COMPARATIVE ANALYSIS OF PERFORMANCE OF D-STATCOM DEVICE USING PSO AND SMPSO TECHNIQUE

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Abstract -*. An electric power distribution system is the final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumer's Electrical distribution systems are primarily designed to meet the consumer's demands for energy. Some examples of smart distribution systems is Distributed Generations. In present work Particle Swarm Optimization (PSO), sinusoidal modulated particle swarm optimization (SMPSO) is carried out initially by randomly generating Reactive power injection by capacitor banks and then the objective function is optimized and convergence is obtained within maximum number of generations. The optimal power flow problem including DSTATCOM is solved using PSO and SMPSO for IEEE-33 bus system. The final performance parameters like voltage magnitude, voltage angle and voltage stability index are obtained for the optimization of objective function for DSTATCOM. It has been observed that the proposed methods provide acceptable solutions and found to be suitable for planning and operation of modern power systems.*

Key Words: Particle swarm optimization PSO, Sinusoidal modulated particle swarm optimization SMPSO,Distribution static compensator D-STATCOM

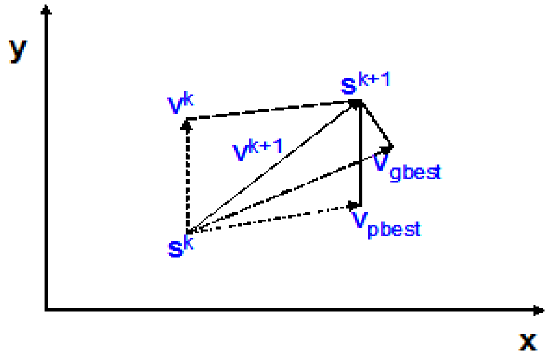
1.INTRODUCTION

1.1 D-STATCOM:

Providing the demand power to the entire load, while maintaining voltage magnitude at an acceptable range is one of the major system constraints. There are two principal conventional means of controlling voltage in distribution systems: series voltage regulators and shunt capacitors. Conventional series voltage regulators are commonly used for voltage regulation in distribution system. These devices cannot generate reactive power and by its operation only force the source to generate requested reactive power. Furthermore, they have quite slow response and these operations are step by step. Shunt capacitors can supply reactive power to the system. Reactive power output of a capacitor is proportional to the square of the system voltage which may reduce its effectiveness in high and low voltages. Hence,for improvement of capacitors in different loading conditions, their constructions are generally the combination of fixed and switched capacitors. Therefore, they are not capable to generate continuously variable reactive power. Distribution STATCOM (D-STATCOM) is a shunt connected voltage source converter which has been utilized to compensate power quality problems such as unbalanced load, voltage sag, voltage fluctuation and voltage unbalance which occur in short duration in millisecond range. In this duration, D-STATCOM can inject both active and reactive power to the system for compensation of sensitive loads, and active power injection into the system.

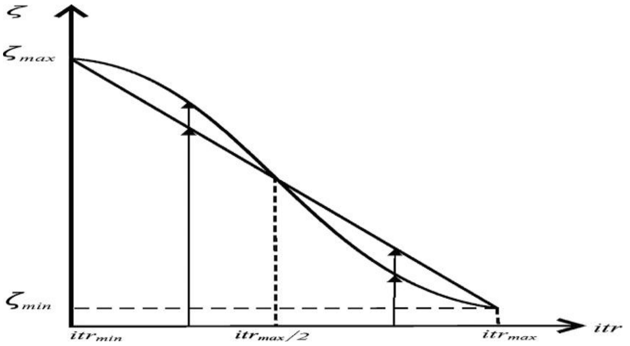
1.2 Particle Swarm Optimization(PSO):

It is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. PSO optimizes a problem by particles around in the search-space according to simple mathematical formulae over the particle's position and velocity. Each particle's movement is influenced by its local best known positions in the search-space , which are updated as better positions are found by the other particles. This is expected to move the swarm toward the best solutions. In past several years, PSO has been successfully applied in many research and application area. It is demonstrated that PSO gets better results in a faster, cheaper way compared with other methods.



1.3 SMPSO (Sinusoidal Modulated Particle Swarm Optimization):

The conventional PSO is regulating only the initial velocity component using inertia weight whereas the cognitive and social components of velocity are randomized to ensure diversity. These components of velocity are added in the regulated initial velocity component to decide movement of the particles. This probably results in higher particle velocities during later part of the search and thus results in poor convergence. Therefore, the following control equation is suggested where a constriction function f is introduced to regulate velocity of particles appropriately during their whole course of the flight.In the proposed version of PSO, the sinusoidal constriction function is varied in accordance to a truncated sinusoidal function between predefined limits ξmin and ξmax. This version of the proposed PSO is termed as Sinusoidal Modulated PSO (SMPSO).If the velocities of particles are well regulated throughout their course of flight using some mechanism, the performance of PSO can be improved.



2.PERFORMANCE OF DISTRUBUTION SYSTEM WITH D -STATCOM USING PSO:

2.1 Mathematical formulation of OPF problem:

The optimal power problem in the distribution system seeks to find an optimal reactive power injection to minimize the total cost of capacitors of the distribution system, while satisfying different constraints. In this thesis, the optimal location of DSTATCOM in a distribution system are obtained by minimizing the objective functions such as total real power loss, voltage magnitude,voltage stability index and voltage deviation in distribution network.

Optimal power system operation seeks to optimize the steady-state performance of a power system in terms of one or more objective functions while satisfying several equality and in equality constraints. Generally, the problem can be formulated as follows.

$F_i(x_i,u_i)$

Subjected to

$G(x_i,u_i) = 0; \qquad H_i(x_i,u_i) \le 0$

OPF objective functions: The objectives considered are as follows:

Objective Function I: Min $f_2 = P_L = \sum_{i=1}^{N_l} I_i^2 R_i$ is total real power loss

Objective Function II: Min $f_4 = VD = \sum_{i=1}^{nb} \left(|V_i - 1|\right)^2$ is the total voltage deviation

Constraints: The OPF problem has two categories of constraints.

Equality Constraints: It is the sets of nonlinear power flow equation that govern the power system,

Power balance constraints:

$$\sum_{i=1}^{N} P_{DGi} = \sum_{i=1}^{N} P_{Di} + P_L$$

Where P_L is the total real power loss in the system

P_{DGi} is the real power generation of DG at bus i

P_{Di} is the power demand at bus i

Inequality Constraints: These are the set of constraints that represent the system operational and security limits like the bounds on the following:

Voltage constraints:

$$|V_{\min}| \le |V_i| \le |V_{\max}|$$

V_i is the voltage magnitude at bus 'i'

Voltage angle constraints:

$$|\delta_{\min}| \le |\delta_i| \le |\delta_{\max}|$$

δ_i is the voltage angle at bus 'i'

Line Current constraints:

$$|I_{i,j}| \le |I_{i,j,\max}|$$

$I_{i,j}$ is the current between buses i and j

Equation (4.6) represents the load bus voltages must be within standard limits, where V_i is voltage magnitude of bus *i*, $V_{\max}$ is the maximum limit of nominal voltage magnitude and $V_{\min}$ is lower limit of nominal voltage magnitude. Equation (4.6) represents the load bus voltage angles within standard limits, where δ is voltage angle of bus i, $\delta_{\max}$ is the maximum limit of nominal voltage angle and $\delta_{\min}$ is lower limit of nominal voltage angle. Equation (4.8) represents the current flows within the thermal limits of the lines where I_i is the current of line i and $I_{i,j,\max}$ is the thermal limit of line $i-j$.

2.2Computational Procedure for solving the problem

The implementation steps of the proposed PSO based algorithm can be written as follows;

Step 1: Input the system data for load flow analysis

Step 2a: Select a DFACTS device and its location in the system

Step 2b: At the generation Gen =0; set the simulation parameters of PSO parameters and randomly initialize k individualS within respective limits and save them in the archive.

Step 3: For each individual in the archive, run power flow to determine load bus voltages, angles, load bus voltage stability indices, generator reactive power outputs.

Step 4: Evaluate the objective function values and the corresponding fitness values for each individual.

Step 5: Find the generation local best **xlocal** and global best **xglobal** and store them.

Step 6: Increase the generation counter

Gen = Gen+1.

Step 7: Apply the PSO operators to generate new k individuals

Step 8: For each new individual in the archive, run power flow to determine load bus voltages, angles, load bus voltage stability indices, generator reactive power outputs.

Step 9: Evaluate the objective function values and the corresponding fitness values for each new individual.

Step 10: Apply the selection operator of PSO and update the individuals.

Step 11: Update the generation local best **xlocal** and global best **xglobal** and store them.

Step 12: If one of stopping criterion have not been met, repeat steps 3-13. Else go to stop 15

Step 13: Print the results

3. PERFORMANCE AND DISTRUBUTION SYSTEM WITH D-STATCOM USING SMPSO(SINE MODULATED PSO):

3.1 Algorithm of Sinusoidal Modulated Particle Swarm Optimization:

The Sinusoidal Modulated Particle Swarm Optimization algorithm can be described in the following steps

Step 1: Initialize an array of particles with random positions and their associated velocities to satisfy the inequality constraints.

Step 2: Check for the satisfaction of the equality constraints and modify the solution if required.

Step 3: Evaluate the fitness function of each particle.

Step 4: Compare the current value of the fitness function. With the particles previous best value (*pbest)* .If the current fitness value is less, then assign the current fitness value to *pbest* and assign the current coordinates (positions) to *pbestx*.

Step 5: Determine the current global minimum fitness value among the current positions.

Step 6: Compare the current global minimum with the previous global minimum (*gbest*). If the current global minimum is better than *gbest*, then assign the current global minimum to gbest and assign the current coordinates (positions) to *gbestx*.

Step 7: Change the velocities according to the present local best and the global best values. Replace those previous values to current best values.

Step 8: Move each particle to the new position and return to step 2.

Step 9: Repeat step 2-8 until a stop criterion is satisfied or the maximum number of iterations is reached.

4. SIMULATION AND RESULTS

Using only PSO

Table4.3.Power loss and Voltage deviation

	PSO	
	Power loss	**Voltage deviation**
With device	**152.46**	**0.56**
Without device	**149.24**	**0.48**

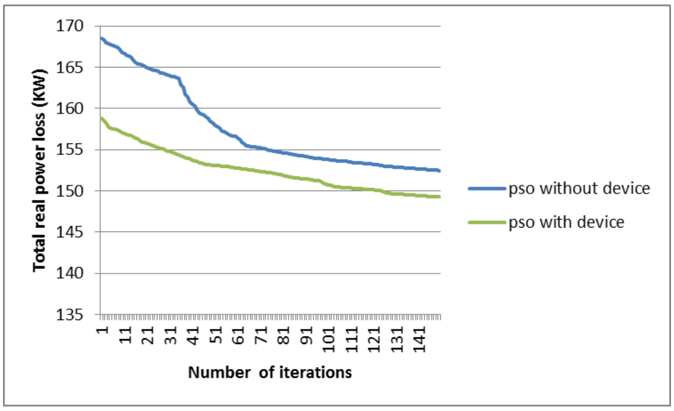


Fig.4.2 Total real power loss with and without device for PSO

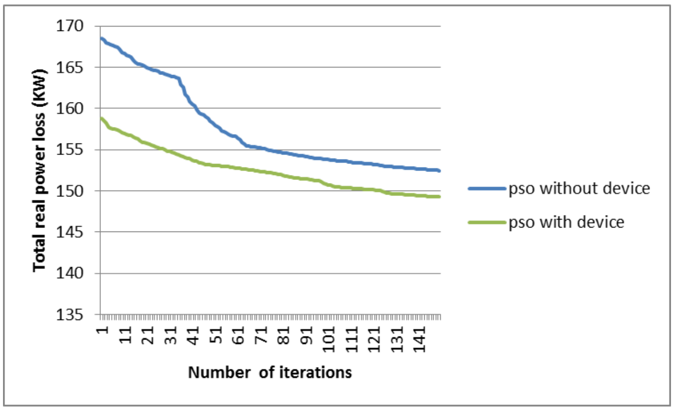


Fig.4.2 Total real power loss with and without device for PSO

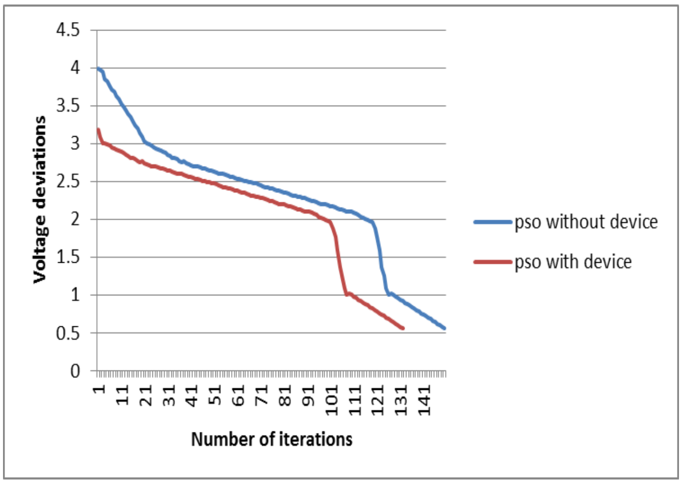


Fig.4.3. Voltage deviations with and without device for PSO

Fig.4.4.Voltage magnitude with and without device

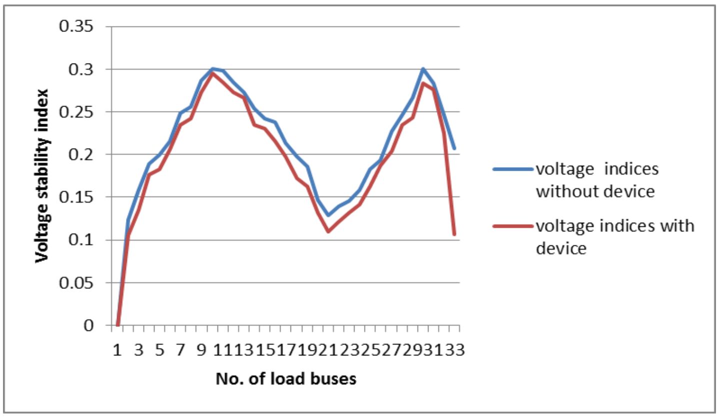


Fig.4.5. Voltage stability index with and without device for PSO

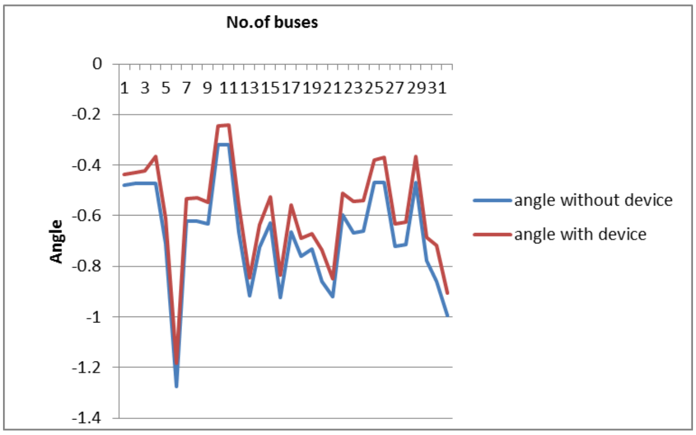


Fig.4.6. Angle with and without device for PSO

RESULTS USING SMPSO:

Table for power loss and voltage deviation

	SMPSO	
	Power loss	**Voltage deviation**
With device	**151.42**	**0.521**
Without device	**148.2**	**0.362**

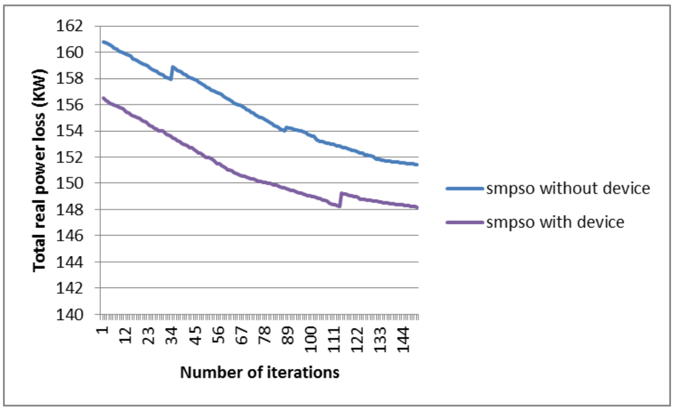


Fig.5.1.Total real power loss with and without device for SMPSO

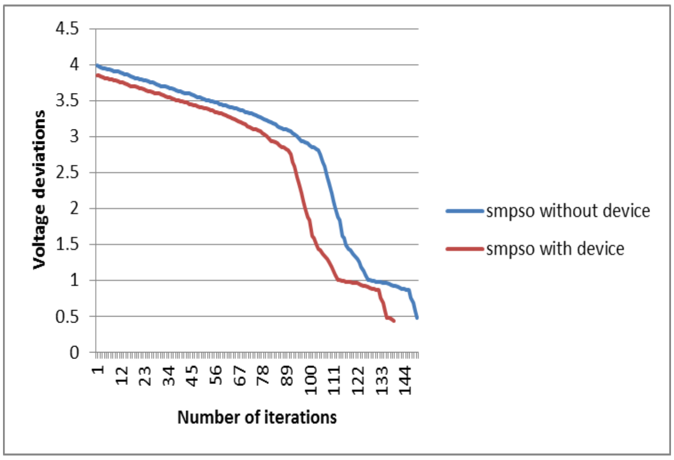


Fig5.2. Voltage deviation with and without device for SMPSO

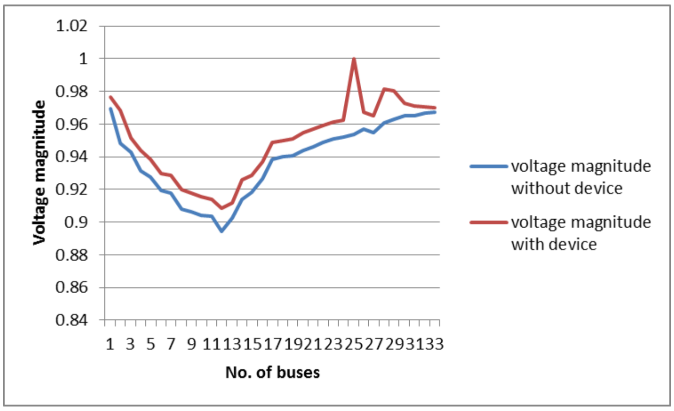


Fig.5.3. Voltage magnitude for with and without device for SMPSO

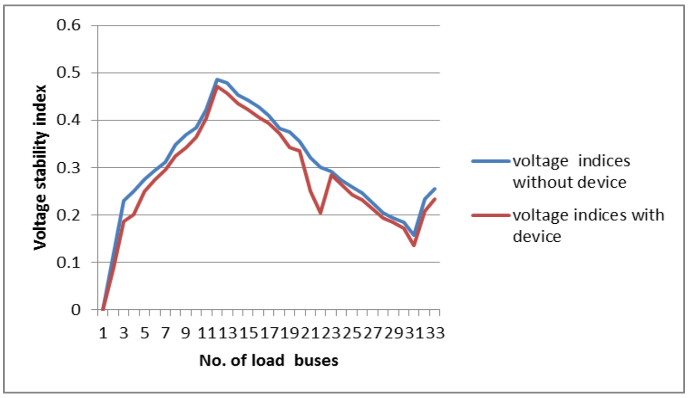


Fig.5.4. Voltage stability index with and without device for SMPSO

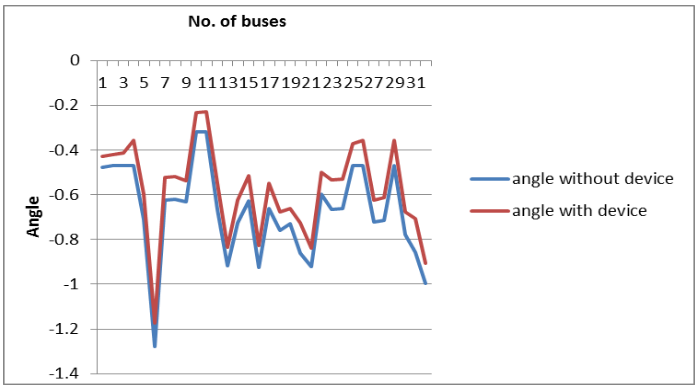


Fig.5.5.Angle with and without device for SMPSO

5.CONCLUSION:

Performance Comparison of PSO & SMPSO. Power loss and voltage deviation with and without device for PSO and SMPSO

	PSO		**SMPSO**	
	Power loss	**Voltage deviation**	**Power loss**	**Voltage deviation**
With device	**152.46**	**0.56**	**151.42**	**0.521**
Without device	**149.24**	**0.48**	**148.2**	**0.362**

The above table represents the maximum and minimum limits for Power loss and voltage deviation with and without device for PSO and SMPSO.The obtained values of Power loss with and without device for PSO and SMPSO when compared SMPSO gives the best result. The obtained values of Voltage deviation with and without device for PSO and SMPSO when compared SMPSO gives the best result.

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