# Particle swarm optimisation for reactive power compensation on Oman 6 bus electrical grid

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**ABSTRACT**

The consistent problem with operators and planners for power systems has been related to minimizing transmission losses. An important role is played by reactive power by keeping voltage stability and reliability in the system in order to support the transfer of real power. The optimal reactive power dispatch is associated with the problem of non-linear optimization along with many constraints. In this paper, a study is highlighted for an algorithm that optimizes reactive power with the help of particle swarm algorithm and compare the result with Newton-Raphson method. Reduction of system active power loss is the goal of the function in the projected algorithm. Here, the control variables identified are transformer tap positions, generator bus voltages, and shunt capacitor banks with switch. This projected algorithm is performed on Oman 6 bus electrical grid as oman electricity transmission company has an instability voltage issue in chosen 6 bus.



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## 1. INTRODUCTION

Security constraint optimal power flow also abbreviated as SCOPF is demonstrated for obtaining reactive power. In the power systems, the operations of the reactive power facilities must be based on the certain system-associated technical requirements [1]. These technical requirements are voltage profile improvement, reduction in transmission line loss. Also, in order to avoid instability, the voltage stability margin is enhanced in order to minimize load perturbation or failure of equipment [2]-[4]. Generally, identified issues with power systems that are restructured are procurement of optimal reactive power, reduction in losses, and efficient control of voltage. These issues can be expressed as a non-linear programming problem (NLP) [5]. The goal is to optimize the formulated function and at the same time substantiating the constraints of the objective function. In this objective function, there are two types of constraints, equality constraints and Inequality constraints. The equality constraints are generally power flow equations whereas the inequality constraints are limits applied on voltages, control variables, line flows, and reactive/active power generation [6]. To handle the problems of linear convex, optimization algorithms that are based on mathematics are known to be highly efficient. Based on previous studies on reactive power and optimized voltage control, the market for reactive power is a non-convex NLP containing multiple feasible regions. Hence, an optimum solution can be pointed anywhere within this region of feasibility. Therefore, these algorithms are extremely sensitive towards the starting points as well as initial conditions [7]. The implementation of stochastic behavior in evolving algorithms based on population helps in achieving an optimum solution. A survey is conducted on smart techniques application for voltage control in reactive power systems [8]. Scholars such as Kennedy and Eberhart worked on developing a progressive and powerful computation technique named PSO which is based on a simple concept and can be executed with few lines of coding. This computer code is based on primitive operators of mathematics and is cheaper to execute in terms of computational memory and speed [9]. This PSO technique is already in use for problem optimization in power systems and is also [10], [11], executed for resolving the popular issues on economic dispatch. For power optimization issues, Yoshida *et al*. [12] has worked on a two-stage method for executing a criterion for voltage stability. In the first stage of the method, the PSO helps in reducing the losses of transmission power. In the second stage of the method, the highest loading constraint of the system is gauged with help of continuous power flow method abbreviated as CPFLOW [13]. The initial solution fulfilling the basic requirements of system is identified as the ultimate best solution. Nevertheless, implementation of the PSO is limited for power market scheduling, particularly the reactive power market which is based on criteria for voltage stability [14].

## 2. PARTICLE SWARM OPTIMIZATION

In the year 1995, Kennedy and Eberhart developed a search technique based on a population named as particle swarm optimization (PSO) method [15]. It is derived from the swarm's natural movement in space searching for food. PSO can be used in optimizing mutidimensional problems, liner and nonliner problems and also single-dimensional problems. These algorithims are executed based on the particle population.

The problem dimension is identified based on variables present in the problem. The particles in the search space are tagged with initial values. With an assumption of an initial velocity, these particles move in search space adjusting their position with respect to global best and personal best points in search space. In each iteration, the component of velocity changes, hence the initial value assumption is crucial [16]. Another important component is inertia weight. Finally, after tracking the complete search space, the particle reaches the best position.

The parameters on which the PSO algorithm depends are inertia component, velocity factor and retardation factor. Hence it is crucial to identify the best value for these parameters [17]. To find the global optimum position, search space is explored extensively based on PSO parameters such as particle's acceleration, velocity and inertia weight. If the values of these parameters are incorrectly assigned, the algorithm may not provide complete coverage and get trapped into a local optimum point. At time denoted as t, the $i^{th}$ particle $X_i(t)$ can be written as:

$$X_I = [X_{I1}(t).X_{I2}(t).\dots\dots\dots\dots\dots\dots..X_{IN}(t)] \quad (1)$$

$$\mathrm{V_I} = [\mathrm{V_{I1}(t)}.\mathrm{V_{I2}(t)}.\dots\dots\dots\dots\dots\dots..\mathrm{V_{IN}(t)}] \quad (2)$$

### 2.1. Basic of PSO model

Where $X_s$ and $V_s$ are optimized parameters, $X_{ik}(t)$ is position of the $i^{th}$ particle with respect to the $k^{th}$ iteration, $V_{ik}(t)$ is velocity of the $i^{th}$ particle with respect to the $k^{th}$ iteration as shown in Figure 1. The particle changes its velocity and positions according to the following [18]:

$$V_i^{k+1} = w * V_i^k + C_p * rand() * \left(p_{besti} - p_i^k\right) + C_g * rand() * (g_{besti} - g_i^k) \quad (3)$$

$$X_i^{k+1} = X_i^k + V_i^{k+1} \quad (4)$$

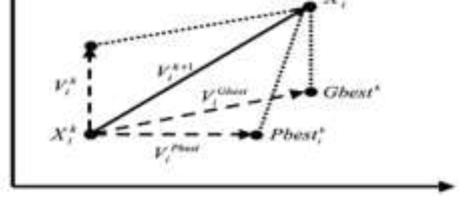


Figure 1. Search technique of the particle swarm optimization (PSO)

Where, $C_p$ is self-confidence range, $C_g$ is known as the swarm range, $V_i^k$ is velocity of the i[th]particle at iteration ‘k’, k is iteration number, w is inertia constant, $P_{besti}$ is value of personal best position of each particle in i[th] iteration, gbesti is value of personal best position of each particle in i[th] iteration and rand () is random number between 0 and 1.

## 2.2. PSO parameters

### 2.2.1. Size of swarm

The size of Swarm is identified based on count of particles in population. This count is associated with the performance of PSO. If there are a very less number of particles, the algorithm is swifted and trapped at a point of local optimization whereas if there is a very large count of particles, algorithm is speed is reduced. There is no particular rule to achieve the idle number of particles but the swarm size is increased with an increase in problem dimension [19].

### 2.2.2. Number of iteration

Based on the problem, the maximum number of iteration is identified in particle swarm optimization. If the iteration count is less, algorithm is stopped at a premature stage whereas if the iteration count is more the algorithm complexity is increased along with an increase in computational time which slows the convergence [20]. In this paper, number of iteration is considered as stopping criteria which is 500 iterations.

### 2.2.3. Components of velocity

The position of the swarm is based on the component of velocity which allows the particle to randomly moved according to particle’s best position and global best points. To start with, a random velocity value is tagged to each particle which is then updated in each iteration. The velocity value can be updated based on (3) for each iteration.

### 2.2.4. Coefficients of acceleration

The trajectory path on which the particle moves is determined by the coefficients of acceleration. This is affected by the experience of particles and other particle in search space. For an efficient tracking of global optimal position and convergence of the complete solution, the coefficients of acceleration must be properly assigned [21].

### 2.2.5. Inertia weight

Another important factor in PSO is inertia weight determines the search space exploration along with convergence. Interia weights are available in several types such as linearly decreasing, random decreasing, and logarithm. Intertia weight which is decreasing linearly helps in improving the performance of PSO. Several types of inertia weights are examined with the iteration count, characteristics of convergence, algorithm complexity for a comparative analysis [22].

## 3. COMPUTATIONAL PROCEDURES

The block diagram for PSO is shown in Figure 2 on the PSO optimization of load flow for reactive power compensation [23], [24]. There are fourteen steps need to be performed to get the results for 6 bus Oman electrical system as shown in Figure 3. Table 1 and Table 2 show the line data and bus data respectively.

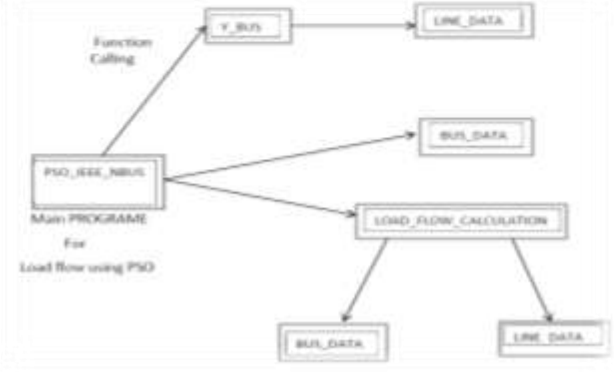


Figure 2. PSO block diagram

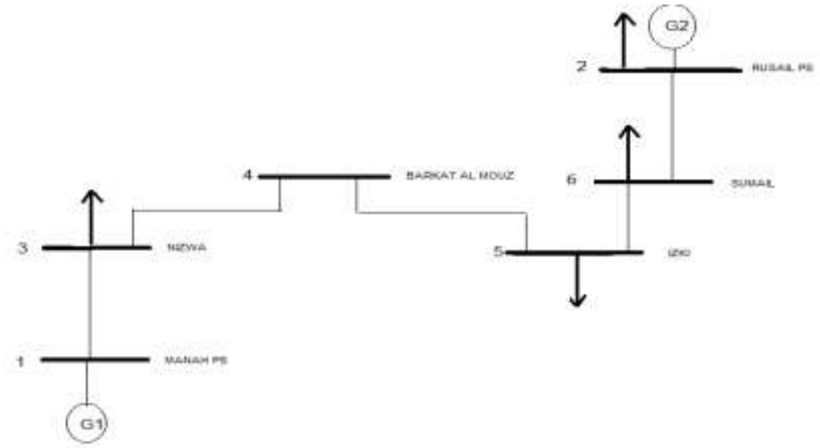


Figure 3. 6-bus Oman electrical grid

Table 1. Line data for a 6-bus Oman electrical grid

| Line No. | Bus Number | | Length (km) | Total Impedances Ω/Length (km) | | Total Impedances p.u/ Length(km) | | Half line charging Admittance p. u | Tap ratio |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | R | X | R | X | B/2 | - |
| 1 | 1 | 3 | 20 | 0.4283 | 2.82100 | 0.002458 | 0.01619 | 0 | - |
| 2 | 3 | 4 | 15.5 | 0.3319 | 2.18620 | 0.001905 | 0.012547 | 0 | - |
| 3 | 4 | 5 | 16.5 | 0.3533 | 2.32730 | 0.002027 | 0.013357 | 0 | - |
| 4 | 5 | 6 | 60.9 | 1.30417 | 8.58994 | 0.007484 | 0.049299 | 0 | - |
| 5 | 6 | 2 | 34.5 | 0.738817 | 4.86622 | 0.004240 | 0.027928 | 0 | |

Table 2. Line data for a 6-bus Oman electrical grid

| Bus No. | Voltage | | Generation | | Load | |
|---|---|---|---|---|---|---|
| | V (p.u) | Θ (deg) | P (MW) | Q (MVAR) | P (MW) | Q (MVAR) |
| 1 | 1.00 | 0 | - | - | - | - |
| 2 | 1.00 | 0 | 70 | 0 | - | - |
| 3 | 1.0 | - | - | - | 115 | 38 |
| 4 | 1.0 | - | - | - | 0 | 0 |
| 5 | 1.0 | - | - | - | 50 | 17 |
| 6 | 1.0 | - | - | - | 102 | 34 |

The steps PSO optimization of load flow for reactive power compensation are as clarified below:

a. NBUS = number of buses and this paper are Oman 6 bus electrical grid.
b. Calling Y bus function.
c. Setting base MVA = 100.
d. Calling bus data function as provided by Oman electricity transmission company.
e. PSO parameter initilization.
   - Number of particles = 66.
   - Maximum number of iterations = 500.
f. Creating storage matrix for variables.
g. Initializing the variables.
   - Voltage magnitude = random values between 0.9 and 1.1.
   - Load angle = random values between 0.3 and -0.3.
   - Velocity of voltage = random values between 0.5 and -0.5.
   - Velocity of theta = random values between 0.5 and -0.5.
h. Initializing the index for checking reactive power limit as in Table 3.

Table 3. Index for checking reactive power limit

| Sl.No. | Condition | PVIND |
|---|---|---|
| 1 | Q calc < Q min | 1 |
| 2 | Q calc > Q max | 2 |
| 3 | Q min < Q calc < Q max | 0 |

i. Computing the initial values for all particles.
j. For i= 1 to maximum number of iteration, initialize inertia weight until reach the stopping criteria which is 500 iterations.
k. Update the values of voltage and angle.
l. Calling load flow calculation PROGRAME to calculate line loss and power injected at each bus.
m. Calculate slack bus power which bus 2 as shown in Figure 3.
n. End.

## 4. RESULTS AND DISCUSSION

As explain above, the algorithm of PSO is implemented on 6-bus Oman electrical system in Matlab by using the bus and line data as in Table 1 and Table 2, and the result as discussed in Table 4 and Table 5 below. The Newton Raphson (NR) as conventional method has been implemented on the same 6 bus electrical system as in [25], and the comparison between results is highlighted as well.

Table 4. Load flow result of 6-bus Oman electrical system by using PSO

| Bus No. | Voltage (P.u) | Angle (Degree) | Injection | | Generation | | Load | |
|---|---|---|---|---|---|---|---|---|
| | | | MW | Mvar | MW | Mvar | MW | Mvar |
| 1 | 1.000 | 0.000 | 479.550 | -423.23 | 479.55 | -423.23 | 0.00 | 0.00 |
| 2 | 1.000 | -2.287 | -309.460 | 69.58 | 201.93 | 69.58 | 0.00 | 0.00 |
| 3 | 1.060 | -4.762 | 289.350 | 293.98 | -194.46 | 331.98 | 115.00 | 38.00 |
| 4 | 1.080 | -5.950 | -533.360 | 785.7 | 289.35 | 785.7 | 0.00 | 0.00 |
| 5 | 1.000 | -8.490 | -533.360 | -447.35 | -483.36 | -430.85 | 50.00 | 16.50 |
| 6 | 0.973 | -5.439 | -104.470 | -123.67 | -19.47 | -98.67 | 85.00 | 25.00 |
| Total | | | 23.530 | 155.012 | 273.5 | 234.512 | 250.00 | 79.50 |

Table 5. Line power flow result of 6-bus Oman electrical system by using PSO

| Bus | | | | Bus | | | | Line Loss | |
|---|---|---|---|---|---|---|---|---|---|
| From | To | P (MW) | Q (Mvar) | From | To | P (MW) | Q (Mvar) | MW | Mvar |
| 1 | 3 | 479.55 | -423.23 | 3 | 1 | -469.49 | 489.46 | 10.06 | 66.23 |
| 3 | 4 | 160.04 | -195.48 | 4 | 3 | -158.96 | 202.6 | 1.08 | 7.12 |
| 4 | 5 | 448.3 | 583.1 | 5 | 4 | -438.92 | -521.25 | 9.39 | 61.85 |
| 5 | 6 | -94.44 | 73.9 | 6 | 5 | 95.52 | -66.83 | 1.07 | 7.07 |
| 6 | 2 | -199.99 | -56.84 | 2 | 6 | 201.93 | 69.58 | 1.93 | 12.74 |
| | | | | Total Loss | | | | 23.53 | 155.012 |

It is obvious that, the real power loss by using PSO is 23.530 MW which is more than what is found by using the NR method which is 1.35 MW. The computational time for PSO (0.69 sec) is less than in NR (1.45 sec). In this implementation, the number of iterations is for PSO, in search for optimized reactive power compensation is 500 iterations and it is also used as the stopping criteria. In case of increasing this number, the computational time of convergence will increase as well. The parameters dependency in PSO algorithm is obtained using different inertia weight by changing different parameters such as tolerance factor, retardation factor, cognitive factors. The comparison between PSO and NR is shown in Table 6 and in terms of voltage magnitude is as in Figure 4.

Table 6. Comparison between NR and PSO

| Criteria | PSO | NR |
|---|---|---|
| Number of iterations | 500 | 5 |
| Total power loss (MW) | 23.53 | 1.35 |
| Computational time(sec) | 0.698793 | 1.45 |

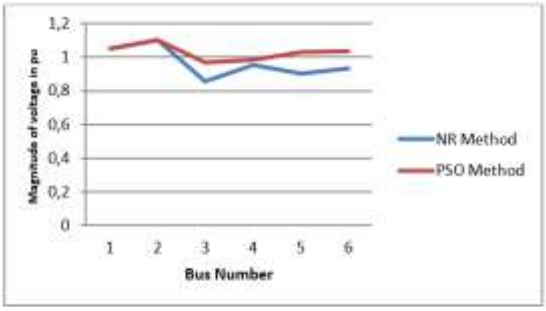


Figure 4. Comparison of voltage magnitude for NR method & PSO method

## 5. CONCLUSION

In this paper, the PSO algorthim was used to obtain the power loss for 6-bus Oman electrical system which will help to determine the reactive power compensation needed to maintain the required voltage profile. In addition, the results have been compare with NR results for the same system and it is clear that PSO is more robust and effective. PSO is more flexible and has better and fast convergence compared to NR method and other techniques.

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## REFERENCES

[1] S. Sindhuja, S. Raj, and A. Viswanathan, “Enhancement of voltage stability in an indian practical utility system under,” *Advances in Natural and Applied Sciences*, vol. 8, no. 21, pp. 52-58, 2014.
[2] M. C. Thakur and M. S. Sahu, “Analysis of voltage stability and transfer capability enhancement of transmission system using facts controllers,” *Advances in Natural and Applied Sciences*, vol. 2, no. 4, pp. 2279-0535, 2013.
[3] A. F. M. Nor, M. Sulaiman, A. F. A. Kadir, and R. Omar, “Voltage instability analysis for electrical power system using voltage stabilty margin and modal analysis,” *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 3, no. 3, pp. 655-662, September 2016, doi:10.11591/ijece.v6i3.10163.
[4] Y. A. Mobarak and M. M. Hussein, “Voltage instability and voltage collapse as influenced by cold inrush current,” *ICGST-ACSE Journal*, vol. 12, no. 1, pp. 9-20, June 2012.
[5] Niranjan, Natasha, Manisha, and Sujata, “Voltage collapse: causes and prevention,” *International Journal Of Engineering Research & Technology*, vol. 4, no. 2, pp. 1-4, 2016.
[6] P. Molekar and V. N. Pande, “Voltage stability assessment and loss minimisation by power system reconfiguration,” *International Journal of Research & Review*, vol. 6, no. 8, pp. 468-477, 2019.
[7] D. Pudjianto, S. Ahmed, and G. Strbac, “Allocation of V AI support using LP and NLP based optimal power flows,” *IEE Proceedings-Generation, Transmission and Distribution*, vol. 149, no. 4, pp. 377-383, 2002, doi: 10.1049/ip-gtd:20020200.
[8] R. C. Bansal, T. S. Bhatti, and D. P. Kothari, “Artificial intelligence techniques for reactive power voltage control in power systems: A review,” *International Journal of Power and Energy Systems*, vol. 23, no. 2, pp. 81-89, 2003.
[9] J. Kennedy and R. Eberhart, “Particle swarm optimization,” *Proceedings of ICNN'95-International Conference on Neural Networks*, 1995, pp. 1942-1948 vol.4, doi: 10.1109/ICNN.1995.488968.
[10] Jong-Bae Park, Ki-Song Lee, Joong-Rin Shin, and K. Y. Lee, “A particle swarm optimization for economic dispatch with nonsmooth cost functions,” in *IEEE Transactions on Power Systems*, vol. 20, no. 1, pp. 34-42, Feb. 2005, doi: 10.1109/TPWRS.2004.831275.
[11] Zwe-Lee Gaing, “Particle swarm optimization to solving the economic dispatch considering the generator constraints,” in *IEEE Transactions on Power Systems*, vol. 18, no. 3, pp. 1187-1195, 2003, doi: 10.1109/TPWRS.2003.814889.
[12] H. Yoshida, K. Kawata, Y. Fukuyama, S. Takayama, and Y. Nakanishi, “A particle swarm optimization for reactive power and voltage control considering voltage security assessment,” in *IEEE Transactions on Power Systems*, vol. 15, no. 4, pp. 1232-1239, Nov. 2000, doi: 10.1109/59.898095.
[13] Hsiao-Dong Chiang, A. J. Flueck, K. S. Shah, and N. Balu, “CPFLOW: a practical tool for tracing power system steady-state stationary behavior due to load and generation variations,” in *IEEE Transactions on Power Systems*, vol. 10, no. 2, pp. 623-634, May 1995, doi: 10.1109/59.387897.
[14] P. Kundur, “Power system stability and control,” *McGraw-Hill*, 1994.
[15] N. I. Deeb and S. M. Shadhidehpour, "An efficient technique for reactive power dispatch using a revised linear programming approach," *Electrical power research*, vol. 15, no. 2, pp. 121-134, October 1988, doi: 10.1016/0378-7796(88)90016-8.
[16] S. Kaitwanidvilai, P. Olarnthichachart, and I. Ngamroo, “PSO based automatic weight selection and fixed-structure robust loop shaping control for power system control applications,” *International Journal of Innovative Computing, Information and Control*, vol. 7, no. 4, pp. 1549-1563, 2011.
[17] M. A. Abido, “Optimal power flow using particle swarm optimization,” *Electrical Power & Energy Systems*, vol. 24, no. 7, pp.563-571, October 2002, doi: 10.1016/S0142-0615(01)00067-9.
[18] Z. Cui, J. Zeng, and G. Sun, “A fast particle swarm optimization,” *International Journal of Innovative Computing, Information and Control*, vol. 2, no. 6, pp. 1365-1380, 2006.
[19] A. R. Jordehi, ‘‘Particle swarm optimisation (PSO) for allocation of FACTS devices in electric transmission systems: A review,’’ *Renewable and Sustainable Energy Reviews*, vol. 52, pp. 1260-1267, 2015, doi: 10.1016/j.rser.2015.08.007.
[20] Y. del Valle, G. K. Venayagamoorthy, S. Mohagheghi, J. Hernandez, and R. G. Harley, "Particle swarm optimization: basic concepts, variants and applications in power systems," in *IEEE Transactions on Evolutionary Computation*, vol. 12, no. 2, pp. 171-195, April 2008, doi: 10.1109/TEVC.2007.896686.
[21] D. H. Tungadio, B. P. Numbi, M. W. Siti, and A. A. Jimoh, "Particle swarm optimisation for power system state estimation," *Neurocomputing*, vol. 148, pp. 175-180, January 2015, doi: 10.1016/j.neucom.2012.10.049.

[22] A. M. Eltamaly, Y. S. Mohamed, Abou-Hashema M. El-Sayed, M. A. Mohamed, and A. N. A. Elghaffar, "Optimum power flow analysis by newton raphson method," *International Journal of Engineering*, vol. 4, no. 2, pp. 51-58, December 2018, doi: 10.1007/s40866-020-00096-2.
[23] Antamil, A. Arief, and I. C. Gunadin, "Allocation of reactive power compensation devices to improve voltage profile using reactive participation index," *Journal of Electrical and Electronics Engineering*, vol. 10, no. 4, pp. 82-90, 2015, doi: 10.9790/1676-10418290.
[24] J. Sovizi, A. A. Alamdari, and V. N. Krovi, "A random matrix approach to manipulator jacobian," *ASME 2013 Dynamic Systems and Control Conference*, vol. 56147, p. V003T39A005, 2013, doi: 10.1115/DSCC2013-3950.
[25] A. AL Mamari and S. F. Bt. Toha, "Voltage stability improvement and transmission loss minimization for a 5-bus Oman system based on modal analysis and reactive power compensation," *International Journal of Innovative Science and Research Technology*, vol. 4, no. 8, pp. 442-448, August 2019.


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