On the basis of relocation of switch is relocated left to right direction by bit shift locator. If a left relocation occurs, the radial topology of Fig. 5(b) is changed to [1 1 1 00 1 0 0 1 1] i.e. Fig. 6(a) or if right relocation occurs than the radial topology changes to [1 1 1 1 1 0 0 1 0 0] i.e. Fig. 6(b).

(c) Genetic Algorithm - Genetic algorithm is globally nature based algorithm. It is based on Darwin theory and the parent child relationship. If product of parent is son. It is not necessary that nature of child will be same as parent. Genetic algorithm starts with reproduction and end with fitness value. In reproduction the new string is generated. This is the artificial version of natural selection based on Darwin survival of the fittest among string .it can be implemented in number of ways. After reproduction cross over operates in cross over two new population generate or string from two existing ones by genetically recombining randomly formed by randomly chosen crossover point. Mutation changes the value of a string position. Fitness function is for evaluation it is defined over genetic representation and measure the quality of the represented solution. There are two basic parameter of G.A one is cross over probability other is mutation probability.

(d) The Butterfly Particle Swarm Based Optimization (BF-PSO) Technique -The Butterfly-PSO (BF-PSO) algorithm is basically based on the nectar probability and the sensibility of the butterfly swarm. The optimal quantity of ambrosia is searched by the help of butterfly intelligent behavior. The butterfly particle swarm optimization learning algorithm (BFPSO) is based on random parameter and acceleration parameter and utilizes the result of sensitivity and other parameter for more accurate result and fast convergence for best optimal solution. for the best optimal result the butterfly every flight is treated as one flight because at each trajectory counts maximum connectivity the search process investigate the best location on sensitivity of the butterfly flight towards flower and probability of the nectar. The communication intelligence such as (dancing, colors, chemical, sound, action and natural process) between all the butterfly gives the information of the optimal solution. The random parameters, acceleration coefficients, probability, sensitivity, lbest and gbest are included in the butterfly learning based particle swarm based optimization to evaluate the optimal solution. In the Butterfly-PSO, individual's best solution denotes the Ibest solution. After that, fitness congestion gives the g best solution.

V CONCLUSION

There are numerous publications in the distribution generation placement. With the use of distributed generation and optimization technique, the active and reactive power losses are reduced significantly. With the proper distribution of load and distributed generation, there will be an improvement in system voltage profile that is reduction in voltage deviation of distribution network. The Location of DG in the system reduces the cost of generation which will be helpful in reducing the power cost. Further challenges will be to improve optimization by modeling of distribution network for which more details will have to be considered.

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