



OPTIMAL CONDUCTOR SELECTION FOR RADIAL DISTRIBUTION NETWORKS USING GENETIC ALGORITHM IN SPDCL, AP – A CASE STUDY

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ABSTRACT

In any radial distribution system, the optimal choice of the size of conductor in each branch of the system, which minimizes the sum of depreciation on capital investment and cost of energy losses, is important. This paper presents the methodology for the selection of optimal conductors, in radial distribution systems. The main objective is to minimize the real and reactive power losses in the system and also to maximize the total saving in cost of conducting material while maintaining the acceptable voltage levels. The optimal selections of conductor sizes are obtained by conventional method and genetic algorithm method. The conductor, which is determined by conventional method will satisfy not only the maximum current carrying capacity and maintain acceptable voltage limits. Apart from this it gives the maximum saving in capital cost of conductor and cost of energy loss in radial distribution system. The number of computations is more in conventional method that is why genetic algorithms are employed for the optimal selections of conductor sizes. The effectiveness of the proposed methods is tested on the feeders of Andhra Pradesh southern power Distribution Company limited.

Keywords: *conductors, feeders, genetic algorithm, conventional method, real power loss, reactive power loss, distributed load flow, cost and savings.*

INTRODUCTION:

A distribution system provides a final link between high voltage transmission systems and consumer services. The power loss is significantly high in distribution systems because of lower voltages and higher currents, when compared to that in high voltage transmission systems. Studies have indicated that as much as 13% of total power generated is consumed as i^2R losses. Reactive currents account for a portion of these losses. Reduction of total loss in distribution systems is very essential to improve the overall efficiency of power delivery. The pressure of improving the overall efficiency of power delivery has forced the power utilities to reduce the loss, especially at distribution level.

The i^2R loss in a distribution system can be reduced by reconfiguring the network. The reconfiguration process changes the path of power flow from the source to the loads. In

recent years, considerable attention has been focused in planning of a distribution system, to reduce the power and energy losses, to reduce the capital investment involved and to provide better quality supply to consumers. Improved modeling techniques and certain optimization and programming approaches has been presented to determine the best location, and suitable interconnections between sub-stations so as to meet the increasing demands more reliably and economically. In these approaches, shunt capacitors are introduced to reduce losses and to provide reactive power compensation, and the size and type of conductors for each feeder segment are designed based on the current carrying capacity of the optimal feeder configuration.

In most of the existing distribution systems, the conductors are not selected in a systematic way. Therefore, the capital cost of conducting material

and power loss in the feeders is more and also the maximum carrying capacity and voltage limits are not generally satisfied.

Several methods of loss reductions in distribution systems have been reported over years. Control of reactive power in distribution systems with end load and fixed load and varying load have been reported giving generalized equations for calculating peak and energy loss reductions and optimum location and rating of capacitors. Other studies have been reported on reactive power compensation that used uniformly distributed load, a simple line feeder that had no lateral tree, or a simple lateral feeder without branches. All these may not be considered as realistic distribution systems.

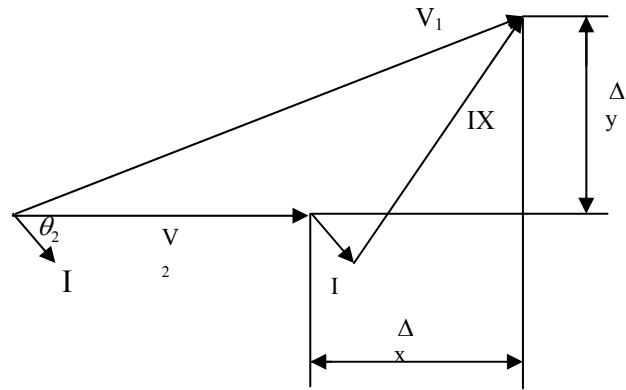
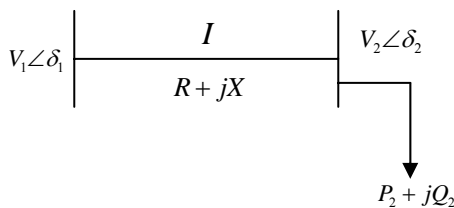
Further, Genetic Algorithms are proposed for selecting the optimal size of conductor for radial distribution networks. The conductor, which is determined by this method, will satisfy the maximum current carrying capacity and maintain acceptable voltage levels of the radial distribution systems. In addition, it gives the maximum saving in capital cost of conducting material and cost of energy loss when compared with conventional method. The proposed methods were tested on the feeders of ASPDCL and the results are very encouraging.

Load flow method:

Load flow calculation is an important and basic tool in the field of power system engineering. It is used in planning and design stages as well as operation stages of the power system. Some applications especially in the fields of optimization of power system need fast converging load flow solutions. The proposed method uses vector distributed load flow method.

Consider a line connected between two nodes as shown in the fig 1

Fig: 2 Basic phasor diagram of a line connected between two nodes



From fig 2 the following equations are derived

$$V_1^2 = (V_2 + \Delta x)^2 + \Delta y^2 \dots \dots \dots > 1$$

$$\text{Where } \Delta x = IR \cos(\theta_2) + IX \sin(\theta_2) \dots \dots \dots > 2$$

$$\Delta y = IX \cos(\theta_2) - IR \sin(\theta_2) \dots \dots \dots > 3$$

Using the equations 3.2 and 3.3 in 3.1 we have

$$V_1^2 = (V_2 + IR \cos(\theta_2) + IX \sin(\theta_2))^2 + (IX \cos(\theta_2) - IR \sin(\theta_2))^2$$

$$V_1 = (V_2 + IR \cos(\theta_2) + IX \sin(\theta_2))^2 + (IX \cos(\theta_2) - IR \sin(\theta_2))^2 \dots \dots \dots > 4$$

To eliminate I from the equation 4 use

$$I \cos(\theta_2) = P_2 / V_2$$

$$I \sin(\theta_2) = Q_2 / V_2$$

Where P₂ = Total active power load including active power loss beyond node 2.

Q₂ = Total reactive power load including reactive power loss beyond node 2.

$$\text{Thus } \Delta x = IR \cos(\theta_2) + IX \sin(\theta_2) = (P_2 R + Q_2 X) / V_2$$

$$\Delta y = IX \cos(\theta_2) - IR \sin(\theta_2) = (P_2 X - Q_2 R) / V_2$$

Thus equation 3.4 becomes

$$V_1^2 = (V_2 + (P_2 R + Q_2 X) / V_2)^2 + ((P_2 X - Q_2 R) / V_2)^2$$

$$= (V_2^2 + 2V_2 (P_2 R + Q_2 X) / V_2 + (P_2 R + Q_2 X)^2 / V_2^2 + (P_2 X - Q_2 R)^2 / V_2^2)$$

$$V_1^2 V_2^2 = V_2^4 + (P_2 R + Q_2 X)^2 + 2V_2^2 (P_2 R + Q_2 X) + (P_2 X - Q_2 R)^2$$

$$V_2^4 + 2V_2^2 (P_2 R + Q_2 X) + (P_2^2 + Q_2^2) (R^2 + X^2) - V_1^2 V_2^2 = 0$$

$$V_2^4 + 2V_2^2 (P_2 R + Q_2 X - V_1^2 / 2) + (P_2^2 + Q_2^2) (R^2 + X^2) = 0 \dots \dots \dots > 5$$

Equation 5 is in the form of ax²+bx+c=0, the roots of this equation are



$$(-b + (b^2 - 4ac)^{1/2})/2a \text{ and } (-b - (b^2 - 4ac)^{1/2})/2a.$$

From the two solutions for V_2 only positive root of quadratic equations gives a realistic value. Thus V_2 is solved as follows:

$$V_2 = \left\{ \frac{(P_2R + Q_2X + 0.5V_1^2) - (P_2^2 + Q_2^2)}{(R^2 + X^2)^{1/2} - P_2R + Q_2X + 0.5V_1^2} \right\}^{1/2} \text{-----}>6$$

This is straightforward solution and doesn't depend on the phase angle, which simplifies the formulation of the problem. In distribution system the voltage angle is not so important because the variation of voltage angle from the substation to tail of distribution feeder is only few degrees. However, if complex power flows in lines are required phase angles also considered.

The equation 3.6 can be written in general form as

$$V_2 = (B[j] - A[j])^{1/2} \text{-----}>7$$

Where subscript '2' is the receiving end of jth branch. subscript '1' is the sending end of jth branch.

$$A[j] = P_2R[j] + Q_2X[j] - 0.5V_1^2 \text{-----}>8$$

$$B[j] = [A[j]^2 - (P_2^2 + Q_2^2)(R[j]^2 + X[j]^2)]^{1/2} \text{-----}>9$$

Where P_2 and Q_2 are total real and reactive power load feed through node 2

After calculating the effective loads at all nodes, the voltages can be calculated using equations 7, 8 and 9.

Let $P_{loss}[j]$ and $Q_{loss}[j]$ be the real and reactive power loss of branch 'j', then the initial estimates of loads are taken as the loads are taken as the effective loads at all nodes and then losses are calculated using the equations

$$P_{loss}[j] = R[j] * (P_2^2 + Q_2^2) / V_2^2 \text{-----}>10$$

$$Q_{loss}[j] = X[j] * (P_2^2 + Q_2^2) / V_2^2 \text{-----}>11$$

3.2 Phase angle calculation:

In this method phase angles can also be calculated along with the voltage magnitudes at the end of convergence. The line diagram is shown below in figure:

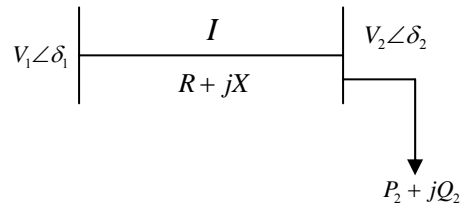


Fig: 3 Line diagram of line between two nodes for phase angle calculation

$$P_{2eff} + Q_{2eff} = V_2 \cos(\theta) \text{-----}>13$$

From equations 12 and 13 we can write

$$P_{2eff} + Q_{2eff} = V_2 \cos(\theta) (V_1 \cos(\delta_1) - V_2 \cos(\delta_2)) \text{-----}>14$$

$$V_2 \cos(\theta) = \frac{P_{2eff} + Q_{2eff}}{V_1 \cos(\delta_1) - V_2 \cos(\delta_2)}$$

$$V_2 \cos(\theta) = \frac{P_2 + jQ_2}{V_1 \cos(\delta_1) - V_2 \cos(\delta_2)}$$

$$P_{2eff} = V_1 * V_2 \cos(\theta) \cos(\delta_1 - \delta_2) \text{-----}>15$$

As the phase angles are already calculated θ is known and V_1 , V_2 and δ_1 are also known at the end of convergence of voltages. δ_1 is taken as zero.

$$\cos(\delta_2 + \theta) = (|Z| / (V_1 V_2)) * [P_{2eff} + (V_2 / V_1) * \cos(\theta) / |Z|] \text{-----}>16$$

$$= (|Z| / (V_1 V_2)) * [P_{2eff} + (V_2 / V_1) * \cos(\theta) / |Z|]$$

$$\text{Let } x = \delta_2 + \theta$$

$$y = (|Z| / (V_1 V_2)) * [P_{2eff} + (V_2 / V_1) * \cos(\theta) / |Z|]$$

$$\text{Then } x = \cos^{-1}(y)$$

$$x = \delta_2 - \delta_1 + \theta$$

$$\text{therefore } \delta_2 = x + \delta_1 - \theta \text{-----}>17$$

Thus the phase angles can be calculated at all buses. After the calculation of angles the accurate power flows are calculated using the converged voltages and the phase angles at each bus, following standard equations. The next section gives the complete algorithm for vector based distribution load flow.

Algorithm:

- Step1:** Read the system line data and bus data
- a) System data: no of buses, no of lines, reference bus or slack bus
 - b) Line data: from bus, to bus, line resistance, line reactance
 - c) Bus data: Bus no, Pld, Qld.
 - d) Read itmax, epsilon, kvab, kv and initial voltages at all buses.



Step2: Form Ybus
identify ie, sending end node (is),
receiving end node
ir), xq and x1 vectors.

Step3: Calculate effective load at each bus
starting from the
last bus
Peffp = Pp+ sum of all loads beyond
the node p.
Qeffp = Qp+ sum of all loads beyond
the node p.

step4: Initialize sum of active power loss
plss=0, sum of
reactive power loss qlss=0, previous
iteration active
power loss pl=0, reactive power loss
ql=0.

Step5: Start iteration count it=1

Step6: Initialize total active power loss tpls[i]
=0, total
reactive power loss tqls[i] =0 for i=1 to
n.
(tpls[i] = total active power loss, tqls[i]
= total reactive power loss)

step7: Assign plss=pl, qlss=ql, pl=ql=0.

Step8: If iteration it=1 go to step 10 else go to
step 9

Step9: Find the effective losses at each bus
for i=n to 1
for j=is[i] to ir[i]
q=xq[j], k=x1[j]
tpls[i] = tploss[i] +tploss[q] +ploss[k]
tqls[i] = tqloss[i] +tqloss[q]
+qloss[k]
line
Where ploss[k] = active power loss
line
qloss[k] = reactive power loss of
kth line

step10: Calculate load at each bus with losses
Active power P[i] = Peffld[i] +
tpls[i].
Reactive power Q[i] = Qeffld[i] +
tqls[i].

Step11: for bus no i=2 to n
for j=is[i], q=xq[j], k=x1[j]
A= (P[i]*r[k] + Q[i]*x[k])-(0.5*
V[q]*V[q])
B= sqrt (A*A -(r[k]*r[k]
+x[k]*x[k])*(P[i]*P[i]
+Q[i]*Q[i]))
V[i] = sqrt (B-A)
ploss[k] = r[k]* (P[i]*P[i] +Q[i]
*Q[i])/V[i]*V[i]
qloss[k] = x[k]* (P[i]*P[i] +Q[i]
*Q[i])/V[i]*V[i]
pl=pl+ploss[k]
ql=ql+qloss[k]

step12: Δpls= plss-pl; Δqlss= qlss-ql
set pls[i] =qls[i] =0 for 1 to ln

step13: if Δpls< epsilon and Δqls<epsilon go
to step 16 else
go to step 5

step14: If iteration > itmax go to step 15

step15: Problem is not converged in itmax
iterations

step16: Problem is converged in it iterations.
Calculate
phase angle at each bus using equation
(3.14). Print voltages and phase angles
at each bus and total active power loss.

Methods of optimal conductor sizes:

i. conventional method:

In normal practice, the conductors used for radial distribution feeders are uniform in cross-section. However the load at the sub-station level is high and it reduces as it reaches to the tail end of the feeder. This indicates that the use of a higher size conductor which is capable of supplying load to source point is not necessarily at tail end point. Similarly use of different conductor cross section for intermediate sections will lead to a minimum both in respect of capital investment cost and line loss point of view. The use of a large number of conductors of different cross sections will result in increased cost of the inventory. A judicious choice can, however be made in the selection of number of size of conductor cross-section for considering the optimal design. In this paper, four different types



of conductor's viz. Squirrel, Weasel, Rabbit and Ferret are used for optimal conductor selection.

Objective Function:

The objective is to select optimal size of the conductor in each branch of the system, which minimizes the sum of depreciation on capital investment and cost of energy losses. In detail, the objective function for optimal selection of conductor for branch jj with k type conductor is

$$\text{Min } F(jj,k) = CL(jj,k) + CC(jj,k) \text{-----}$$

----->4.1

i) Cost of energy losses (CL): The annual cost for the loss in

branch jj with k type conductor is,

$$CL(jj, k) = \text{Peak loss}(jj, k) [cpl + cel * fl * 8760] \text{-----}$$

----->4.2

where cpl=annual demand cost of power loss (Rs/KW)

cel=annual cost of energy loss (Rs/KWh)

fl=loss factor

Peakloss = real power loss of branch jj under peak load conditions with k type conductor.

ii) Depreciation on capital investment (CC): the annual capital cost for branch jj with k type conductor is,

$$CC(jj, k) = fid * [\text{cost}(k) * \text{len}(jj)] \text{-----}$$

----->4.3

where fid=interest and depreciation factor.

cost(k) =cost of k type conductor (Rs/KM)

len(jj) =length of branch jj (KM)

Once the loss factor is found, we can determine the capital energy cost of energy losses. This cost equals 8760 times the product of the loss factor, distribution system peak load losses and energy cost. Annual demand cost of power loss (cpl) represents the Marginal Cost, which is the additional cost that is incurred in generating one more unit or conversely the cost that is saved if one unit less is generated (1Kw or 1Kwh).

Depreciation enables the correct cost for economic use of assets to be charged in a balance sheet before the profit is cleared. The practical system data for annual cost of power and energy losses are given as follows.

$$\text{Annual demand cost of power loss (cpl)} = 1000(\text{Rs/KW})$$

$$\text{Annual cost of energy loss (cel)} = 0.5(\text{Rs/KWh})$$

Loss factor (fl) =0.2

Interest and depreciation factor (fid) =0.1

Constraint equations

i) Feeder voltage: the feeder voltage at every node in the feeder

must be above the acceptable voltage level, i.e.

$$|V(m2.k)| > V_{min} \text{ for } m2=2, 3, \text{-----}n$$

ii) Maximum current carrying capacity: current flowing through branch jj with k type conductor should be less than the maximum current carrying capacity of k type conductor, I_{max}(k), i.e.

$$|I(jj, k)| < I_{max}(k) \text{ for all branches } jj=1, 2, \text{-----}n$$

Algorithm

The detailed Algorithm for Determine Economic Size of the Conductor is given below

Step1: Read the conductor data along with system load and line data

a. Read objective function constants (cpl, cel, fl, fid).

b. Read V_{min}, K_{vab}, K_{Vb}.

Step2: Set the conductor count 'k' =1.

Step3: Run the VDLF load flow method.

Step4: Calculate current and real power losses under peak

load condition of branch jj with k type conductor.

Step5: Calculate the objective function of branch jj with k



type conductor.

$$\text{Min } F(jj,k) = CL(jj,k) + CC(jj,k)$$

Step6: Repeat the procedure from step no. 3 for all conductors.

Step7: Arrange the objective function values of the n different types of conductors for all branches in ascending order.

Step8: Set the branch count 'jj' =1.

Step9: Select minimum cost type of conductor for branch jj.

Step10: Check for voltage & current constraints i.e.

$$V(m2, k) > V_{min} \quad \text{for } m2=2, 3, \dots, n$$

$$I(jj, k) < I_{max}(k) \quad \text{for } jj=1, 2, \dots, n$$

If satisfied, print the result of optimal type of conductor for branch jj. else go to step no.9

Step11: Repeat the procedure from step no 11 for all branches.

Step12: Run the load flow for optimally selected conductors.

Step13: Print the voltages, total real power losses, reactive power losses& the sum of the total cost of conductor and energy losses per year.

Step8: Set the branch count 'jj' =1.

Step9: Select minimum cost type of conductor for branch jj.

Step10: Check for voltage & current constraints i.e.

$$V(m2, k) > V_{min} \quad \text{for } m2=2, 3, \dots, n$$

$$I(jj, k) < I_{max}(k) \quad \text{for } jj=1, 2, \dots, n$$

If satisfied, print the result of optimal type of conductor for branch jj.else go to step no.9

Step11: Repeat the procedure from step no 11 for all branches.

Step12: Run the load flow for optimally selected conductors.

Step13: Print the voltages, total real power losses, reactive power losses& the sum of the total cost of conductor and energy losses per year.

ii.Genetic algorithm:

A GA is an algorithm with some of the principles of genetics included in it. The genetic principles "Natural Selection" and "Evolution Theory" are main guiding principles in implementation of GA.The GA combines the adaptive nature of the natural genetics and search is carried out through randomized information exchange. The search is carried out randomly and information gained from a search is utilized in guiding the next search. Genetic Algorithms is examples of such search techniques. Genetic Algorithms surpass all the above building blocks that are different from those of conventional algorithms. It is different from them in the following aspects.

1. GA works with a coding of the parameter set, and not the parameters themselves.



2. GA searches from a population of point and not from a single point like conventional algorithms.
3. GA uses objective function information, not derivative or other auxiliary data

The different steps for implementation of Genetic Algorithms are described below.

Selection of parameters:

Before going to the actual steps, various parameters of GA with respect to the case is to be selected. In this case numbers of branches are selected as parameters. These parameters are encoded using suitable techniques.

There are various encoding techniques. The binary encoding technique is Chosen, because of its simplicity for encoding and decoding. The other encoding techniques are decimal, weighed sum, etc.

In this problem, only one parameter is encoded, these values give conductor size. in each branch of the system. For each branch, string length is taken as 2. Therefore total length of the string is two times that of the total number of branches

Population Size and Initialization of

Population:

The size of population i.e., no. of chromosomes in a population, is direct indication of effective representation of whole search space in one population. The population size affects both the ultimate performance and efficiency of GA. In this problem, a population size of 10 is chosen. The population is initialized with 1's and 0's randomly, so that they can have wide search space.

```

SL=2*ln;
for i=1:SP
for j=1:SL
    opn[i]
[j]=(rand()<RAND_MAX/3)?0:1;
where
    SP=population size
    SL= string length
    
```

Genetic String Representation

Before applying a GA to any task, a computer compatible representation or encoding must be developed. These representations are referred to as chromosome. The most common representation is a binary string, where sections of the string represent encoding parameters of the solution. The number of bits assigned to a given parameter will determine the numerical accuracy.

Encoding and Decoding

Implementation of a problem in a GA starts from the parameter encoding (i.e., the representation of the problem). The encoding must be carefully designed to utilize the GA's ability to efficiently transfer information between chromosome strings and objective function of problem. The proposed approach uses the string length that represents the conductor size in each branch of the system. Two bits are reserved for each branch. The figure represents the encoding scheme of the string size.

D0	D1	D2	D3	D4	D5	D6	D7	D8	D9
$x2^1$	$x2^0$	$x2^1$	$x2^0$	$x2^1$	$x2^0$	$x2^1$	$x2^0$	$x2^1$	$x2^0$

Where $D_i \in (0, 1) \quad i=1, 2, 3, \dots, SL$

Evaluation of a chromosome is accomplished by decoding the encoded chromosome string and computing the chromosome's fitness value using the decoded parameter. The decoding of string can be expressed as:

$$Enc[j] = \sum (D_i \times 2^i) \text{ for } i=1 \text{ to } 2; j=1 \text{ to } ln$$

Evaluation of Fitness Function

The evaluation is a procedure to determine the fitness of each string in the population and is very much application oriented. Since the GA proceeds in the direction of evolving better fit strings and the fitness value is the only information available to the GA, the performance of the algorithm is highly sensitive to the fitness values. In case of optimization problems the fitness is the value of the objective function to be optimized.

The fitness function which has chosen in this problem is

$$Fit[w] = 1.0 / (+0.005 * obj[w]);$$

Where obj=objective function;

Genetic Operation

Genetic operators are the stochastic transition rules employed by GA. These operators are applied on each string during each generation to



generate a new and improved population from the old one. A simple GA consists of three basic operators: Elitism, Crossover and Mutation.

Elitism

The copying of best population to next population is called "Elitism". If the probability is high, then the convergence rate increases. But it will not be too high to get the good result. The implementation of elitism is done by choosing the best population from the previous generation. The population is chosen as 10 so initially the performance index for all the population is calculated and then the chromosomes are arranged in the descending order according to their fitness value. Then the first 20% of the population is copied to the next generation.

Crossover

Uniform crossover technique is adapted in this problem. For carrying out the crossover, there is a need to identify the parents. The parent selection is done by using the Roulette wheel technique.

This parent selection is to be repeated two times to get the two parents for crossover. After selecting the parents, a random number is generated between 0 and 1, and then this random number is compared with the crossover probability (P_c). If it is less than P_c , crossover is performed. If it is greater than P_c , Par1 and Par2 are directly selected as Chld1 and Chld2. The crossover probability is taken as 0.70.

Mutation

Mutation is the process of random modification of the value of a string position with a small probability. It is not a primary operator but it ensures that the probability of searching any region in the problem space is never zero and prevents complete loss of genetic material through reproduction and crossover. The mutation probability is taken as 0.01.

Algorithm:

The detailed algorithm to determine Economic size of the conductor is given below

step1: Read the genetic data along with system load, line and conductor data

a. Read objective function constants

(cpl, cel, fl1, fid).
b. Read V_{min} , kvab, KVb.
c. Read the genetic operator

values

(population size, P_e , P_c , P_m , etc)

Step2: Initialization of population.

Step3: Set the iteration count to '1'.

Step4: Set chromosome count equal to '1'.

Step5: Decode the chromosomes of the population and determine the conductor number from the normalized form.

Step6: Run the VDLF load flow method.

Step7: Calculate the objective function.

Step8: Calculate the fitness value of the chromosome, using the formula
$$\text{Fit}[w] = 1.0 / (1 + 0.005 * \text{obj}[w]);$$
where w = chromosome count.

Step9: repeat the procedure from step no.5 until chromosome count > population size.

Step10: Sort the chromosomes and all their related data in the ascending order of fitness.

Step11: Calculate the error (Fit [1]-Fit [PS]). the error (Fit [1]-Fit [PS]).

Step12: Check if the error is less than 0.0001 & check whether voltage and current constraints are satisfied, if yes go to 17.

Step13: Now copy the P_e % (ei) chromosomes of old population to new population starting from the best ones from the top.

Step14: Now perform crossover and mutation operators respectively for generating remaining chromosomes.



Step15: Now, replace old population with new population.

Step16: Increment iteration count. If iteration count <max.

Count, go to 4. else go to 18.

Step17 : Print the message “problem is converged”. Print the total real power loss, reactive power loss, converged voltages.

step18: Print the message “maximum number of iterations have reached, yet the problem has not converged”.

RESULTS

The effectiveness of the proposed method is tested on 28 bus feeder of ASPDCL, Kadapa. A Binary coded Genetic Algorithm (GA) and proposed conventional methods are applied to solve the problem. The best result is tabulated. The program is written in MATLAB software.

Although the conventional method seems to be sensitive to the tuning of some weights or parameters, according to the experiences of many experiments, the following conventional method and GA parameters can be used.

Genetic data

- Population size = 10
- Elitism probability = 0.2
- Cross over probability = 0.7
- Mutation probability = 0.01

Table 2 and Table 3 summarize all the results for various buses. Comparison of total cost obtained from GA and conventional method in optimal conductor selection for 11kv feeder shown in Fig. 2.

Result Analysis

As seen in tabulated results, the GA method can obtain higher total cost savings and higher loss reduction than conventional method, thus resulting in the higher quality solution. This is, because GA carries out randomized search techniques, due to which the computation time required will be less when compared to conventional method, thus these data are

evidence of the superior properties of the GA method.

CONCLUSION

Algorithms have been developed for the determination of the global or near-global optimal solution for the optimal conductor solution problem.

The solution algorithms have been tested for test system with 28 bus system. The GA approach has demonstrated an ability to provide accurate and feasible solutions within reasonable computation time.

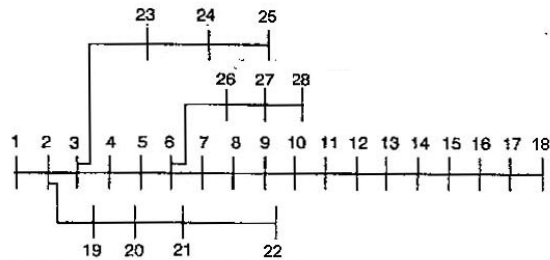


Fig.4 Single line diagram of 28 Bus System

Table2: system data of the feeder

Br no.	Sendin g end	Rece iving end	R(Ω)	X(Ω)	Line length (km)
1	1	2	1.8	0.7	0.5
2	2	3	2.2	0.9	0.07
3	3	4	1.3	0.5	0.074
4	4	5	0.9	0.3	0.2
5	5	6	3.6	1.5	1.7
6	6	7	2.7	1.1	0.3
7	7	8	1.4	0.6	0.8
8	8	9	2.7	1.1	1.04
9	9	10	3.6	1.5	0.07
10	10	11	2.7	0.7	0.9
11	11	12	1.3	0.3	0.07
12	12	13	4.1	1.1	0.54
13	13	14	4.1	0.8	1.4
14	14	15	3.0	0.7	0.03
15	15	16	2.7	1.1	0.07
16	16	17	4.1	0.7	0.04
17	17	18	2.7	0.7	0.13
18	2	19	3.4	0.9	0.7
19	19	20	1.3	0.3	0.17
20	20	21	2.7	0.7	0.11
21	21	22	4.9	1.4	0.73
22	3	23	3.5	1.0	1.7
23	23	24	3.0	0.8	0.3



24	24	25	5.5	1.5	0.08
25	6	26	2.7	0.7	1.01
26	26	27	1.3	0.3	0.07
27	27	28	1.3	0.3	0.9

Table3: electrical characteristics of 11kv conductors

S. no	Conductor name	R (Ω/km)	X (Ω/km)	Cost (RS/km)	Imax (A)
1	Squirrel	1.371	0.39	11695	107
2	Weasel	0.911	0.38	11695	139
3	Rabbit	0.514	0.37	17752	193
4	Ferret	0.73	0.36	11700	130

Table4: load data of the feeder

Bus no.	Real power(kw)	Reactive power(kvar)
1	140	90
2	80	50
3	80	60
4	100	60
5	80	50
6	90	50
7	90	40
8	80	40
9	90	50
10	80	50
11	80	50
12	90	40
13	70	50
14	70	40
15	70	40
16	60	40
17	60	30
18	70	30
19	50	40
20	50	30
21	40	30
22	50	30
23	50	20

24	60	30
25	40	20
26	40	20
27	40	20

Table5: comparison of converged voltages between conventional method (CM) and genetic algorithm (GA) method:

Bus no.	V(p.u)(CM)	V(p.u)(GA)
1	1	1
2	0.9965	0.9923
3	0.9944	0.9918
4	0.9929	0.9898
5	0.9912	0.9888
6	0.9817	0.9850
7	0.9725	0.9765
8	0.9642	0.9760
9	0.9637	0.9740
10	0.9633	0.9738
11	0.9507	0.9724
12	0.9586	0.9718
13	0.9564	0.9699
14	0.9523	0.9689
15	0.9514	0.9680
16	0.9506	0.9679
17	0.9502	0.9673
18	0.9500	0.9672
19	0.9917	0.9914
20	0.9914	0.9909
21	0.9910	0.9906
22	0.9906	0.9903
23	0.9900	0.9920
24	0.9897	0.9899
25	0.9896	0.9897
26	0.9715	0.98
27	0.9712	0.9799
28	0.9711	0.9799



Table6: comparison of real and reactive power loss between conventional method (CM) and genetic algorithm (GA)

	With selected conductors(C M)	With selected conductors(G A)
Real power loss(p.u)	0.49	0.45581
Reactive power loss(p.u)	0.2545	0.2
Net savings in total cost(Rs)	17686.3	20077

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