J. Basic. Appl. Sci. Res., 3(2s)172-179, 2013
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ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

The Optimal Design of a New Medium Voltage Distribution Feeder Routing With a New Look to the Genetic Algorithm

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Received: June 10 2013
Accepted: July 10 2013

ABSTRACT

A new look to genetic algorithm foroptimal design of a new medium voltage distribution feeder routing is presented in this article. the initial solution based on authentic references is determined and then , with implementation of proposed genetic algorithm, the objective function which consists of investment cost and energy loss cost, is minimized.And finally the existing solution will be improved. This method can be implemented on single-stage or multi-stage power distribution system planning. It is simulated on 30 and 53 load point networks and results have been investigated.

KEYWORDS: Distribution system planning, Geneticalgorithm,feeder cross section, Medium voltage feeder routing.

1.INTRODUCTION

Optimal power distribution system planning is one of the most important tasks in power systems and must beperformed in such a way that suggested scheme operates in optimal condition and some limitations like authorized limit of busses voltages , suitable capacity of lines, suitable number of loads that feeding routs and authorized capacity of production points in system be satisfied. references [3],[4]study distribution system planning with the aim of determining sizes and optimal places of super- distribution postsand medium voltage feeder routing with minimum spanning tree method. In reference [5] ant colony algorithm is usedfor optimal power distribution system planning in reference [5]. Objective function includes fixed costs which is related to line investment costsand posts,and unfixed (changeable)costs related to systems operation. the power system expansionrelated to annual load developmentsis done using genetic algorithm and ant colony algorithm in references [6],[7] respectively. In reference [8], apower distribution planning approach is implementedwhose aim is to determine the size and optimal places of super-distribution posts and medium voltage feeder routing. Reference[9] studies medium voltage feeder routing and determining its cross section area with an objective function of fixed and unfixed costs and reliability costs, using seeking programming approach. In reference[10] an objective function which is consisted of outage cost ,active feeder loss cost and investment and storage cost is minimized, using simulated annealing approach and optimal route of medium voltage feeder between pre-determined routs is selected. in reference[11] genetic algorithm is implemented for optimal expansion of power distribution systems with an objective function of feeder establishing investment cost and future super-distribution posts. In mostof referencesfeeder routing is done considering only pre-supposed routs. In this paper it is endeavored to implement medium voltage feeder routing without using pre-supposed routes, by imposinggenetic algorithm in a new approach on the resultsof minimum spanning tree method and reach optimal definite solution.

This methodreach thedefinite solution with better speed . on the other hand in this approach it is possible to determine some routes that haven't the possibility of establishing medium voltage feeder (because of geographical limitations), so no feeder establishing is done in such routs.

2. DIRECT POWER FLOW

Direct distribution power flow is an important and basic tool in investigating each power system both in planning and operation. Optimization ofa power system, requires continues solution of distribution loads. the approach which is used in this paper for distribution loads, is direct distribution power flow. In this methodinformation aboutsystems voltages and currents is gathered in two BIBC and BCBV matrixes with full relations and without making simplification which has high convergence speed.this approach profitsradius net properties and avoid using admittance matrix.

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3. MEDIUM VOLTAGE FEEDER ROUTING ALGORITHM

medium voltage feeder routings must be done in such a way that minimizing the cost of investment and losses in distributionsystem that are objective functions of the optimization problem. The suggested algorithm in this paper includes two stages.In thefirst stage, system feeders are classified on the basis of reference [3] and an initial solutionis resulted for the system.And in the second stage, operatorstry to make it close to the definite optimal point using genetic algorithm.

3-1. FIRST STAGE

With an example a post feeder classification and its allocated loads is explained by minimizing spanning free approach[3].

In figure (1) consider ‘s’ and‘ś’as(1).

S={post}, ś ={all loads points} (1)

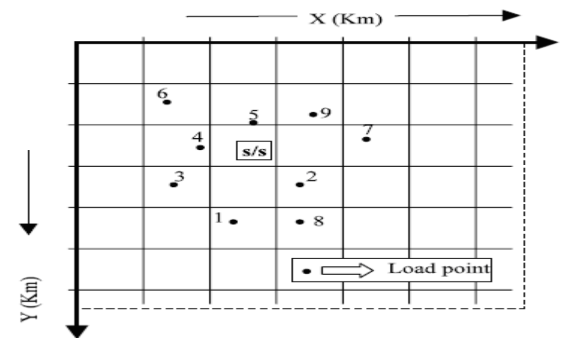

Figure (1) load point locations of studied distribution system [3]

The distances between all load points of ‘ś’ set to ‘s’ set is calculated and each of load points of ‘ś’ set that had lower distance is connected to the post and then transfer to ‘s’ set. In thissection the number of load points that are selectedfrom‘ś’set and transfer to ‘s’ set will be determined by the number of output feeder of the post.

Its supposed that it ispossibleto establish two output feeder from the post , and load points 4 and 5 arethe load points that have lowest distance from post. So ‘s’ and ‘ś’ set are as(2):

S={(post,4),(post,5)} (2)

S ={1,2,3,6,7,8,4}

In this situation, connected feeders from post to the load points 4 and 5, are considered as system output feeders. now again the distance between other load points of‘ś’ set and members of‘s’ set is calculated and like previous stageeach of these load points of ‘ś’ set that have the lowest distance is selected to connect to the system. note that in this stage calculating the distances performone time for member of ‘ś’ set to " load point 4 ", and another time to " load points 5 "and deleted from post distance calculation. Each member of ‘ś’ set that has the lowest distance from output feeders, is connected to that feeder. two condition are investigated:

First condition : if load point 9 has the lowest distance from load point 5, then load point 9 is connected to load point 5 in new system and ‘s’ and ‘ś’ set will become as(3):

S={(post,4),(post,5,9)} (3)

S = {1,2,3,6,7,8,}

Second condition : if load point 3 has the lowest distance from post, load point 3 in new system is connected to load point 4 and ‘ś’ and ‘s’ set are as(4):

S={(post,4,3),(post,5)} (4)

S={1,2,6,7,8,9}

And this trend continuesas mentioned and repeated untill‘ś’ set has no member else. note that the number of output feeder from post can be determined on the basis of geographical limitations e in establishing output feeder.

3-2: SECOND STAGE

In this stage, resultant system of the first stage is considered as a system which is close to optimal operational point [3] and definite optimal point would be attained by using presented genetic algorithm operators in this part. System’s information includes spatialcoordinates , number of loads , load points and the method of connecting load points to each other.these information is stored in two coo-new (including load points coordinates and the number of load points with n*3 dimensions, that n is the number of load points plus 1 considering super-distribution post as a node) and M-relation (the method of connecting load points to each other with n*n dimension) matrixes. In the appendix a sample distribution net (figure (10)) and its related M-relation matrix is given. The net which is obtained from minimizing spanning tree method, is named initial solution close to the optimal point; figure(2).

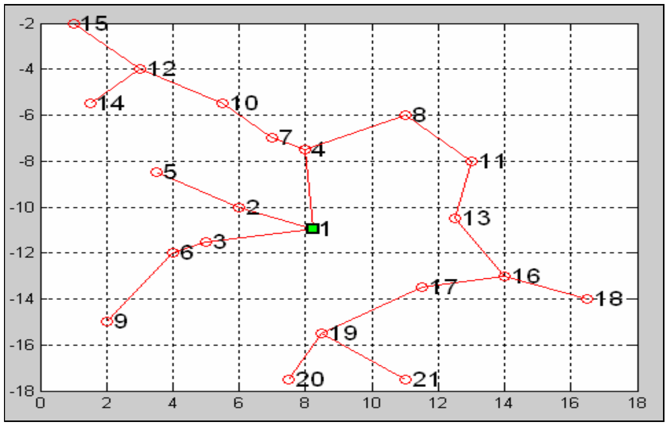

Figure (2) network of the shortest path method

genetic algorithm in computational operations (generations) operates on the population of chromosomes, and random variations are pperformed on the set of chromosomes by applying genetic operators. After applying these operators , the sequence of choromosoms are beeing decoded, and different solutions on the operation point of view will be evaluated on the basis of objective function(5) which Consists of investment and energy losses costs,then next generation selection would be performed on the basis of this evaluation.

$$F=\sum_{j=1}^{ns} L_j \times C(con_j)+\sum_{i=1}^{N} P_{loss,i} \times C_E \times PW^i \times 8760 \times LSF_i \qquad (5)$$

$$PW=(\frac{1}{1+\text{int}\, r})$$

ns is the number of net feeders ,Lj is the length of feeder J,(CONj) is the cost of feeder in section j,N is the life of lines (yaer) , Ploss,i is the power losses in year 'i' (kilowatt), CE is energy cost , PW is current value, LSFI is losses in year and 'intr' is the rate of benefit. In calculating equation (5), it must be noticed that loads development rate for each year is considered. Energy losses for each year can be obtined from muliplying carrier losses power in the number of hours for one year (8760) and losses index[4],[5]. Genetic algorithm changes net connections by usin related operators and try to improve existing system and minimize objective function. Suggested operators of genetic algorithm that are applyed on initial solution,have been performed in this paper.

CROSS OVER

Cross over operates on two chromosoms of existing population and change their features accidentally.

two parents are beeing affected by cross over that have good features, beeing combined to each other and make two children.At this part M-relation matrix is used instead of one string of number 0 and 1 chromosom. If in this matrixa little change is made and a new matrix be made, this new matrix can be considered as previose matrix child, because it has most of previos matrixs features. In this operator the system can be devided into two parts by changing a 1 to 0. in other word one part remains feedless.Created islandsare named so as the part that contains the post is set 1 and the other part named set 2.

Now,from set 1 in figure (3)determined number of points are selected that have the lowest distance from load point 11 (accidental load point from set 2) and are stored in matrix A1.members of island 2 are also stored in matrixA2.

A1=[8,4,7,10,1] (6)

A2=[11,13,16,17,18,19,20,21]

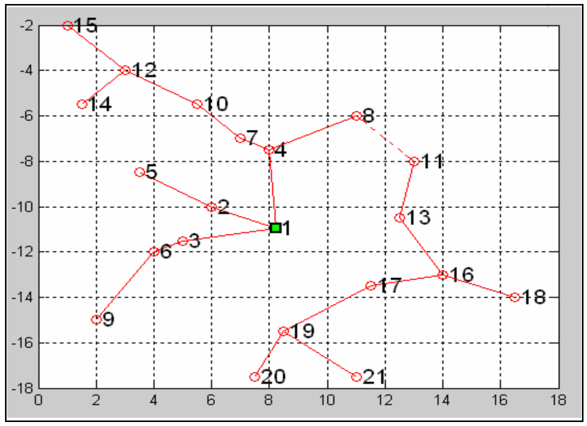

Figure (3) before applying the genetic algorithm operators

now, its time to select one of A1 set members accidentally and attach to one of A2 set members in order tofeed the islanded part. to avoid impossiblesolutions, the algorithm operates in such a way that for example point 1 (accidentally) from A1 setis selected and determined number of load pointsfrom A2 set are chosen accidentally that have the least distance from load point 1 and are placedin new set A22.

A11=[1]

A22=[13,17,19] (7)

Now one of members of A22 set is attached to node 1 accidentally and figure 4 will be obtained.

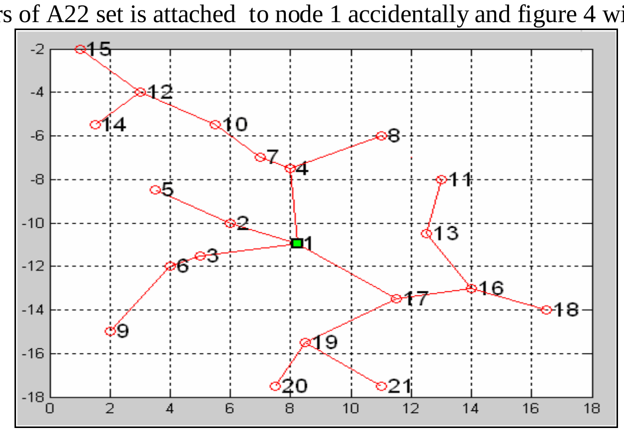

Figure (4) after applying cross over operator

MUTATION

This operator makes a great change in the existing solution and relax the problem from local optimal point that maight be guided to a better solution.whit this operator a great change in chromosome is made and the solution area can be searched. Applying this operator to the system is like cross over operator presented in previous part, just instead of one line be opened and one line be closed, two or tree lines are opened and closed simultaneously.this cause a great chnge in the topology of existing solution.

PERTURBATION

This operator in genetic algorithm causes slight changes in solution and help the problem reaches to definit optimum value if the solution is close to definite optimal point. This operator works in such way that makes new chromosoms by causing very slight change in chromosoms or good chromosoms. For example, its possible that changing in just one of feeding routes in the planned system, lead to a better solution. these slight changas are applied on good chromosoms and add another solution to next generation. For exaple, if the system of figure(4) is the best solution that has been transfered to the next genertion,to apply perturbation operator on it,one of system lines like line 1-3 is disconnected and point 1 or one of its close points(points 2 and 17) is connected to one of front points to points 3 (points6) or points 3 or its close points to point 1 accidentally (figure 5).

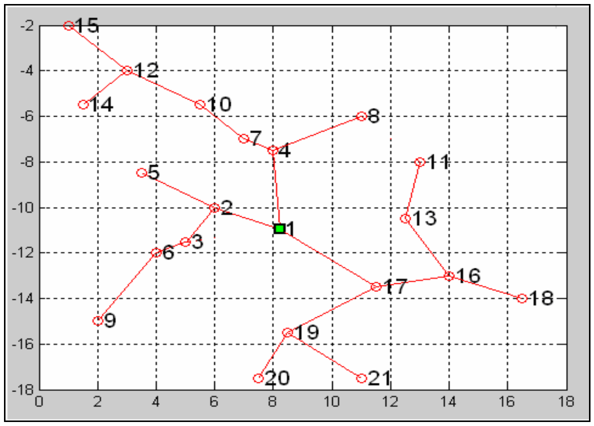

Figure (5) after applying perturbation operator

SELECTION

Selection is an operator that determines next generation chromosoms from current population on the basiss of survival of the fittest law. this operation is the most important stage in genetic algorithm that has playes an important role in the process. Ther are different methods for this operation that can be referedas rolette wheel and tournment approaches.in this paper tournament approach is used.in this approach determined number of chromosomes with high suitability are selected and transfered to the next generation.in this generation determined number of chromosome are made from trnsferred chromsomes whith described opertors workings.because there isnt specific convergent condition for genetic algorithm, completion criterion of optimizing operation is on the basis of repeating production of new chromosomes and after determinied number of productions, optimizing is finished. The benefits of new apprach in using genetic algorithm operators in making new solution is that in this condition the possibility of loop creation doesn't exist. also by observing some obligations like selecting the points without electricity near system for making electricity in the feedless port, unpossible solution will not be made. Without observing aboveobligations, there is possibility of attaching farest load points in to each other for giving electricity to the feedless points as a new solution that might cause problems in convergency and infact considered as an impossible solution.

4. SELECTING FEEDER OPTIMAL CROSS SECTION

The aim of selecting feeder optimal cross section is to design medium voltage system that minimizes objecive function which consists of investment and active power losses costs. Refrence[12] uses evolutionary algorithm approach to determine cross section.

The used approach in this paper is peresented in[13].

Refrences[13] and [14] use innovative approach fordetermining cross section. In designing system its required to apply sub program of selecting cross section in each stage, so an approach with high performance speed and strong solution is needed.

5. REVIEWING SAMPLE SYSTEMS

Above mentioned approach reviewed on systems with 30 and 53 load points.information of load points and load points locations is available in table (3) of index for studying system with 30 load points,and for system with 53 load points is available in[3]. Economical and technical data is given in table (1) and(2) respectively.table (4) shows comparssion between results related to system designing on the basis of presented approach in this paper. This comparission shows that suggested approach is better for medium voltage feedering.

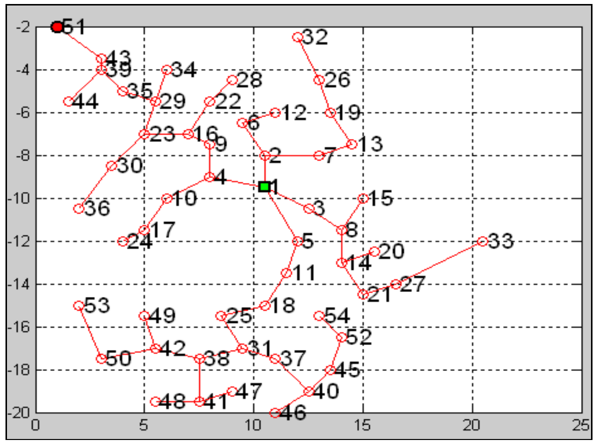

Figure (6) the network routing [3]

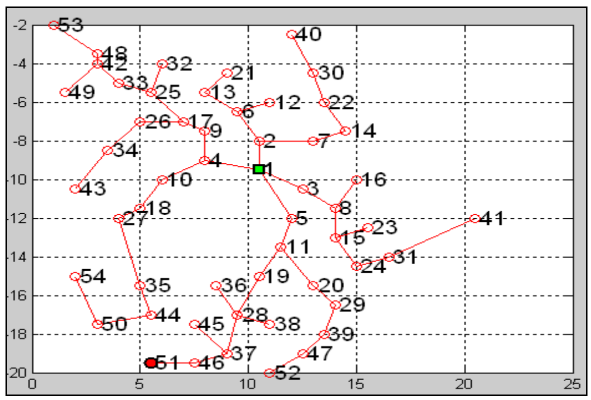

Figure (7) the network routing the proposed method

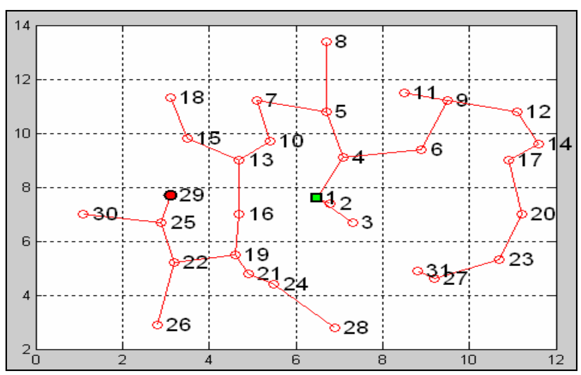

Figure (8) the network routing [3]

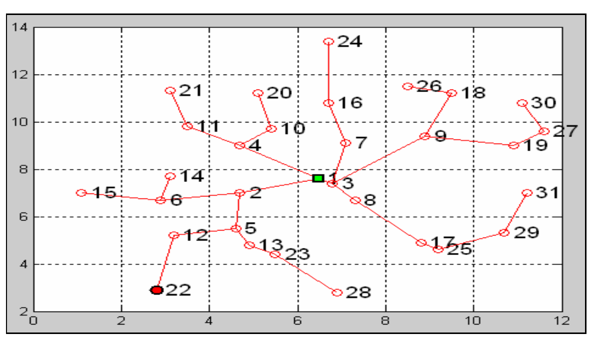

Figure (9) the network routing the proposed method

Table (1) results comparison

Figure num.	Objective function value	Active power loss (kW)	Least network voltage
Figure 6	1.31E+09	91.23	0.95
Figure 7	1.15E+09	100.3	0.9501
Figure 8	1.27E+09	641.3	0.8112
Figure 9	6.29E+08	659.3	0.956

CONCLUSION

This paper presents an approach for medium voltage feeder routing by designing distribution systems with new feauured of genetic algorithm. This feeder routing approach leads to optimal solution whit higher speed because of applyingrequired reformations on obtained solution from authorized sources and applying controlled genetic algorithms operators. Obtained results are better fromthe investment and enrgy looses costs point of view. Presented approach in[3],[4] depends on point locations,figure (8), so by using suggested appeoach high improwment can be obtained;table (1).

APPENDIX

Table (2) network economical information

N	10 years	V nominal	11 kV
Lntr	15 %	CE	30
Lsf	0.45	Min voltage	0.95 pu
Power factor	0.85	Load growth	7 %

Table (3) conductors technical information

Conductor Type	Cross Section (mm^2)	Resistance (Ω/km)	Reactance (Ω/km)	Price (R/km)	Max Current (Amp.)
Squirrel	12.9	1.376	0.3896	1E+07	80
Weasel	19.35	0.9108	0.3797	1.2E+07	100
Rabbit	32.26	0.5441	0.3673	1.5E+07	120
Raccon	48.39	0.3657	0.3579	1.7E+07	150

Table (4) load points and location information for the study of system with 30 load points

Load point num.	Axis X coordinate	Axis Y coordinate	Load 0.001*kVA	Load point num.	Axis X coordinate	Axis Y coordinate	Load 0.001*kVA
1	5.8641	4.3129	2.50E+05	26	2.477	7.3246	3.15E+05
2	5.4724	4.2836	2.50E+05	27	2.7304	6.6228	3.15E+05
3	5.5415	3.845	2.50E+05	28	3.2604	6.8275	3.15E+05
4	4.6659	3.2602	2.50E+05	29	3.1912	6.1257	3.15E+05
5	4.4585	3.7865	2.50E+05	30	3.8364	5.7164	3.15E+05
6	3.6982	3.7865	2.50E+05	31	3.4447	5.3655	3.15E+05
7	3.7903	2.7632	2.50E+05	32	3.5369	4.6637	3.15E+05
8	4.6198	2.4123	2.50E+05	33	4.9654	5.3947	3.15E+05
9	5.4954	2.4123	4.00E+05	34	4.7811	6.3889	3.15E+05
10	5.9562	2.6462	4.00E+05	35	5.3341	6.7398	2.50E+05
11	6.394	3.0848	4.00E+05	36	5.5876	6.2427	2.50E+05
12	6.394	2.3246	4.00E+05	37	6.1406	5.2485	2.50E+05
13	6.1406	1.7982	4.00E+05	38	4.182	4.4298	4.00E+05
14	4.6198	4.3129	4.00E+05	39	2.1083	5.5409	2.50E+05
15	3.3295	4.1374	4.00E+05	40	6.6935	6.7105	2.50E+05
16	3.1912	3.6988	4.00E+05	41	6.8318	4.3129	2.50E+05
17	2.9608	3.348	4.00E+05	42	5.3802	7.4708	2.50E+05
18	2.3387	4.1959	2.50E+05	43	4.735	7.4708	2.50E+05
19	7.0392	3.2602	2.50E+05	44	4.159	7.1199	2.50E+05
20	4.9194	1.9152	3.15E+05	45	3.5369	7.7339	2.50E+05
21	4.1359	1.8275	3.15E+05	46	7.2696	5.1023	2.50E+05
22	3.2604	1.7398	3.15E+05	47	6.8779	5.7456	3.15E+05
23	2.5691	1.9444	3.15E+05	48	4.5276	8.1725	3.15E+05
24	7.523	2.9094	3.15E+05	49	4.3433	8.845	3.15E+05
25	4.4124	9.7222	3.15E+05	50	3.9055	9.3129	3.15E+05

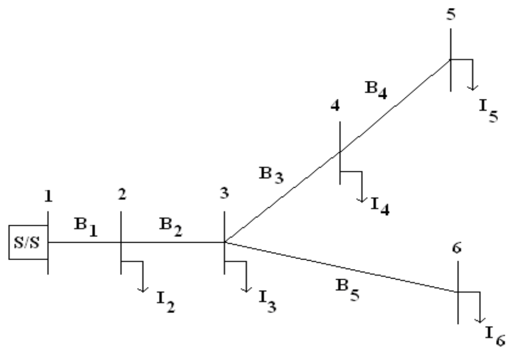

Figure (10) case study network

$$\begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix}$$

Figure (11) M-relation matrix

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