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FEEDER RECONFIGURATION FOR POWER LOSS REDUCTION OF DISTRIBUTION SYSTEM USING HYBRID PARTICLE SWARM OPTIMIZATION AND CUCKOO SEARCH APPROACH WITH DG

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Abstract— The distribution system feeder reconfiguration plays vital role in power loss reduction. The power loss reduction is significant aspect for efficient distribution system power flow. There are many ways for reducing system power loss. The main objective of this paper is feeder reconfiguration is employed for system power loss reduction. The network reconfiguration in distribution system is performed based on opening sectionalizing and closing tie switches of the system. The most significant benefit of network reconfiguration is voltage profile improvement, power loss reduction and freeing up the distribution system capacity. The proposed method is tested ona 33 bus distribution system. The distribution system feeder reconfiguration is modeled by MATLAB platform. In this paper, hybrid particle swarm optimization and cuckoo search algorithm is applied to get the optimal switching strategy for the network reconfiguration operational planning. The simulation results from the power flow analysis have shown that the implementation of this hybrid approach leads to enhancement in voltage profile, real power loss reduction and percentage of power loss.

Index Terms— Feeder reconfiguration, cuckoo search algorithm, distributed generation, distribution network, power loss reduction, particle swarm optimization, voltage profile.

1 INTRODUCTION

THE increased power demand and high load density in dense populated area makes the operation of the power system more complex in nature. To meet and satisfy the load demand, the system is so required to expand by increasing system capacity and number of feeders. But, it is so delicate to achieve due to various technical and non technical constraints. So, it is necessary to meet the demand by increasing the system capacity by minimizing power losses in system. The power loss reduction and voltage profile improvement are the significant factors indicating the distribution system performance. The well planned distribution system must have low power losses. Several articles discussed and proposed in reducing the power losses in distribution system. Needless to say, the powerful distribution systems must have low power loss. There is a greater demand for quality and reliability of electricity supply in every sector for sustainable development of economy.

The power distribution network feeder reconfiguration is an important operational planning of optimizing the distribution system, which is significant to enhancing the system security, the efficiency, and the reliability of the system by operating switches in a distribution system: normally closed switches and normally open switches. In this paper, the network reconfiguration is employed to reduce power losses in system by hybrid Particle Swarm Optimization and Cuckoo Search Algorithm. This method is tested for 33 bus system bench mark using Matlab simulation tool.

2 LITERATURE SURVEY

Many works have been reported by using various methodologies in explaining the network reconfiguration problem by considering single objective function and multi objective function. Several methods have been proposed to reduce power loss in the distribution system. V. Farahani, S.H.H. Sadeghi, H.A. Abyaneh, S.M.M. Agah, and K. Mazlumi [1], explains the conductor replacement and capacitor placement in distribution system. C.L.T. Borges and D.M. Falcao [2], describes the DG allocations for power loss minimization. Nick, R. Cherkaoui, and M. Paolone [3], explains the optimal energy storage system allocation in system. C.F. Chang [4], explains the network reconfiguration and capacitor placement for power loss reduction.

The network reconfiguration is one of the methods for power loss reduction, especially in the automated system where the network topology can be certainly controlled, because of its simple implementation, low-cost investment. A. Zidan and E.F. El-Saadany [5], explain the operation of network reconfiguration. According to that, in the electrical dis-

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tribution systems, the network structure can be changed by closing the tie switches and opening the sectionalizing switches, which could significantly affect the system total power loss, this process is called system reconfiguration. C.F. Chang [4], explains another method to reduce electrical power loss in the distribution system is the capacitor placement. The additional installation of capacitors in distribution systems provides reactive power compensation and to obtain the most beneficial system by identifying the optimal location and sizing of capacitor. This methodology helps the system voltage profile and minimization of power loss. O. Badran, S. Mekhilef, H. Mokhlis, and W. Dahalan [6], describes the meta-heuristic approach to solve the network reconfiguration problems for the system power loss minimization.

Several methods of meta-heuristic approaches have been proposed to achieve the minimization of power loss through system reconfiguration. J. Olamaei, T. Niknam and G. Gharehpetian [7], explains the Particle Swarm Optimization method, K. Nara, A. Shiose, M. Kitagawa and T. Ishihara [8], described the implementation of Genetic Algorithm, C.T. Su, C.F. Chang, and J.P. Chiou [9], explains the Ant Colony Search Algorithm, Y.J. Jeon, J.C. Kim, J.O. Kim, K.Y. Lee and J.R. Shin [10], shows an efficient Simulated Annealing, T.T. Nguyen and A.V. Truong [11], implemented Cuckoo Search Algorithm for power loss reduction and voltage profile improvement, A.M. Imran and M. Kowsalya [12], explains the Fireworks Algorithm and T.T. Nguyen, T.T. Nguyen, A.V. Truong, Q.T. Nguyen and T.A. Phung [13], describes the Runner Root Algorithm for power loss minimization of the system. S. Naveen, K. Kumar and K. Raja Lakshmi [14], mentioned the modified foraging optimization algorithm for power loss minimization by feeder reconfiguration. B. Amanulla, S. Chakrabarti and S. Singh [15], shows the system reconfiguration by considering reliability and power loss.

3 Problem Formulation

3.1 Objective Function

The distribution system reconfiguration problem is carried out in this work. The prime objective is to minimize the power loss without violating the system constraints. The constraints of system reconfiguration problem include no load can be left out of service, the radial structure must be maintained, bus voltage must be within limits and line current must be within the range. The objective function for the minimization of power loss can be expressed as follows [16]:

$$MinimizeObjective = \sum_{n}^{nb} Ri \frac{\left(P_i^2 + Q_i^2\right)}{V_i^2} \qquad (1)$$

Subjected to:

All load points must be served.

The radial structure must be retained.

det(B)=1 or -1 (2)

Bus voltage should be between limits.

$V_{min} \le |V_j| \le V_{max}$ (3)

Line current should be within the premising range.

$$0 \le |I_i| \le I_{i,max} \qquad (4)$$

where, power loss minimization is the objective function in (kW), nb is total number of lines, Ri is resistance of line i, Pi is real power at sending end of line i, Qi is reactive power at sending end of line i, Vi is voltage at sending end of line i, B is bus incidence matrix, Vmin is bus minimum voltage limit (0.9 p.u.), |Vj| is voltage magnitude of bus j, Vmax is bus maximum voltage limit (1.0 p.u.), |Ii| is current magnitude of line i, Iimax is maximum current limit of line i.

4 Proposed Methodology

4.1 Particle Swarm Optimization

The Particle swarm optimization is population size based intelligent, stochastic optimization method of swarm movement idea over a particular given space. This algorithm updates the swarm velocities and the each swarm member exact positions from its past activity. In PSO, the velocity v_n^d and position x_n^d of the dth dimension of the nth particle are updated as follows:

$$V_n^d = w.V_n^d + c_1.r_1.(p_{best\,n}^{\;d} - x_n^d) + c_2.r_2.(g_{best\,n}^{\;d} - x_n^d) \qquad (5)$$

$$x_n^{d+1} = x_n^d + v_n^d \qquad (6)$$

where, xi : position of the nth particle
vn : velocity of particle n
pbest n : best location in search space ever visited by particle n
gbest : best location was found so far
w : inertia weight that controls the impact of previous velocity of particle on its new one
r1, r2 : independently uniformly distributed random variables with range (0,1)
c1, c2 : positive constants (acceleration) coefficients which controls maximum step size

The new velocity is calculated by using equation (5) from its past velocity and to the exact distance of its new position from its own best position and other swarm positions too. Generally, the value of each component in velocity, v can be stated between the range from -vmax to vmax to control unnecessary distance travelled by particles outside the search area. Then the particle flies and reaches towards a new position. This process is repeated until a user-defined stopping criterion is reached. The linearly decreasing inertia weight from maximum value wmax to minimum value wmin is used to update the inertia weight as:

$$w^k = w_{\max} - \frac{w_{\max} - w_{\min}}{k_{\max}}.k \qquad (7)$$

where, Kmax is maximum iteration.

4.2 Cuckoo Search Algorithm

The brief algorithm steps of CSA given below:

1. Read the system line and load data
2. Run system base case load flow and save the initial vol-

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tages and losses

3. Change the switches states
4. Define the constraints and bounding, algorithm parameters and the number of iterations
5. Initiate the random population host nest for iteration
6. Get a cuckoo randomly by levy flight
7. Evaluate the fitness function as require and select the nest ‘n’ randomly
8. Check fitness condition, if yes replace by new solution
9. Remove ‘pa’ for bad nests and build new one and keep and pass best solution
10. If constraints satisfied and then save best solution of optimal feeder reconfiguration.

4.3 Hybrid PSO-CSA Optimization

The hybrid PSO-CSA optimization gives very significant and promising results than PSO and CSA optimization techniques. The results are evaluated and shown in table 1.

5 Test Case and Simulation Results

The hybrid PSO-CSA method is tested and verified for IEEE-33 bus test system having system operating voltage 12.66 kV and the total real power and reactive power of 3.715 MW and 2.295 MVAR respectively. This simulation uses MATLAB tool with 32 bit, core i3 processor. Fig.1 is IEEE-33 bus test case system.

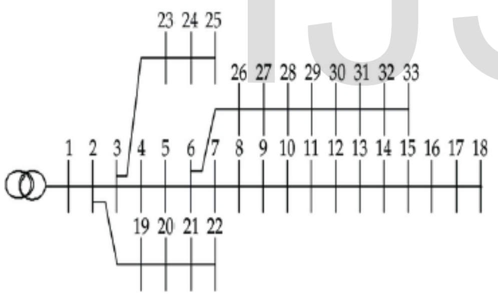

Fig. 1. A 33 bus IEEE test case system.

The test case was analyzed by choosing power loss of the system for 33 bus system. The power losses and voltage profiles are found using load flow method and results of all nodes of the system are found and are discussed in table I. The simulated results are verified by hybrid particle swarm optimization and cuckoo search algorithm approach with integration of DG. The voltage profile in all the nodes made with acceptable limits by restructuring of system with placing DG in nodes. Many works are presented considering the objective function with voltage level of entire feeder and so on. In this work, feeder reconfiguration is done with DG placing in the system. The results from table I show the tie switches before and after reconfiguration system with the system and mentioned system power loss and power loss reduction, voltage profile and simulation time for 33 bus test distribution system. Fig. 2. shows the voltage profile of 33 bus test system where bus 18 with least voltage profile.

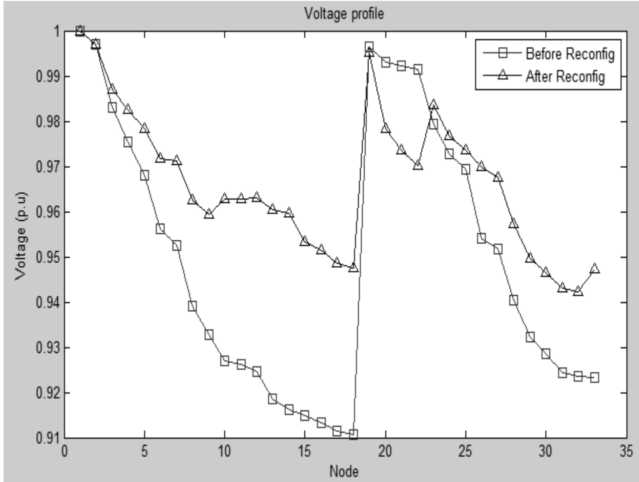

Fig. 2. Voltage profile of 33 bus test case system.

TABLE 1
Simulation Results of 33 Bus System Before and After Feeder Reconfiguration

	Before Reconfiguration	After Reconfiguration
Tie switches	33 34 35 36 37	7 32 33 34 37
Power loss	202.418 kW	77.7733 kW
Power loss reduction (%)	----	61.5779 %
Minimum voltage	0.91075 pu	0.92934 pu
Elapsed time		37.555060 s

Where, kW= kilowatts, p.u= Per-unit and s=Seconds

The Table 1 shows the proposed hybrid Particle Swarm Optimization and Cuckoo Search results of tie switches status, power loss and percentage of loss reduction and simulation time. And gives noticeable results by proposed hybrid approach.

6 Conclusion

The proposed hybrid Particle Swarm Optimization and Cuckoo Search Algorithm is gives the noticeable solution for minimizing power loss from 202.418 kW to 77.7733 kW with power loss reduction about 61.5779% and voltage profile improvement to 0.92934 p.u from 0.91075 p.u. The result revealed feasible switching states for the IEEE 33 bus distribution system as compared to the original network. The optimal locations of tie switches were found as 7, 32, 33, 34, 37 from before reconfiguration 33, 34, 35, 36, 37 switches of the network. From the simulation results of the test case system, it was observed that the proposed solution was the best optimal configuration and had the greatest minimum power loss and voltage profile improvement. Therefore, the proposed hybrid approach can provide good analysis as well as find the best set solution for optimal distribution operational planning under different load conditions.

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REFERENCES

[1] V. Farahani, S.H.H. Sadeghi, H.A. Abyaneh, S.M.M. Agah, and K. Mazlumi, “Energy loss reduction by conductor replacement and capacitor placement in distribution systems,” IEEE Transactions on Power Systems, 28(3), pp. 2077-2085, 2013.

[2] C.L.T. Borges and D.M. Falcao, “Optimal distributed generation allocation for reliability, losses, and voltage improvement,” International Journal of Electrical Power & Energy Systems, 28(6), pp. 413-420, 2006.

[3] M. Nick, R. Cherkaoui, and M. Paolone, “Optimal allocation of dispersed energy storage systems in active distribution networks for energy balance and grid support,” IEEE Transactions on Power Systems, 29(5), pp. 2300-2310, 2014.

[4] C.F. Chang, “Reconfiguration and capacitor placement for loss reduction of distribution systems by ant colony search algorithm,” IEEE Transactions on Power Systems, 23(4), pp. 1747-1755, 2008.

[5] A. Zidan and E.F. El-Saadany, “Distribution system reconfiguration for energy loss reduction considering the variability of load and local renewable generation,” Energy, 59, pp. 698-707, 2013.

[6] [6] O. Badran, S. Mekhilef, H. Mokhlis, and W. Dahalan, “Optimal reconfiguration of distribution system connected with distributed generations: a review of different methodologies,” Renewable and Sustainable Energy Reviews, 73, 2017, 854-867.

[7] J. Olamaei, T. Niknam and G. Gharehpetian, “Application of particle swarm optimization for distribution feeder reconfiguration considering distributed generators,” Applied Mathematics and Computation, 201(1-2), pp. 575-586, 2008.

[8] K. Nara, A. Shiose, M. Kitagawa and T. Ishihara, “Implementation of genetic algorithm for distribution systems loss minimum reconfiguration,” IEEE Transactions on Power Systems, 7(3), pp. 1044-1051, 1992.

[9] C.T. Su, C.F. Chang, and J.P. Chiou, “Distribution network reconfiguration for loss reduction by ant colony search algorithm,” Electric Power Systems Research, 75(2), pp. 190-199, 2005.

[10] Y.J. Jeon, J.C. Kim, J.O. Kim, K.Y. Lee and J.R. Shin, “An efficient simulated annealing algorithm for network reconfiguration in large-scale distribution systems,” IEEE Transactions on Power Delivery, 17(4), pp. 1070-1078, 2002.

[11] T.T. Nguyen and A.V. Truong, “Distribution network reconfiguration for power loss minimization and voltage profile improvement using cuckoo search algorithm,” Electrical Power and Energy Systems, 68, pp. 233-242, 2015.

[12] A.M. Imran and M. Kowsalya, “A new power system reconfiguration scheme for power loss minimization and voltage profile enhancement using fireworks algorithm,” Electrical Power and Energy Systems, 62, pp. 312-322, 2014.

[13] T.T. Nguyen, T.T. Nguyen, A.V. Truong, Q.T. Nguyen and T.A. Phung, “Multi-objective electric distribution network reconfiguration solution using runner-root algorithm,” Applied Soft Computing, 52, pp. 93-108, 2017.

[14] S. Naveen, K. Kumar and K. Raja Lakshmi, “Distribution system reconfiguration for loss minimization using modified bacterial foraging optimization algorithm,” Electrical Power and Energy Systems, vol. 55, pp.128– 143, 2014.

[15] B. Amanulla, S. Chakrabarti and S. Singh “Reconfiguration of Power Distribution Systems Considering Reliability and Power Loss”, IEEE Trans on Power Delivery, vol. 27, no. 2, pp. 918-926, 2012.

[16] R.S. Rao, S.V.L. Narasimham, M.R. Raju and A.S. Rao, Optimal network reconfiguration of large-scale distribution system using harmony search algorithm, IEEE Transactions on Power Systems, 26(3), pp. 1080-1088, 2011.