# Genetic Algorithm approach in FACTS devices location for the improvement of energy efficiency in distribution networks

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## 1 Interest of work

The European Union ratified the Kyoto Protocol in May 2002 and committed to reduce emissions of six greenhouse gases. There are different aspects to be considered in order to reach this goal and of them is energy efficiency in power systems. Energy efficiency can be improved along the power system and here the focus is set to the transmission and distribution network. Overall losses in a transmission and distribution system are considered normal in a range of 6% and 8%. There are are different ways to achieve a better energy efficiency in distribution networks, such as high efficiency transformers and cables or applications like Flexible AC Transmission Systems (FACTS). More over, several optimization techniques can be applied to maximize energy efficiency in distribution networks. Several optimization techniques can be applied to maximize energy efficiency in distribution networks. Among them: Ant Colonies Optimization (ACO), [1]. Particle Swarm Optimization (PSO) [2]. Artificial Neural Networks (ANN), [3]. Evolutionary Programming (EP) [4]. Genetic Algorithms (GA) [5].

## 2 Objectives

The application of FACTS devices, employing a GA optimization technique, can actually improve energy efficiency in power systems. GA will be applied so that the location of FACTS devices and the reactive power considered are optimal. GA is applied to a power system of $N_{bus}$ nodes to maximize energy efficiency ($\eta$). For each individual $i$ out of the possible $N$, an array carries the values that represent the i-th individual: the node, $N_{node}$, the FACTS device reactive power $Q_{facts}$ and the efficiency $\eta_i$. Two different MATLAB programs are applied to the distribution network:

- A power flow program to evaluate the network's efficiency;
- A GA based program to optimize FACTS location and so improve energy efficiency.

These programs are meant to evaluate the evolution of network efficiency through the number of generations along with the best node/best reactive power evolution. The process sorts out individuals of the population considering their efficiency values and evaluates the stop criterion set for the problem. Later on, the algorithm applies the GA rules that are necessary to grow the population and in the final phase the algorithm outputs the best values reached for each generation.

## 3 Main contribution

The algorithm is applied to a 33 bus radial distribution system using data presented in [6]. The simulation is set for a number of generation $N_{gen}$ and the maximum number of best individuals is set to be $N_{best}$. These individuals are the new genitors of the new population and in order to establish the individuals ranking, system efficiency is evaluated through the power flow program. For each new population the first 3 individuals with the best efficiency are chosen to reproduce and their behavior is implemented considering their probability of reproducing, including also crossover and mutation. Figure 1 shows the evolution of the efficiency through the number of generations and also the evolution to the best node with the best reactive power input.

For this specific study the results obtained show an efficiency of $\eta_{GA} = 0.9405$. It is important to mention that as a consequence of using a random function to generate the value of $\alpha$, the results may vary for each run of the program. This result show how the efficiency of the study network is actually improved.

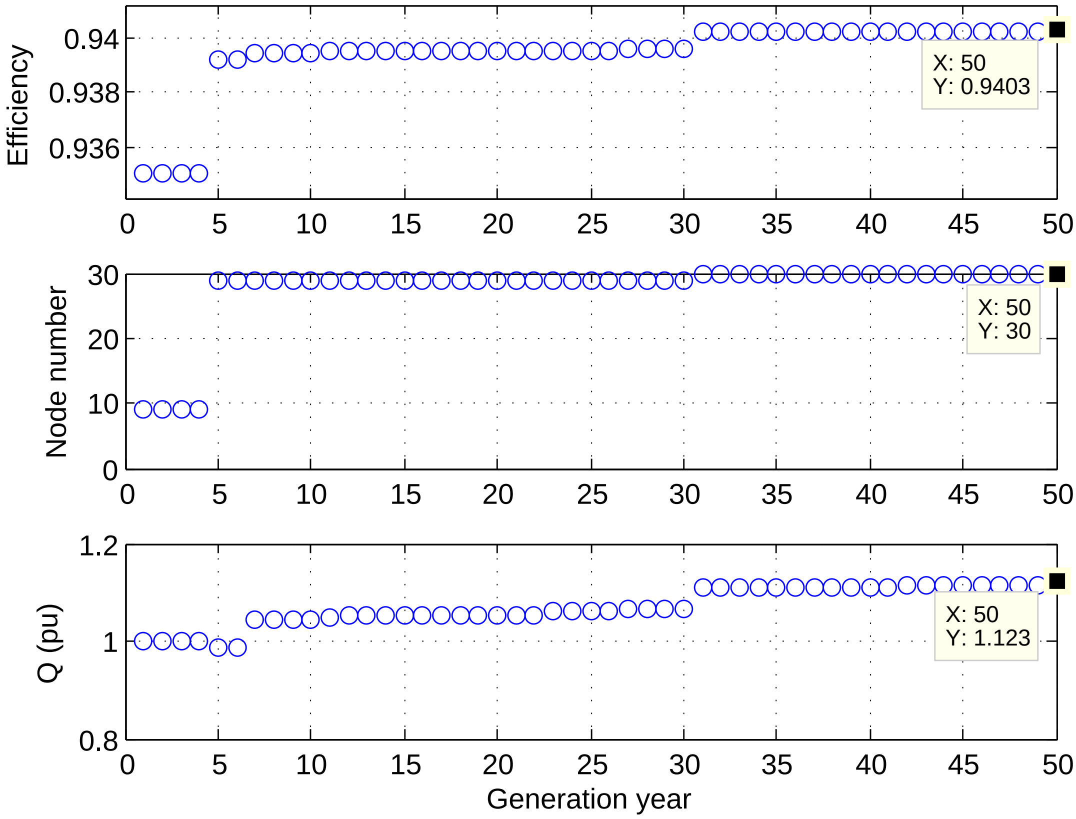


Figure 1: Efficiency Evolution

# References


[1] Mohd Fatihi Mustafar, Ismail Musirin, Mohd. Rozely Kalil, and Mohamad Khayat Idris. Ant colony optimization (aco) based technique for voltage control and loss minimization using transformer tap setting. In *Proc. 5th Student Conference on Research and Development SCOReD 2007*, pages 1–6, 12–11 Dec. 2007. 1

[2] M. A. Abido. Optimal power flow using particle swarm optimization. *International Journal of Electrical Power & Energy Systems*, 24(7):563–571, Oct. 2002. 1

[3] J.N. Fidalgo and J.A.P. Lopes. Forecasting active and reactive power at substations' transformers. In *Proc. IEEE Bologna Power Tech*, volume 1, page 6pp., 23–26 June 2003. 1

[4] Q.H. Wu and J.T. Ma. Power system optimal reactive power dispatch using evolutionary programming. *IEEE Transactions on Power Systems*, 10(3):1243–1249, 1995. 1

[5] S. Gerbex, R. Cherkaoui, and A.J. Germond. Optimal location of multi-type facts devices in a power system by means of genetic algorithms. *IEEE Transactions on Power Systems*, 16(3):537–544, Aug. 2001. 1

[6] P.S. Nagendra Rao K.C. Divya. Models for wind turbine generating systems and their application in load flow studies. *Electric Power Systems Research*, Volume 76:844–856, June 2006. 1