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MINIMIZATION OF VOLTAGE DEVIATION USING PARTICLE SWARM OPTIMIZATION

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Abstract: This paper presents an efficient and reliable Particle Swarm Optimization algorithm for solving voltage deviation. Voltage deviation is the capability of a power system to maintain up to a standard voltages at all buses in the system under standard conditions and under being subjected to the disturbance .This PSO programming is applied to the IEEE 14 bus system. The optimization problem with objective function linearly shows that the particle swarm optimization more effectively improves the voltage profile in power system.

Keywords: Voltage Deviation, Particle swarm optimization (PSO)

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INTRODUCTION

The Power System is very large and widely distributed. It is made up of generators, transformers, transmission lines, circuit breakers, isolators, relays, switches, and controlling panel etc. Now, in present number of generating stations are more as compare to past. Yet, there is a shortage of Power due to increase in consumer demands, severe market deregulation, electricity theft .The loss of power sources could increase the load demand of any part of the transmission network causing voltage depression, leading ultimately to voltage collapse.

Different techniques may be voltage deviation of power systems to find the possible ways to improve the voltage stability boundary [1]. Voltage is considered as one of the most important parameters of the quality of power supply. Its deviation from the normal value may be damaging and costly.PSO can be applied for optimal placement of capacitor[9],reactive power control[10],reactive power dispatch[11],as well as voltage control[12].

In this paper, PSO technique is deeply studied. Voltage deviation is considered as main objective function. Problem formulation for voltage deviation is done. Matlab programming is applied to IEEE 5 bus and IEEE 14 bus system.

1. Basic Concept of Particle Swarm Optimization

The PSO is based on the behavior of colony of living things like colony or swarm of insects such as ants, bees, termites, waspsd. PSO is inspired by a flock of birds and fish schooling [2],[3]. PSO is population based algorithm. The word “Particle” denotes a bird in a flock or bee in a colony.” Swarm” means moving particles which have certain velocity.” Optimization” means obtaining best results from given circumstances.

The PSO algorithm was originally proposed by Kennedy and Eberhart in 1995.They proposed an algorithm where each particle is located randomly in space. Particle is assumed to have two characteristics a) Position b) Velocity.

Each particle wonders around in the space and remembers its best position .This individual best position (obtained by using its own knowledge) is called “Pbest”. Particle achieve best position in a group (obtained by sharing knowledge among a group) is called “Gbest”. Individuals or particles in swarm, approach the optimum through its present velocity, previous experience and the experience of its neighbours [4].The formulae used to find modified position and velocity are shown in equation (1)and (2).

$$Xi(t) = Xi(t-1) + Vi(t) \quad (1)$$

$$Vi(t) = w*Vi(t-1) + \Phi1*rnd1*(Pi - Xi(t-1)) + \Phi2*rnd2*(Pg - Xi(t-1)) \quad (2)$$

$$Vi(t) = Inertia + Cognitive + Social. \quad (3)$$

Where, Xi(t) = New particle position

Xi(t-1) = Previous position

Vi(t) = New particle Velocity

Vi(t-1) = Previous Velocity

w = Inertia Weight

Φ1 & Φ2 = Two positive numbers

rnd1&rnd2 = Two random numbers with uniform distribution in the range of (0,1)

Pi = Individual best position (Pbest)

Pg = Global best position (Gbest)

Equation (3) shows three components.

First component shows the term inertia which develop the tendency of the particle to continue in the same direction in which it was travelling.(Shi and Eberhart 2001)introduced the concept of inertia weight to the original version of PSO, in order to balance the local and global search during the optimization process[5].

Second component shows the linear attraction towards the best position found by the given particle. This component is referred to “self knowledge”.

Third component shows linear attraction towards the position found by any particle .This component is referred to “group knowledge.

PSO Algorithm:

Consider a objective function which has to maximize or minimize.

Suppose Maximize,

Take maximizing function to be f(x).

With $X^l \leq X \leq X^u$

Where X^l ⟶ Lower bounds of X

X^u ⟶ Upper bounds of X

The PSO can be applied through the following steps:

1. Assume Size of the swarm (number of particles) is N.

2. Generate the initial position of X in the range X^l and X^u randomly as $X_1, X_2, - - - - - - - X_N$.

Particle position 'j' in iteration 'i'is given by X^i_j .Initially particles are having values $X_1(0), X_2(0), - - - - - - - X_N(0)$.

And the objective function is given by $f_1(0), f_2(0) - - - f_N(0)$.

3. Set iteration number as i =1.

4.a) i)Find Pbest with highest value of objective function for j^{th}particle.

ii)Find Gbest with highest value of objective function for any particle in N number of particles.

b)Find Velocity of particle j in i_{th} iteration using equation(2)

c)Find position of particle j in i_{th} iteration using equation(1)

5. Check the convergence of current solution. If position of all particle converges to same set of values stop iteration. Unless repeat step 4 by updating equation number as i = i+1.And computing new values of Pbest and Gbest. The process is continued until all particles converge to same optimum solution.

2. Problem Formulation

Voltage is very significant in power management; as it must be high sufficient to support loads . Hence, voltage must be controlled from every position and should be maintained.. Generally Vref is taken as 1.0 p.u.

$F=V_{dev}=\sum_{i\in Npq}(|Vi-Vref|/Npq)$

Where,

Vdev=Voltage Deviation

Vref=load bus reference voltage value

Vi=load bus voltage

Npq=load bus number

Subject to 0.95<Vm (per unit) <1.1.

Voltage stability index is may be used to find weak bus . [8]

$$L=\sum_{Y=1}^{30}|1-Vm(y)|$$

Where Vm=Magnitude of voltage

PSO parameters used in this system is as follows,

Table No.1: PSO parameters

Parameters	PSO
Population Size	10
Inertia weight	0.9-0.4
Constant Φ_1	1.4
Constant Φ_2	1.4
No. of Iterations	20

4. Simulation Result

On the IEEE-14 bus test system (shown in Fig-`1) the proposed PSO algorithm technique have been tested. The data for the mentioned system is taken from [7]. A MATBAB code for PSO algorithm was developed for simulation purposes. Weak bus is found with

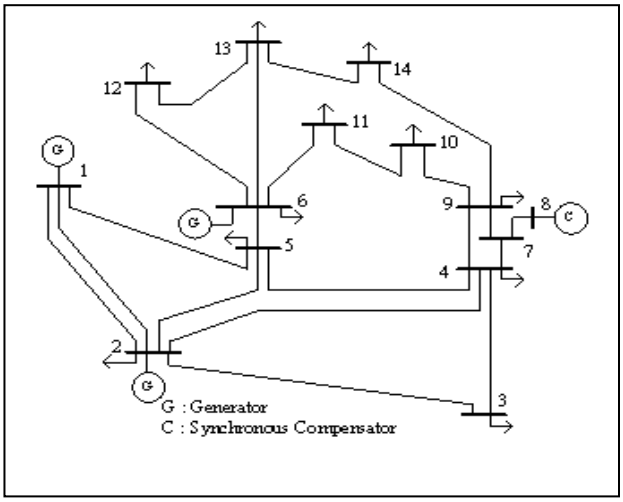

Fig 1: IEEE 14 Bus System

The program is tested for the various buses of the

IEEE 14 test bus system, for which the voltage deviation is minimum. The table no.2 and figure no.2shows the simulation results for various buses

Table No.2: Simulation result at various buses

Sr No.	Bus No.	Min % VD
1	4	1.1108
2	5	1.0857
3	9	0.9063
4	10	0.8505
5	11	0.8616
6	12	0.8952

7	13	0.8531
8	14	0.8562

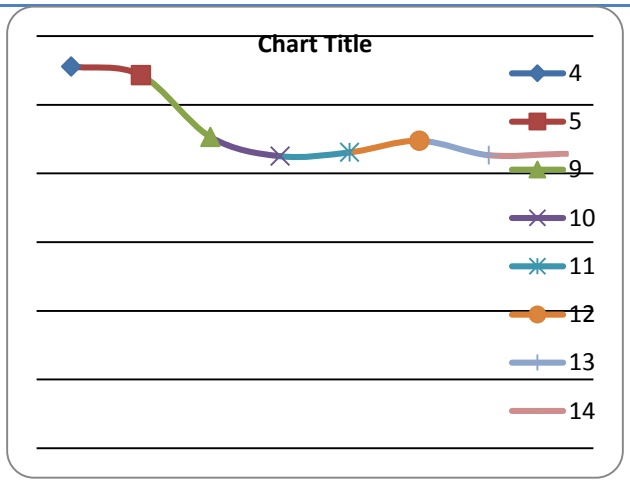

Fig 2: Min % of VD at buses in IEEE 14 bus System

5. CONCLUSION:

The result obtained from the IEEE-14 bus system test, the power system shows that the PSO algorithm can easily find out minimum voltage deviation. And it is clearly seen that the bus No. 10 is more feasible and even economical at which voltage deviation is minimum. Minimum voltage deviation is helpful in optimal placement of Facts device also.

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