OPTIMAL REACTIVE POWER DISPATCH BY USING FIREWORKS ALGORITHM

M. Selvalakshmi, Senior Assistant Prof. Mr. S. Jaisiva.

Student, Electrical & Electronics, IFET College of Engineering, Villupuram, India.

Abstract: In this project a recently developed optimization technique named as fireworks algorithm to compensate the reactive power. the main objective is minimize the power loss in transmission line and /or minimizing in voltage deviation in power system due to sparks or explosion . Is necessary for secured operation of power system with regard to voltage stability. The fireworks algorithm(FA) nature inspired is introduced to solve multi constrained optimal reactive power flow problem in power system. Generator bus voltage, transformer tap position and switchable shunt capacitor banks are used as variable to control the reactive power flow. Fireworks algorithm was tested on standard IEEE -30bus system in Matlab and the result are compared with other method to prove the effectiveness of the new algorithm . The result are quite emerging and the algorithm is found to be simple and easy to implement. In this project load flow studies are done by using N-R method.

IndexTerms – **Fireworks algorithm, Optimized reactive power flow.**

INTRODUCTION

The increased demand for electric power and the insufficient power generation and transmission facility forces the power system networks is being operated under stressed conditions. The security of a power system is under threat when it is operated at stressed conditions and may result in voltage instability. Nowadays voltage instability has become a new challenge to power systemss planning and operation. Insufficient reactive power availability or non-optimized reactive power flow may lead a power system to insecure operation under heavily loaded conditions . By reallocating reactive power generations in the system by adjusting transformer taps, generator voltages and switchable VAR sources, the problem can be solved to a far extent. Apart from the above mentioned methods, the system losses can also be reduced via redistribution of reactive power in the system for improving the stability of a power system. Large amount of reactive power flow in a system is indicated by the real power loss in the system.Therefore minimizing the real power loss ensures optimized reactive power flow (ORPF) through the lines. Reactive power optimization by real power loss minimization increases the power system economics to some extent. Reactive power optimization by minimization of real power loss has long been attempted for voltage stability improvement .Optimal reactive power flow is an important tool in terms of secure and operation of power system. It is a powerful concept for power system Operation and planning . In ORPF, the network active power loss is reduced and voltage profile is improved while satisfying a given set of operating and physical constraints. Reactive power flow is optimized by properly setting the values of control parameters. A number of conventional optimization methods have been exploited for this objective. Techniques such as non linear programming technique , gradient based optimization algorithm are used to solve ORPF problem algorithms are used to solve ORPF problem. But it has several disadvantages like large numerical iteration, insufficient convergence properties; which leads to large computation and more execution time.

The recently developed meta-heuristics based algorithms are proving better performance than the conventional methods. They find global best or nearly global best solutions for engineering problems. These algorithms are better utilised for power system optimization. Some of them are Tabu Search , Simulated Annealing (SA) , Genetic Algorithm (GA) , Evolutionary Programming (EP) Hybrid Evolutionary Programming (HEP), Particle Swarm Optimization PSO , Chaotic Ant Swarm Optimization (CASO), Bacterial Foraging Optimization (BFO) , Ant Colony Optimization (ACO) , Differential Evolution (DE) and Quantum Genetic Algorithm (QGA) are developed which provides fast and optimal solution. Conventional methods are sensitive to initial guess of the search point where functions have multiple local minima and not efficient in handling problems of discrete variables . In addition to this a lot of algorithms have been presented to solve optimal reactive power dispatch. Chien-Feng Yang proposed a system for limiting voltage variations by means of switchable shunt reactive compensation and transformer tap setting . Other new optimization techniques are based on using fuzzy logic , Newton raphson decomposition method .

FA algorithm is a recent development and it very simple and easy to implement . This algorithm has less number of parameters and has good convergence characteristics. Here in this paper, the FA method is used for ORPF problem. The performance of this method is related with other algorithms to prove its efficiency.

PROBLEM FORMULATION

The objective of this work is to optimize the reactive power flow in a power system by minimizing the real power loss and sum of load bus voltage deviation. An augmented objective function is formed with the two objective components and weights.

1 Objective function

The objective function of this work is to find the optimal settings of reactive power control variables including the rating shunt of var compensating devices which minimizes the real power loss and voltage deviation. Hence, the objective function can be expressed as:

$$F = \min\{WPL + (1 - W)VD\} \qquad (1.1)$$

Where w is tihe weighing factor for real power loss and voltage deviation and is set to 0.7.

2 Real power loss minimization (P_L)

The total active or real power of the system can be computed as follows

$$Ploss = \sum_{k=1}^{NL} Gk[V1^2 + V^2 - 2[vi][vj] \cos \delta_{j - \delta_{ij}}] \qquad (1.2)$$

Where , N_L is the total number of lines in the system ; G_k is the conductance of the 'k' v_i and v_j are the magnitudes of the sending end and receiving end voltages of the line ; δ_i and δ_j are angles of the end voltages

3 Load bus voltage deviation minimization (vd)

Bus voltage magnitude should be maintained within the allowable range to ensure quality service. Voltage profile is improved by minimizing the deviation of the load bus voltage from the reference value (it is taken as 1.0 p.u. in this work).

$$V_D = \sum_{k=1}^{NPQ} [(Vi - Vref)] \qquad (1.3)$$

4 Constraints

The minimization problem is subject to the following equality and inequality constraints

I EQUALITY CONSTRAINTS

Load Flow Constraints:

The equality constraints represent the load flow equations, which are given below for i_{th} bus:

$$= \sum_{j=1}^{NB} vi\ vjYijcos\ (\delta ij + \gamma j - \gamma i) \qquad (1.4)$$

$$= \sum_{j=1}^{NB} ViVj\gamma ijsin(\delta ij + \gamma i - \gamma j) \qquad (1.5)$$

Where Pgi , Qgi are the active and reactive power of i_{th} generator, P_{Di} , Q_{Di} the active and reactive power of i_{th} load bus

II INEQUALITY CONSTRAINTS:

Generator constraints:

Generator voltage and reactive power of i_{th} bus lies between their upper and lower limits as given below:

$$\begin{cases} vgi\ min \leq vgi \leq vgi\ max & i = 1,2 \dots \dots \dots NG \\ Qgi\ min \leq Qgi \leq Qgi\ max & i = 1,2 \dots \dots NG \end{cases} \qquad (1.6)$$

Where Vgi min ,Vgi max are the minimum and maximum voltage of i_{th} generating unit and Qmin gi , Qmax gi are the minimum and maximum reactive power of i_{th} generating unit.

i Load bus constraints:

$$VL1min \leq VL1 \leq L1\ max \qquad i = 1,2 \dots \dots NL \qquad (1.7)$$

Where VL1min,VL1max are the minimum and maximum load voltage of ith unit

ii Transmission line constraint SL1SL1 max $i = 1,2 \dots \dots \dots NTL$ (1.8)

Where VL1min,VL1max are the minimum and maximum load voltage of ith unit

iii Transformer tap constraints

$$Ti\ max \leq Ti \leq Timax \qquad (1.9)$$

Where Ti max Ti max are the minimum and the maximum tap setting limits of ith trans.

Shunt compensator constraints:

$$SL1 \leq SL1\ max \qquad i = 1,2 \dots NT \qquad (1.10)$$

FIREWORKS ALGORITHM

In recent years, Swarm Intelligence (SI) has become popular among working on optimization problems all over the world.SI algorithms,e.g.Particle Swarm Optimization (PSO) , Ant System , Clonal Selection Algorithm , and Swarm Robots , etc., have advantages in solving many optimization problems. Among all the SI algorithms ,PSO is one of the most popular algorithm for searching optimal locations in a D-dimensional space. In 1995, Kennedy and Eberhart proposed PSO a powerful global optimization algorithm inspired by the behavior of bird blocks . Since then, the PSO has attracted the attentions of researchers around the globe, and a number of variants of PSO have been continually proposed . Like PSO, most of swarm intelligence algorithms are inspired by some intelligent colony behaviors in nature. In this paper, inspired by the emergent swarm behavior of fireworks, a novel swarm intelligence algorithm called Fireworks Algorithm (FA) is proposed for function optimization. The FA is presented and implemented by simulating the explosion process of fireworks. In the FA, two explosion (search) processes are employed and mechanisms for keeping diversity of sparks are also well designed. To validate the performance of the proposed FA, comparison experiments were conducted on nine benchmark test functions.

IMPLEMENTATION OF FIRE WORKS ALGORITHM:

Framework of the FA

Step1:   Randomly select n locations for fireworks;

Step 2: While stop criteria=false do

Step3:   Set down n fireworks respectively at the n locations:

Step 4: For each firework xi do

Step 5:   Calculate the number of sparks that the firework yields: si,

Step 6:   Obtain locations of ˆ si sparks of the firework xi using Algorithm 1;

Step 7: end for for k=1:ˆ m do

Step 8: Randomly select a firework xj; Generate a specific spark for the   firework ;

Step 9:   end for

Step10: Select the best location and keep it for next explosion generation;

Step11:Randomly   select   n−1   locations   from   the   two   types   of   sparks   and   the

current fireworks according to the probability ; end while.
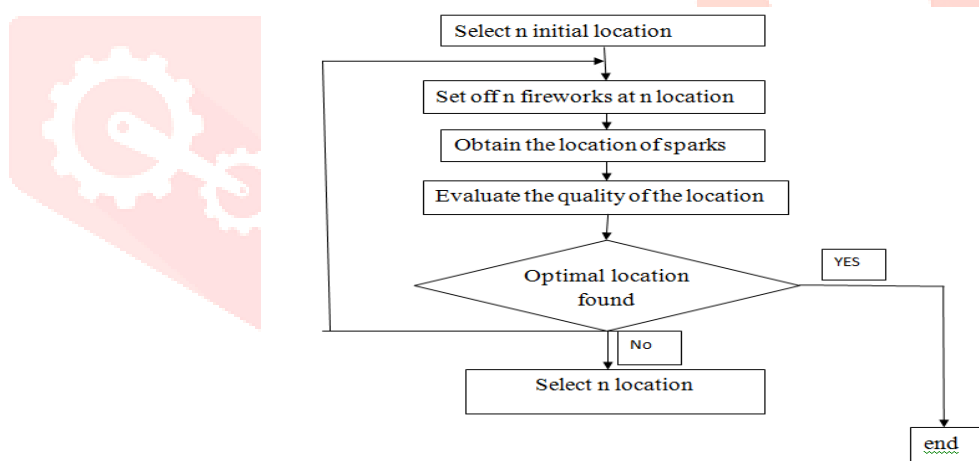
FIREWORK ALGORITHM FLOW CHART

Fig 1:Firework algorithm flow chart

IEEE 30 BUS SYSTEMS

    The performance of the proposed Fireworks algorithmfor minimizing real power loss is tested on IEEE 30 bus system. The algorithm is coded in MATLAB environment and a BT 950 processor, 2.1 MHz, 4GB RAM based PC is for the simulation purpose the control variables are Generator bus voltage magnitudes, transformer tap settings and VAR outputs from shunt compensating devices are the control parameters in optimal power flow problems. These control parameter values are adjusted for loss reduction. The test system taken has six generating units connected to buses 1, 2, 5, 8, 11 and 13. There are 4 regulating transformers connected between bus numbers 6-9, 6-10, 4-12 and 27-28. Two shunt compensators are connected in bus numbers 10 and 24.
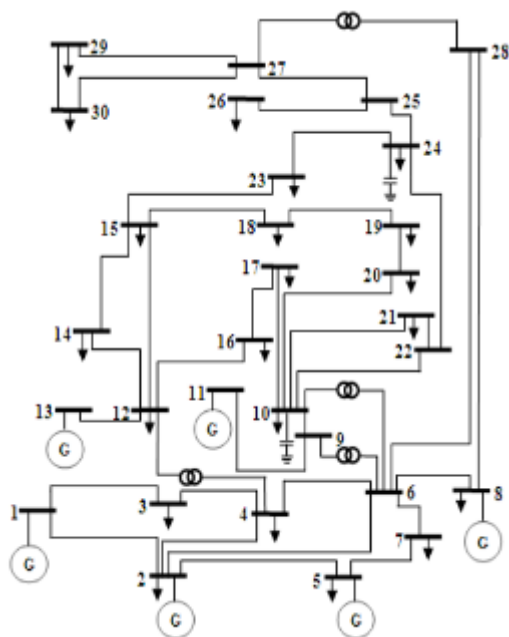
IEEE 30 BUS

Fig 2.Single line diagram of IEEE 30 bus system

NUMERICAL VALUE

The performance of the proposed fireworks algorithm for enhancement of voltage profile by minimizing real power loss is tested on IEEE 30 bus system. The objectives of introducing SVC in the improve power loss of the line operating very closer to their loading limits.

Table 1. Voltage Deviation Value

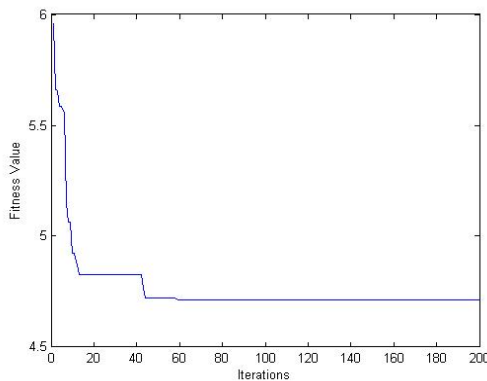| SI.NO	POWER LOSS	VOLTAGE DEVIATION
1	5.744	4.463

Fig 3. convergence condition

CONCLUSION

In this proposed, a novel FA Based optimization algorithm is proposed to solve multi-objective optimal reactive power flow problem. The performance of the proposed algorithm for solving ORPF problems is demonstrated using IEEE-30 bus system. The results are compared to those of other algorithms like PSO and CPSO. The test results clearly exhibit that FA outperforms other reported methods in terms of solution quality. The superiority of the proposed FA method is more pronounced for large system as is evident from IEEE-30 bus system. From all simulation results it may finally be concluded that among all the algorithms, FA based optimization method is capable of achieving global optimal solution. This project shows that such tremendous results with different objective functions shows that makes the proposed FA optimization technique is good in dealing with power system optimization problems.

REFERENCES

[1] P.K. Roy , S.P. Ghoshal , S.S. Thakur, "Optimal VAR Control for Improvements in Voltage Profiles and for Real Power Loss Minimization using Biogeography Based Optimization", Electrical Power and Energy Systems, Vol. 43, No.1, pp. 830–838, December 2012.

[2] Abbas Rabiee, MaziarVanouni, MostafaParniani, "Optimal Reactive Power Dispatch for Improving Voltage Stability Margin Using a Local Voltage Stability Index", Energy Conversion and Management, Vol. 59, pp. 66-73, July 2012.

[3] KursatAyan, Ulaskilic, "Artificial Bee Colony Algorithm Solution for Optimal Reactive Power Flow", Applied Soft Computing, Vol.12, No. 5, pp. 1477–1482, May 2012.

[4]M. Varadarajan, K.S. Swarup, "Differential Evolutionary Algorithm for Optimal Reactive Power Dispatch, Electrical Power & Energy Systems, Vol. 30, No. 8, pp. 435–441, October 2008.

[5]AmitSaraswat, AshishSaini, "Multi-Objective Optimal Reactive Power Dispatch Considering Voltage Stability in Power Systems using HFMOEA", Engineering Applications of Artificial Intelligence, Available online 18 July 2012.

[6] Altaf Q.H. Badar , B.S. Umre, A.S. Junghare, "Reactive Power Control Using Dynamic Particle Swarm Optimization for Real Power Loss Minimization", Electrical Power & Energy Systems, Vol. 41, No. 1, pp. 133 136, October 2012.

[7] Reza Sirjani , Azah Mohamed, HussainShareef, "Optimal Allocation of Shunt Var Compensators in Power Systems Using a Novel Global Harmony Search Algorithm", Electrical Power & Energy Systems, Vol. 43, No.1, pp. 562–572, December 2012.

[8] SerhatDuman ,UgurGuvenc , Yusuf Sonmez , NuranYorukeren, "Optimal Power Flow Using Gravitational Search Algorithm Energy Conversion and Management", Vol. 59, pp.86–95, July 2012.