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Power loss reduction in radial network using flower pollination approach

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Abstract *- With increase in population, the demand for electricity is increasing every day and for maintaining demands of customers it is necessary that power distribution is properly maintained without losses. But losses in our system also increases with demand and for reducing those losses various techniques have been used before and hence improving the voltage profile of the system. In this thesis Flower pollination algorithm which is an optimization technique is used for capacitor placement and sizing .The results obtained are compared with previously computed technique named Bacterial foraging optimization algorithm which is recomputed in this thesis. Both the algorithms are implemented in the form of MATLAB® programmes. Power loss values and voltage profile graphs are obtained using both algorithms. The algorithms are tested on IEEE 14 bus system and results are compared obtained for both algorithms.*

Key Words**: power loss reduction, flower pollination approach, matlab, bfoa technique**

1. INTRODUCTION

Electricity is first generated at generating stations like hydro power plants, thermal plants and then power is transmitted for further use through high voltage transmission system to receiving end substations and from there the power is stepped down so that it can made available to buyers. The power generated can be transferred using:-

(i) Power transmission systems: - It forms loops structure

(ii) Power distribution systems: - It forms radial structure.

The voltage is stepped down to the lower values at the receiving end stations (i.e. 11 kV or 33 kV or 66 kV). The power from the primary sub-station is transferred to the secondary substation. Substation has various equipments like step down transformer, voltage regulators various switch gears fault detecting devices and also various bus systems. The voltage is reduced to 11 kV. Links to these secondary substations and customers is called as distribution system. The distribution system can be subdivided into two parts: primary and secondary distribution.

1.1 Primary distribution system: -

The interconnection connecting distribution substations and distribution transformers is called primary distribution systems.

1.2 Secondary distribution system:-

The power is received from low side voltage secondary side of distribution transformers and supplied to various connected loads through service mains.[1]

1.3 Various parts of distribution system:-

Feeder:-The power is transferred from generating stations to various substations through feeders. Power reaches through feeders where usually at 11 kV is stepped down through step down transformers for further use. Radial feeder, Ring feeder, Meshed feeder and parallel feeder are various types of feeders.

Distributors:-The power is distributed to various loads through distributors. The value of voltage remains unchanged throughout the distributors. Various tapping's can be provided to sub distributors through it.

SERVICE MAINS: - The power is delivered to various loads from distributors through service mains.

2. REQUIREMENTS OF GOOD DISTRIBUTION SYSTEMS

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i. It is important that continuity of the supply is ensured so that in case of any faulty conditions consumers should not suffer.
ii. The distribution system should be efficient.
iii. Safety is another requirement of good distribution systems and it is important that consumers are safer at any point.
iv. Layout of distribution should be good that is why in metropolitan cities underground distribution system is preferred because of this advantage.

3 CLASSIFICATION OF DISTRIBUTION SYSTEMS

3.1 Nature Of Current:- Distribution can be classified on the basis of nature of current which may be further classified as D.C distribution system and A.C distribution system .

3.1.1 A.C distribution system:- In today's world power is generated ,transmitted and distributed as ac power. AC power is preferred because it can be changed, stepped-up or

stepped down using transformer which may be by using step up transformer or step down transformer respectively. This advantage is one of the most important advantages of AC - distribution system that is why it is preferred universally.

Advantages

i. Voltage/power can be easily stepped up or stepped down using suitable transformer.
ii. Maintenance cost is low and it is one of the most important advantages economically.
iii. Ac distribution system is one of the most efficient power systems as power can be easily controlled.

Disadvantages

i. The construction is complicated.

ii. Cost for AC distribution system is higher because more copper is required.

3.1.2 D.C distribution system:- In today's world some of the applications may require DC supply like variable speed machine operations and DC motor storage battery. For this AC power is converted to DC power using rectifiers, rotary converters. The DC distribution is done either by 2 wire or 3 wire system.

i. **2 wire system: -** It consists of 2 wires one wire is positive wire or may be called as outgoing wire and other is called negative wire called as incoming wire and various loads can be connected in parallel.

ii. **3 wire system: -** It consists of three wires one wire is positive, one wire is negative and third wire is neutral wire.

Advantages of DC

i. DC networks require two conductors whereas AC networks require three conductors so DC distribution system is more economical.

ii. In distribution systems different surge nuisance are absent and there is zero inductance, capacitance and phase displacement.

iii. Full cross section of conductors is used as there are no line to line losses in conductors.

iv. Corona effect is minimum.

Disadvantages

i. One of the biggest disadvantages of dc distribution system is that it cannot be stepped up or stepped down.

ii. One of disadvantage is that system becomes multifaceted and dc switches and circuit breakers have to be employed and this becomes disadvantageous.

3.2 On the basis of construction:- Distribution network may be classified on the basis of construction which may be classified as underground distribution system and over head distribution system.

Overhead system is generally used because it is 5-10 times cheaper than underground system.

3.2.1 Overhead distribution vs. underground distribution system

i. If we consider from the safety point of view underground distribution system is more safer than overhead distribution system because underground laying does not makes contact with public or any living human so its ensures safety whereas if we consider the overhead system if by chance any damage occurs to line than it may cause hazard and cause damage to life and property.

ii. If we consider the cost of laying the line in any distribution system, the cost is more in case of underground distribution system where as cost in low in case of overhead distribution system so underground distribution system is expensive.

iii. Overhead distribution system is much more flexible than underground distribution system because it's easy to increase or decrease capacity of line in overhead distribution system where as it is much more complicated and difficult if we want to increase or decrease the capacity in underground distribution system.

iv. The chances of faults in underground systems are less as compared to overhead system but location and clearing of faults in overhead distribution systems is much easier than underground distribution system.

v. If we consider from appearance point of view underground distribution system is consider much more suitable than over head distribution system.

vi. The life of underground distribution system is much more than that of overhead distribution system.

vii. Interference with communication lines is very less in case of underground than overhead distribution systems.

4. NEED OF CAPACITORS :-

A machine usually draws active power and reactive power if the capacitor is not present. Now in a system where we connect capacitors in parallel with motor then reactive power get neutralized. Now transformer will give only active power.This is how reactive power compensation is done.

In todays world capacitor placement is an important aspect in our distribution systems because during early times losses were less but with increase in the demand losses also increased and also cost of these losses also increased so capacitor placement became important. Now in this work our main focus is capacitor placement and sizing and various methods are there some of which are explained.

5. VARIOUS METHODS FOR CAPACTIOR PLACEMENT :-

5.1 Analytical methods:- In earlier times when we didn't have compelling techniques or were not utilized on the grounds because they were costly so analytical methods were used to determine capacitor placement .In this method an approach was introduced by willis which was called two-third method.In two- third method a capacitor of rating two-third of feeder load was used and installed at two- third of feeder span. In analytical method ,saving function because of capacitor placement was given as:-

$$S=Ke\Delta E + Kp\Delta P - KcV$$

$Ke\Delta E$ =economic only because of capacitor placement.

$Kp\Delta V$ =peak power due to capacitor placement.

KcC=capacitor installation due to cost of erection [2]

5.2 Heuristic methods :-

These methods are based on guided search or type of instructions. At each point it will guide to work so that best results are found.It gives good solution but does not gives guranted good results and these methods are easier to implement which was its main important and benefitial point but due to lack of guranted better result optimally cannot be trusted [2].

5.3 Artifical intelligence technique :- This technique is latest in the system and is fast and now consider as best and suitable for research related works some of them are:-

5.3.1 Particle swarm optimization (PSO) :-

This technique was given by Dr. Eberhart and Dr. Kennedy in 1995 and was based on the behaviour of bird flocking or fish scooling.In this method bascially a group is formed and whole working is in group, specifically to achieve objectives and the particles work in group so that they can easily reach target .Considering ants or birds or fishes as particles . Now suppose group of birds are searching for food so suppose there is only one point where food is sited and all the birds do not know precisely where food is kept so best tactic can be that to chase the bird which has easier access to that food. Compared to other methods its is easier and only few parameters are there to be adjusted [3].

5.3.2 Simulated annealing :-

This method is basically inspired by the process of annealing which can be explained as first giving heat to the material and then allowed to cooled down and then studied.For example considering a metal is to be changed to another state so first its heated or heat is given until it changes to liquid form then particles are arranged in the order or shape which is needed and then again allowed to cooled down so this is one example on which simulated annealing works.

5.3.3 Artificial neural networks :-

This is technique which was formed in same way a human brain works and idea was made that like wise a human brains which has millions of neural connections in the same way we can model this system in terms of silicon and wires as neurons and dendrites.

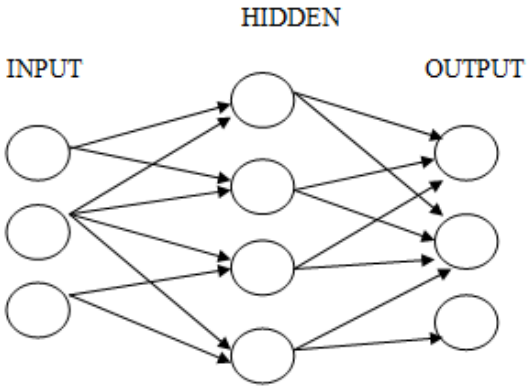


Figure Depicting neural networks is shown.

6.PURPOSED ALGORITHM

Flower Pollination Algorithm

FPA is a global optimization algorithm which is used for the optimization of the solutions. Global pollination is considered under cross pollination and Biotic Pollination. In global pollination process pollen travel a long distance because insects can fly over long distance. Pollination is divided into two types that are biotic pollination and abiotic pollination. Mostly the pollination occurred in flowers are biotic pollination in which pollinators are included for pollination. In abiotic pollination no pollinator is needed for pollination. Lower pollination process is achieved through cross-pollination or self-pollination. In cross-pollination, pollens are transferred from a different plant. The biotic and cross-pollinations occur at long distances, so they are performed by insects that can fly for long distances such as bees, birds, and bats.

The previously mentioned flies are considered as global pollinators. This algorithm works in the four steps that are following: -

1. Population Initialization

2. Exploration Process3. Exploitation Process

4. Solutions Update

By using the above mentioned characteristics of the pollination process, pollinators and consistency of flower following rules are generated for FP algorithm.

Flower Consistency: $x_i^{t+1} = x_i^t + \gamma L(\lambda)\left(x_i^t - B\right)$

Where

x_i^t: is the pollen i or solution vector xi at iteration t, and B is the current best solution found among all solutions at the current generation/iteration.

Here γ is a scaling factor to control the step size. In addition, L(λ) is the parameter that corresponds to the strength of the pollination, which essentially is also the step size.

- Global Pollination: Biotic and Cross Pollination
- Local Pollination: Abiotic and Self Pollination
- Reproduction Ratio: it is proportional to the degree of similarity between two files.

Methodology Steps

1) Initialize the Data Bus and Iteration.
2) Set ITE counter is equal to 0.
3) Calculate Load to for Branch current.
4) Apply Flower Pollination algorithm and follow this steps.
   - Initialize Pollen in form of branch Current.
   - Update the Pollen.
   - If pollens are optimized then update the voltage. ITE = ITEH. Otherwise go to step 4

5) Check ISITE < ITE_{max}

6) Gives Output A

7) Check Vmax <Ɛ then calculate the active and Reactive Loss. Otherwise go to B.

8) End

7.THE OBJECTIVE FUNCTION:

Min f = min (TLP)

where TLP is the total power loss of the radial distribution system.

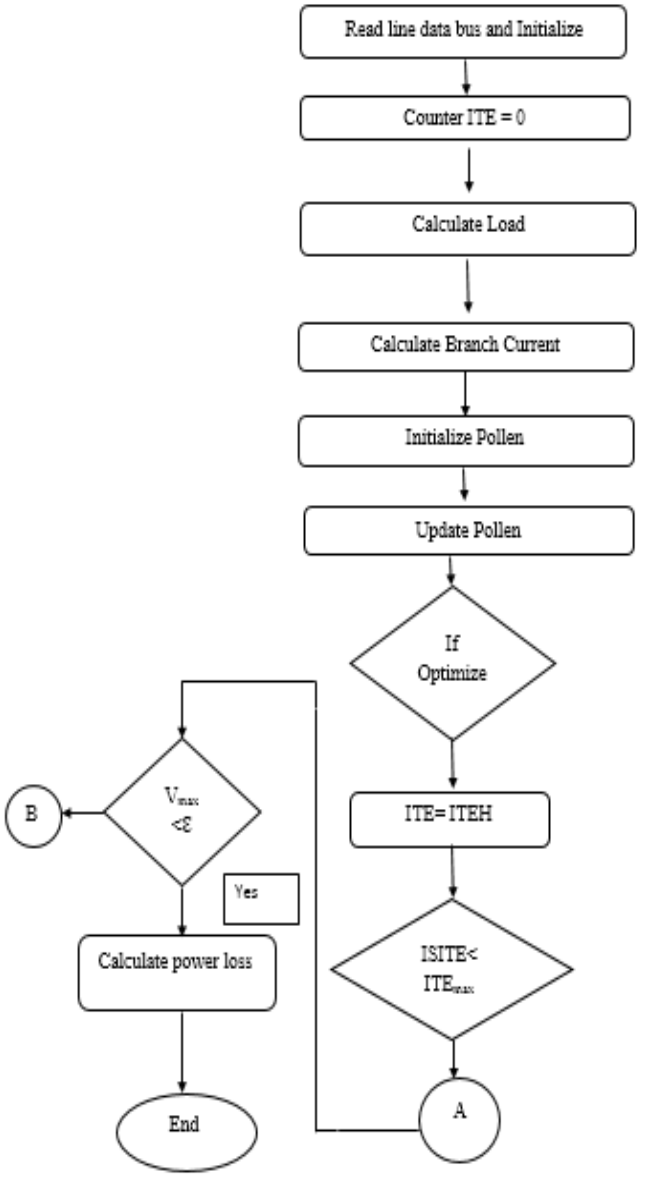
Subjects to

|Vi min| ≤ Vi ≤ |Vi max| i = 1, 2, ... N

Vi min is the minimum voltage of the ith bus

Vi *max* is the maximum voltage of the ith bus

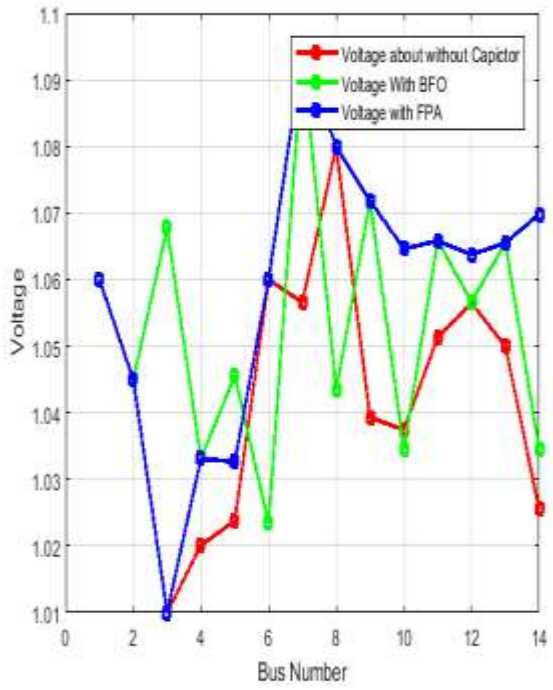
FLOW CHART FOR THE PURPOSED ALGORITHM



Flow chart for purposed algorithm

8.RESULTS

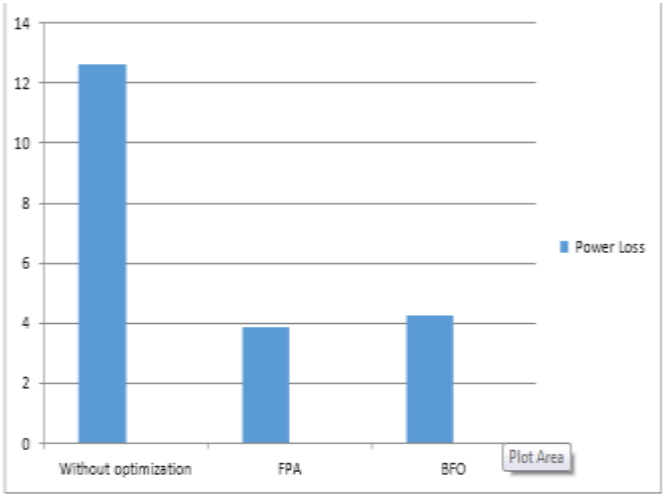
In figure the results shows the voltages without capacitor, FPA and BFO on the different buses. The x-axis represents the bus number and y axis represents the voltage. The red, green, and blue line on the graph shows the changes in the voltages according to the bus.



Comparison of purposed algorithm with different algorithm

Table 5. 1 Comparison of Power Losses

Algorithm	Power Loss (kW)
Without optimization	12.6210
FPA	3.886
BFO	4.2340



7.CONCLUSION

The thesis work was carried out to minimize the power losses in a 14-bus radial distribution system and to improve voltage profile of the system. The objective was achieved by allocating capacitor banks at different nodes. In the first phase suitable locations of capacitors on the buses which are more sensitive are calculated using flower pollination algorithm and in the second phase suitable sizing of capacitors is done using flower pollination algorithm. Then the results obtained were compared with previously used technique named bacteria foraging algorithm and it was recomputed again on 14 bus system and purposed algorithm gave better results in terms of power loss reduction and voltage profile improvement.

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