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IMPLEMENTATION OF GENETIC ALGORITHM FOR MINIMUM LOSS RECONFIGURATION OF DISTRIBUTION NETWORK IN MATLAB

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Abstract:

This paper introduces the implementation of genetic algorithm for reconfiguration of distribution network to minimize power loss in Matlab environnement. The program is validated by a distribution network.

Keywords:

Optimal operation configuration, distribution network, genetic algorithm, power loss reduction, implementation.

Tóm tắt:

Bài báo giới thiệu cách xây dựng chương trình tìm cấu trúc vận hành của lưới phân phối có tổn thất nhỏ nhất dựa trên thuật toán di truyền. Chương trình được viết trong môi trường Matlab và được kiểm chứng thông qua tính toán tìm cấu trúc tối ưu cho một lưới điện cụ thể.

Từ khoá:

Cấu trúc vận hành tối ưu, lưới phân phối, thuật toán di truyền, giảm tổn thất, xây dựng chương trình.

1. INTRODUCTION

Electricity distribution networks supply directly power to load so their main important tasks are to ensure power quality and reliability. Besides, loss reduction of the networks is an important problem which should be considered. There are many solutions to reduce losses in distribution networks for example: compensation, selection of appropriate transformer,... This paper proposes minimum loss reconfiguration. This means to determine the open and closed status of sectionalized and tie-switches which minimize the total distribution line losses subjected to the power carrying line capacity, voltage limits, radial network and other constraints.

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Moreover, with the development of automation systems on the network and especially the tendency to build a smart grid, the control of sectionalized and tie-switches will be very convenient and fast so we can change network structure on load.

Due to the change of load power over time the voltage, power flow and power losses change. So depending on the load mode an optimal configuration is applied for minimum power losses but still ensure the constraints of voltage, reliability, capacity of the lines...

Many research focus on the distribution system reconfiguration for loss minimization, such as the heuristic methods [1-4], the artificial intelligence methods [5-8]... This paper deals with the implementation of genetic algorithm for minimum loss reconfiguration of distribution networks in Matlab. To validate the program, a test for a distribution network of 32 bus was carried out. The organization of the paper is as follows:

- Section I: Introduction.
- Section II formulates a problem.
- Section III introduces the genetic algorithm for solving the problem proposed in section II and the implementation the algorithm in Matlab.
- Section IV represents the applications and results.
- Conclusions are given in section V.

2. FORMULATION OF THE PROBLEM

The objective of the problem is to find out the structure so that the total active power losses in the network is the smallest but still should meet the technical conditions.

The objective function:

$$\text{Min f} = \sum_{i=1}^{\text{total number of lines}} k_i R_i \left(\frac{P_i^2 + Q_i^2}{U_i^2} \right) \qquad (1)$$

Where:

k_i represents the status of the branch; k_i = 0 indicates an open branch, k_i = 1 indicates a close branch;

R_i: Resistance of the branch i;

U_i is the voltage of the ending node of the branch i;

P_i and Q_i are respectively active and reactive power flowing through the branch i.

Constraint conditions:

- Power carrying capacities.

$$\begin{aligned} k_i P_i &\le P_{imax} \\ k_i Q_i &\le Q_{imax} \end{aligned} \qquad (2)$$

- Bus voltage limits:

$$U_{jmin} \le U_j \le U_{jmax} \qquad (3)$$

- Kirchhoff’s current law.
- Kirchhoff’s voltage law.
- Connectivity of the system: there is no isolated bus and structure is radial.

3. IMPLEMENTATION OF THE GENETIC ALGORITHM FOR MINIMUM LOSS RECONFIGURATION IN MATLAB

The genetic algorithm allows us to find the optimal solution based on natural selection, genetic and evolution process.

Starting by a population (called initial population), the algorithm performs the operations: selection, crossover, mutation to produce a new generation. Thank to inheritance the new generation is better. The principle of the genetic algorithm is shown in figure 1 [5].

In genetic algorithm, each configuration is called chromosome. The number of bit in the chromosome is equal to the total number of sectionalized and tie-switches.

A set of chrosomones is called population.

To apply the genetic algorithm to find a minumum loss configuration for distribution networks, binary encoding is used. In this encoding, every chrosomone is a string of bits, 0 or 1. The bit 0 represents an open switch and the bit 1 represents a closed switch.

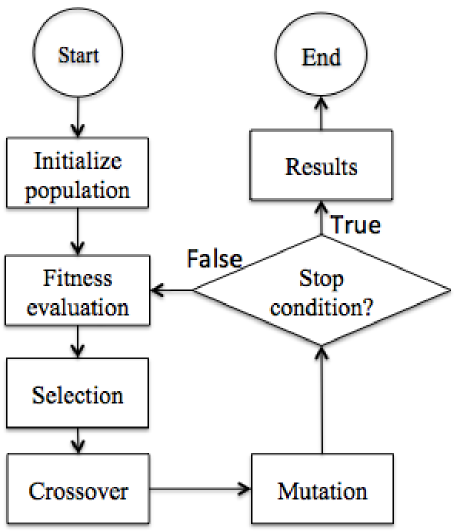

Figure 1. Genetic Algorithm

For a distribution network containing 3 switches: the first switch is closed, the second one is open, the third one is closed, this corresponds to a binary encoding 101.

Figure 2 represents the minimum loss reconfiguration by the genetic algorithm [5, 8].

Population initialization: a population is randomly generated or by using branch-exchange.

Population decoding: From each bit of a chromosome, the corresponding branch is determined to be open or closed. This helps us to rebuild the structure of the distribution network of each chrosomone.

Load flow for each structure (corresponding to each chromosome) is performed by Gauss-Seidel method.

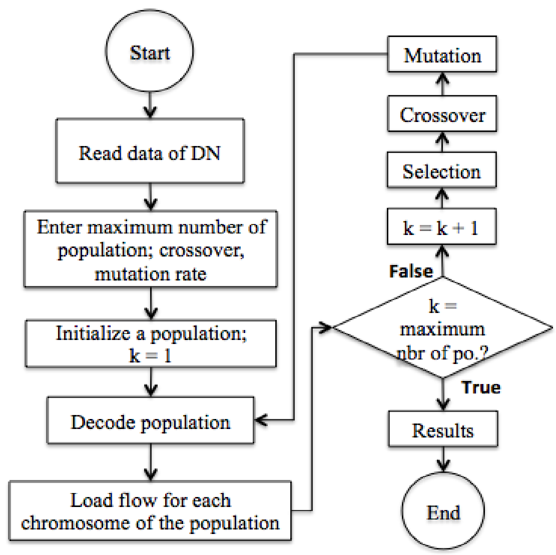

Figure 2. Minimum loss reconfiguration by the genetic algorithm

Selection, crossover and mutation operations are performed with rates enterring by the user.

The algorithm on figure 2 is implemented in Matlab environment. Main functions of the program are as follows:

- readData.m-Function for bus and branch data loading: Bus and branch data is entered in 2 sheets of 1 excel file. This function reads the data from the file and assigns to corresponding variables;

- lfGS.m-Function for load flow analysis based on Gauss-Seidel method;

- initPopu.m-Function for initialize population;

Appendice 2. Load power and branch resistance and reactance

Bus	P load (kW)	Q load (kVAr)	Branch	R (Ohm)	X (Ohm)
2	100	60	1	0,0922	0,047
3	90	40	2	0,493	0,2512
4	120	80	3	0,3661	0,1864
5	60	30	4	0,3811	0,1941
6	60	20	5	0,819	0,707
7	200	100	6	0,1872	0,6188
8	200	100	7	0,7115	0,2351
9	60	20	8	10,299	0,74
10	60	20	9	1,044	0,74
11	45	30	10	0,1967	0,0651
12	60	35	11	0,3744	0,1298
13	60	35	12	1,468	11,549
14	120	80	13	0,5416	0,7129
15	60	10	14	0,5909	0,526
16	60	20	15	0,7462	0,5449
17	60	20	16	12,889	1,721
18	90	40	17	0,732	0,5739
19	90	40	18	0,164	0,1565
20	90	40	19	15,042	13,555
21	90	40	20	0,4095	0,4784
22	90	40	21	0,7089	0,9373
23	90	40	22	0,4512	0,3084
24	420	20	23	0,898	0,7091
25	420	20	24	0,8959	0,7071
26	60	25	25	0,2031	0,1034
27	60	25	26	0,2842	0,1447
28	60	25	27	10,589	0,9338
29	120	70	28	0,8043	0,7006
30	20	600	29	0,5074	0,2585
31	150	70	30	0,9745	0,9629
32	210	10	31	0,3105	0,3619
33	60	40	32	0,3441	0,5302
			33	0,5	0,5
			34	2	2
			35	2	2
			36	2	2
			37	0,5	0,5

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Biography:

Thanh Son Tran received the engineer's degree in electrical engineering from Hanoi University of Science and Technology in 2004, the M.Sc. degree in electrical engineering from Grenoble Institute of Technology in 2005, and the Ph.D degree in electrical engineering from Joseph Fourier University, France in 2008. He was a PostDoctoral Researcher in Grenoble Institute of Technology Enterprise from 2009 to 2010.

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