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Improvement Of Stability In IEEE 14 Bus System Using PSO-GSA Tuned STATCOM

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Abstract: In the present scenario, power system voltage stability analysis has become vital for secure power system operation and satisfactory design. The voltage collapse is the process by which voltage instability leads to loss of voltage in a significant part of the system. It is the process by which the sequence of events accompanying voltage instability leads to a blackout or abnormally low voltages in a significant part of the power system. This paper addresses the on line monitoring of voltage stability of power system using hybrid gravitational search algorithm and particle swarm optimization for the optimal location and capacity of STATCOM. The proposed work is simulated in MATLAB and tested for IEEE 14 bus system. The optimization problem has been selected as multi objective problem with voltage deviation, power losses, maximum loadability and STATCOM size into consideration. A comparison of results with base case and changing the load conditions with GSA optimized case and with proposed optimization is shown in the work.

I. INTRODUCTION

Expansion of power system along with restructuring and deregulation the complexity of system is increasing continuously. Demand for additional load and requirement of good power quality by consumers makes the use of compensation devices a necessity. These compensation devices add to utilities complexity and expenses, so it becomes important to use them at a location which offers a better compensation and proper utilization of these devices. Reactive power compensation is a very important issue in electrical power systems and by the use of flexible ac transmission system (FACTS) devices we can control the reactive power flow to the power network and hence the system voltage fluctuations and stability. Voltage collapse problems in power systems have been permanent concern since several major blackouts throughout the world have been directly associated with this voltage collapse problem. The collapse points are also known as maximum loadability points. The power flow control and static stability limits of power system can be considerably modified using the new reactive compensation equipments. The Newton Raphson method is a powerful method of solving nonlinear algebraic equations. It works faster and surely converge in many cases but it require large computer memory.

he authors in [10] presented a technique to improve voltage stability margin of power system in contingency condition based on reactive power generation management of shunt capacitors along with active and reactive power generation management of each unit. Chang et.al [11] presented a procedure for application schemes for a coordinated control system of R. Raghavan multiple FACTS controllers to enhance the voltage stability.

The authors in [7] studied the effect of STATCOM, TCSC, SSSC and UPFC on static voltage stability in power systems. UPFC and STATCOM give slightly higher Maximum Loading Point and better voltage profiles compared to TCSC and SSSC. It was found that these controllers significantly enhance the voltage profile and thus the loadability margin of power systems. The effectiveness of the STATCOM to control the power system voltage was presented in [9]. Wang *et al.* [6] in their paper summarized the details of various publications concerned with STATCOM. There are about 119 papers have been presented in the field of power system stability using STATCOM during 1990 to 2004. Simple heuristic approaches are traditionally applied for determining the location of FACTS devices in a small power system. However, more scientific and sophisticated methods are required for placing and sizing of FACTS devices in a larger power network. FACTS sizing and allocation constitutes a milestone problem in power systems. (2) Genetic algorithm has been successfully applied by Jong-Young Parkto *et al.* (12) to determine optimal numbers and locations for capacitor installation in distribution system. Particle Swarm Optimization (PSO) has been a powerful tool for power system optimization problems as early as 1995 [15]. The PSO mimics the behaviors of individuals in a swarm to maximize the survival of the species. In PSO, each individual decides based on its own experience Pbest as well as other individual's experiences Gbest [16]. The algorithm searches a space by adjusting the trajectories of moving points in a multidimensional space. The individual particles are drawn stochastically towards the position of present velocity of each individual based on their own previous best performance, and the best previous performance of their neighbors [17]. Hirotaka Yeshida *et al.* [13] proposed a method to expand the original PSO to handle a mixed-integer nonlinear optimization problem (MINLP) and determines an on-line Volt Nar Control (VVC) strategy with continuous and discrete control variables.

In this work previous work is taken to a step ahead, using a hybrid optimization algorithm which is a combination of gravitational search algorithm (GSA) and particle swarm optimisation (PSO). The combination of these two algorithms is successful due to different nature of these. PSO is a local optimisation algorithm where as GSA is a global optimisation algorithm and combination of local to global optimisation results in improved results. We will test our results on IEEE 14 bus system with 1.6 times loading on buses to generate the disturbance in the system.

II. PROPOSED WORK

The hybrid GSAPSO algorithms work in the manner that GSA becomes alive to update the velocity of particles in the PSO algorithm. The combination of two different optimization algorithms is done in a way that local optimization algorithm is controlled by global optimization GSA algorithm. The update in position of particles in PSO required update in which is updated by GSA by the formula

$$v_i^d(t+1) = rand_i x v_i^d(t) + a_i^d(t)$$

This make the convergence faster with each minima point checked. Initialization of velocity in GSA too is random but later it is controlled by formulation defined in 3.1. Output of fitness function becomes the local best for the PSO and based on that local best position is calculated, which is updated by the velocity update equation in PSO. This velocity is added into the old position of particle which was local best position obtained from PSO, to get the new position. This new position is updated as direction of minimum fitness function value. This way GSA tunes the direction of particles in PSO.

A step by step algorithm for the proposed work is given as:

STEP1. Initialize the random positions and velocities of particles.

STEP2. Consider the searching space dimension as twice the number of STATCOMs as their size and bus position is to be tuned.

STEP3. Initialize the weighting parameters of PSO as 0.5 and 1.5.

STEP4. Generate the random positions of particles initially within limit of STATCOM values which is 10-50 MVAR and calculate the fitness function for each particle.

STEP5. Compare the fitness value of each particle with the previous best position of bacteria. If fitness function value is less for this new position than previous position then it will be assigned as new.

STEP6. The present bets position is termed as current position of particle for PSO and output of fitness function is Jlocal for the PSO.

GSA Starts here:

STEP7. The current position selected in previous step is used to get the mass for each agent as per GSA algorithm. The minimum value of fitness function is selected as best and maximum as worst position and using the formulas, mass of each agent can be calculated as:

$$m_i(t) = \frac{fit(t) - worst(t)}{best(t) - worst(t)}$$

$$M_i(t) = \frac{m_i(t)}{\sum_{j=1}^{N} m_j(t)}$$

STEP8. Gravitational force is calculated as:

$$F_{ij}^d(t) = G(t).\left(M_{pi}(t) \times \frac{M_{ai}(t)}{R_{ij}(t)} + \varepsilon\right).\left(x_j^d(t) - x_i^d(t)\right)$$

The formula is described in section 3.1.

STEP9. This new velocity is the direction of particle in PSO is updated as

$$velocity = velocity + c1 * acceleration + c2(gbest - current\ position)$$

Here gbest is the global best position of particles in PSO and acceleration is calculated in GSA as $a_i^d(t) = F_i^d(t)/M_{ii}(t)$.

GSA ends here

STEP10.Add the new velocity to old position of particles and get the new updated positions which is conserved towards the minimization of objective function.

STEP11.Above all steps repeats till iterations last.

STEP12.Result will be positions of particles with minimum fitness function output. These positions are size and bus location of STATCOM.

Following these steps in optimization of GSA and PSO an optimal value of STATCOM is achieved in our work.

Fitness function calculation

The term fitness function which is the soul of our optimization algorithm is defined for the parameters which affect the stability of the system. Each time position of bacteria or in other words STATCOM's location and size is given as input to fitness function and the reactive power of it is added to the load's reactive power of system. Based on this updated power of system, following four parameters values are calculated:

1. The voltage deviations in the system
2. Power system total loss
3. Have the minimum possible STATCOM sizes and
4. Load ability limit

The size and position of STATCOM should be such that above first three parameters should be minimized and last once should be maximized. Thus in our case we have defined a multi objective problem which will be turned into a single objective to make the task simpler.

The mathematical formula to calculate above parameters is discussed as:

1. Voltage deviation of the system: It is favorable that bus voltages be as close as possible to 1 p.u. Equation (4.1) shows the voltage deviation in all buses.

$$F_v = \sqrt{\sum_{i=1}^{nbus} (V_i - 1)^2} \quad (2.1)$$

Where F_v is the voltage deviation, 'nbus' is the number of total buses in the system and Vi is the bus voltage.

2. Power loss: The second term is related to power system total loss and minimizing it in power systems that are given by equations (4.2) and (4.3).

$$P_{LK} = P_{sending} - P_{receiving} \quad (2.2)$$

$$F_l = P_{loss} = \sum_{i=1}^{nlines} P_{LK_i} \quad (2.3)$$

Where P_{LK} indicates the loss in line ending to buses 1 and k, and FL= Floss represents the total loss of power network and 1....41 is the no. of lines in the IEEE 30 bus system.

3. STATCOM Size: The third term is related to having the minimum possible STATCOM sizes considering the control of STATCOM that is given by (2.4)

$$F_s = \sum_{i=1}^{no\ of\ STATCOM} Q_i$$

4. Maximum Loadability: From the power system static stability viewpoint, the maximum loadability of power system is extremely important and hence it plays an important role in our study too. Finally, the fourth issue is determining inverse of maximum loadability, given as follows:

$$F_{ML} = \frac{1}{\lambda}$$

These are four parameters which have to be calculated and minimized to achieve the stability of the system. This multi objective function is converted into single objective by adding these four in continuation to minimize the fitness function. The single objective function is defined as:

$$fitness\ value = w_1 F_v + w_2 F_l + w_3 F_s + w_4 F_{ML}$$

Where w_1, w_2, w_3, w_4 are weights which are defined as:

$$w_1 = 1$$

$$w_2 = \frac{1}{base\ power}$$

$$w_3 = \frac{1}{no\ of\ STACOM * 50}$$

$$w_4 = 1$$

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This objective function should be minimized and for those STATCOM size and location it is settled to a minimum value, those are considered as the final locations and sizes. The w_3 is multiplied with 50 Mvar which is the maximum allowed limit of size of STATCOM. In our case we have considered the maximum size 50MVar and minimum as 10 MVar.

III. RESULTS

In our work as proposed in last section PSO-GSA is used to get the STATCOM size and location which is to be placed in IEEE 14 bus system. Initially IEEE 14 bus system is tested for 3 and 5 number of STATCOMs. The more number of STATCOM increase the cost too. Although cost has not be calculated the cost so general concept is discussed yet it is a good practice if less number of extra resources are used for enhancing the stability. To introduce the disturbance in ideal system, load power has been increased to 1.6 times and results are analysed. A comparison for every case is done for GSA and proposed GSA-PSO. A fitness function plot is shown in figure 3.1.

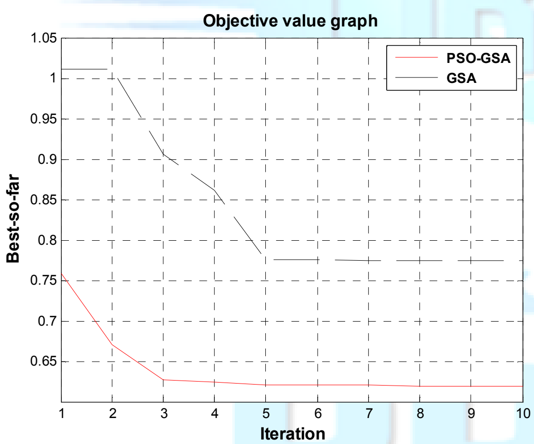

Figure 5.1: Fitness function value plot for GSA-PSO and GSA

Fitness values are decreasing in it so we expected a good tuned variable values. Moreover the value is decreased more for GSA-PSO than GSA. So a better performance for improvement of voltage stability can be expected by GSAPSO. After optimization, bus location and STATCOM size are variables to be tuned, so after the tuning values are shown in table 3.1.

Table 3.1: Variables values after optimization for IEEE14 bus system with 1.6 times loading.

GSA		GSA-PSO	
Bus Location	STATCOM Size	Bus Location	STATCOM Size
4	10	7	15.323227
10	10	5	26.712061
13	10	4	12.760835

The comparative results for voltage profile are shown in figure 3.2. It is clearly seen that voltage profile improvement in proposed case is more than only GSA. Line losses are calculated for both cases as shown in figure 3.3. Total loss comparison in all lines is shown in figure 3.4. Improvement in line losses are also there in proposed case. It reduces from 41.0474 MVar in GSA tuned case to 40.2729 MVar in proposed case. 0.67.

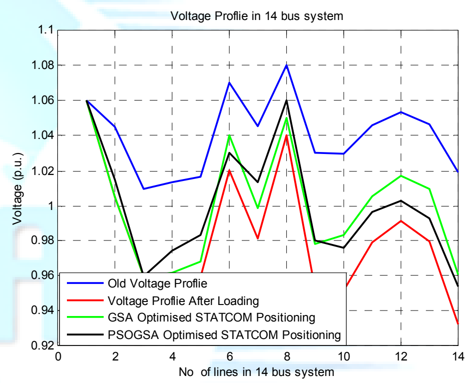

Figure 3.2: Comparison of voltage profile for IEEE14 bus system with 1.6 times loading.

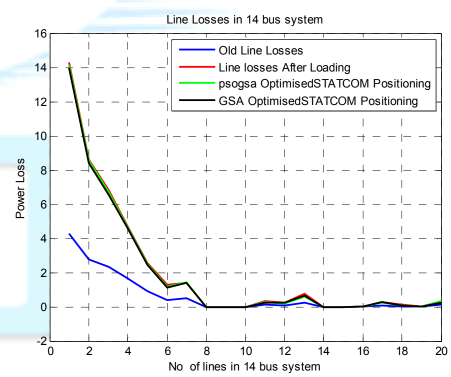

Figure 3.3: Line losses for IEEE14 bus system with 1.6 times loading.

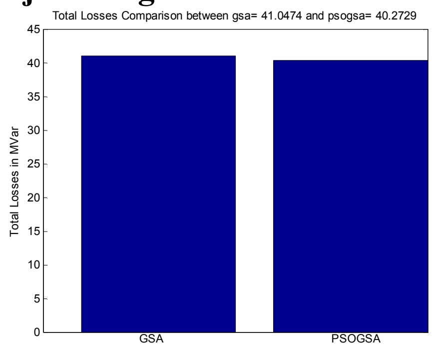

Figure 3.4: Total line loss for IEEE14 bus system with 1.6 times loading

IV. CONCLUSION

Monitoring of voltage stability under load variation and single line contingency with load variation has been presented in this work. The effectiveness of this method has been demonstrated on the IEEE 14 bus system. In this paper, the voltage stability enhancement problem of distribution system has been analyzed through optimal position and sizing of STATCOM. Optimization problem for the minimization of the voltage deviation, power losses, loadability of lines and sizing of STATCOM as the objective function is formulated and verified. Combination of GSA and particle swarm optimization has been adopted to identify the optimal location of the STATCOM placement and the optimal value of it. The optimization results obtained for IEEE 14 bus test system is analyzed and reported for the base case and for 1.6 times loading conditions.

REFERENCES

[1]. Prof. Aziz Ahmad, Dr. Anwar Shehzad, V.B. Shrivastava," Power Quality Improvement Using Statcom in Ieee 30 Bus System", Advance in Electronic and Electric Engineering, Volume 3, Number 6 (2013)

[2]. Kumarasamy, K.; Raghavan, R., "Particle Swarm Optimization algorithm for voltage stability improvement using multiple STATCOM," in Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM), 2012 International Conference on , vol., no., pp.235-242, 13-15 Dec. 2012

[3]. Mubeena.M.M, Baratraj E, Reshma.C.K," Optimal Placement of STATCOM in Power Systems", International Journal of Emerging Trends in Engineering Research (IJETER), Vol. 3 No.1, (2015)

[4]. Nagalakshmi Sanivarapu, R.Kalaivani, Dr.S.R.Paranjothi," OPTIMAL LOCATION OF STATCOM TO IMPROVE VOLTAGE STABILITY USING PSO", IJAET, Vol.II, Issue IV, October-December, 2011

[5]. K. Ravi and M. Rajaram," Optimal location of facts devices for solving multi objective optimal power flow (OPF) using improved shuffled leaping frog algorithm", Scientific Research and Essays Vol. 7(40), pp. 3421-3427, 23 October, 2012.

[6]. VANDANA,S.N. VERMA," VOLTAGE STABILITY ENHANCEMENT THROUGH OPTIMAL LOCATION OF STATCOM", Proceedings of 3rd IRF International Conference, 18th May-2014, Hyderabad, India

[7]. Avinash. R, Savyasachi. G. K,Gowtham. N,Rakshith. P," Optimal Location of STATCOMS using FVSI", International Advanced Research Journal in Science, Engineering and Technology Vol. 2, Issue 6, June 2015

[8]. Dilip Sahasrabudhe, Pawan Pandey," VAR Management to Improve Maximum Loading In IEEE 30 Bus System Using FACTS Controllers", Int. Journal of Engineering Research and Applications, Vol. 3, Issue 5, Sep-Oct 2013

[9]. A.A. Abou El Elaa, M.A. Abidob, S.R. Spea," Differential evolution algorithm for optimal reactive power dispatch", Electric Power Systems Research 81 (2011)

[10]. H. Omidi, B. Mozafari, A. Parastar and M.A. Khaburi, "Voltage Stability Margin Improvement using Shunt Capacitors and Active and Reactive Power Management," proceeding of IEEE Electrical Power & Energy Conference 2009

[11]. Byunghoon Chang, Byongjun Lee, and Joe H. Chow, "A Novel Operation Strategies for Shunt-Type FACTS Controllers in the KEPCO System," IEEE Transactions on Power Systems, VOL. 24, No.3, AUGUST 2009

[12]. Jong-Young Park, Jin-Man Sohn, and Jong-Keun Park, "Optimal Capacitor Allocation in a Distribution System Considering Operation Costs," IEEE Transactions on Power Systems, Vol. 24, No.1, FEBRUARY 2009 pp. 462-468.

[13]. Shwetal Patel and Bhavin Trivedi," VOLTAGE STABILITY ENHANCEMENT USING STATCOM BY CONVENTIONAL ALGORITHM", Int. J. Engg. Res. & Sci. & Tech. 2014

[14]. G. Naveen Kumar1, M. Surya Kalavathi2 and R. Harini Krishna," Optimal Placement Of Svc And Statcom For Voltage Stability Enhancement Under Contingency Using Cat Swarm Optimization", International Journal of Advances in Engineering & Technology, Nov. 2012.

[15]. J. Kennedy, R. Eberhart, "Particle swarm optimization" Proceedings of IEEE International Conference on Neural Networks (lCNN'95), vol. IV, pp. 1942-1948, Perth. Australia. 1995.

[16]. H. Yoshida, K. Kawata, Y. Fukuyama, S. Takayama, Y. Nakanishi,"A particle swarm optimization for reactive power and voltage control considering voltage security assessment" IEEE Trans, Power Systems, vol. 15(4). pp. 1232-1239, Nov 2000.

[17]. M. Clerc, 1. Kennedy, "The particle swarm explosion, stability and convergence in a multidimensional complex space", *IEEE Trans,* Evolutionary Computation, vol. 6(1), pp. 58-73, Feb 2002.

[18]. Swagatam Das, Arijit Biswas, Sambarta Dasgupt and Ajith Abraha," Bacterial Foraging Optimization Algorithm: Theoretical Foundations, Analysis, and Applications", Foundations of Computational Intelligence Volume 3,2009

[19]. Cheng-Hung Chen, Miin-Tsair Su, Cheng-Jian Lin, and Chin-Teng Lin," A Hybrid of Bacterial Foraging Optimization and Particle Swarm Optimization for Evolutionary Neural Fuzzy Classifier", International Journal of Fuzzy Systems, Vol. 16, No. 3, September 2014