Available online at www.scientiaresearchlibrary.com

Scientia Research Library **ISSN 2348-0424**
USA CODEN: JETRB4

Journal of Engineering And Technology Research, 2016, 4 (2):1-8
(*http://www.scientiaresearchlibrary.com/arhcive.php*)

IMPLEMENTATION OF EVOLUTIONARY ALGORITHM FOR PROFIT BASED POWER GENERATION USING FACTS DEVICES

M.Karthikeyan[1*] , Dr.T.SreeRenga Raja[2]

[1,2]*Assistant Professor ,Anna University,BIT CampusTiruchirappalli, India*

ABSTRACT

In this paper, a differential evolution algorithm has been implemented to determine the optimum solution for scheduling of generator unit with minimum operating cost. The proposed algorithm is implemented to identify the location of Flexible Alternating Current Transmission systems (FACTS) devices with regard to less fuel cost and power loss minimization. It is based on steady state power injection model of UPFC. It has a great flexibility that can control both generating powers and bus voltage simultaneously. The feasibility of this algorithm has been verified on IEEE 30 bus system with and without FACTS device.

Key words: Evolutionary Algorithm, UPFC, Optimization, Fuel Cost.

INTRODUCTION

Evolutionary algorithms are optimization techniques based on the concept of a population of individuals that evolve and improve their fitness through recombination and mutation. These individuals are evaluated and those that perform better are chosen to compose the population for next generation. After several iterations the individuals improve their fitness as they explore the solution space for optimal value. The field of evolutionary computation has experienced significant development in the field of optimization. These are capable of solving complex optimization problems such as those with a non-continuous, non-convex and highly nonlinear solution space. These algorithms have been improved by using parallel computation to search the solution of global optima with great convergence characteristics which has been successfully implemented to solve the economic dispatch problem [1-12].

Optimal Power flow (OPF) has become one of the most important problems in planning process of modern power systems. It is the fundamental tool that enables electric utilities to specify economic operating and secure states in power systems. The main objective is to optimize the desired objective function such as fuel cost with valve point effects, piecewise quadratic cost function, voltage profile improvement by satisfying equality and inequality constraints with proper adjustment of control variables. The inequality constraints involve the transformer tap ratio, generating powers and bus voltages.

MATERIAL METHOD

Optimal Power Flow with FACTS Controllers

The OPF is one of the nonlinear constrained optimization problem of power systems. It requires the result obtained by solving the nonlinear equations that specify the secure operating level of the power system.It is formulated as constrained optimization problem

$Minimize\ S(v,y)$

$subject\ to\ a(y)=0$

$b(y)\geq 0$

$where\ v$ - set of control variables

y - set of dependent variables

$S(v,y)$ - Objective function

UPFC

UPFC comprises of two converters which is voltage based combined by a linking capacitor. In that one act as a series compensated device [TCSC] which operates either as inductive reactance or capacitive reactance by adjusting the variable reactance part of the corresponding transmission line and the other act as shunt compensated devices [SVC] that controls the voltage either by adding or removing the reactive power from the corresponding transmission line[2]. The variable reactance in the series compensated device can be written as

$$Z_{ij}=Z_L+jX_{TCSC}$$
$$X_{TCSC}=\Gamma_{TCSC}.X_L$$

$where\ Z_L$ - line impedance

X_{TCSC} - line reactance of the located transmission line

Γ_{TCSC} – degree of compensation of series connected device.

The shunt connected devices act as variable susceptance that add or removes the reactive power in the corresponding bus to maintain the secure level of operation which is written as

$$\Delta Q_{is}=Q_{svc}$$

Where Q_{svc} – injected reactive power of SVC in the corresponding bus

Hence the limit of the compensating device is given by

$$-0.8X_L\leq X_{TCSC}\leq 0.2X_L$$

$$-200MVAR\leq Q_{svc}\leq 200MVAR$$

The location for fixing the compensating device in the network is identified based on the value of control parameter. This is calculated based on the index value of the stability limit of each transmission line. UPFCs are placed in worst valued bus and the areas of tightly loaded to decrease the tension in the network. By running the load flow program the stability index is predicted for all the lines by connecting the compensating device and the index value with higher is selected for placing the device[9].

Mathematical Formulation:

Fuel cost reduction is our objective function that satisfies the equality and inequality constraints. The function is expressed as

$$Min\sum_{i=1}^{g}(a_i P_{gi}{}^2 + b_i P_{gi} + c_i)\$/h$$

Subject

$$Pg_i - Pd_i - \sum_{j=1}^{nb} V_i \| V_j \| Y_{ij} | \cos(\theta_{ij} - \delta_i + \delta_j) + P_{inj,m} = 0 \; Qg_i - Qd_i + \sum_{j=1}^{nb} V_i \| V_j \| Y_{ij} | \sin(\theta_{ij} - \delta_i + \delta_j) + Q_{inj,m} = 0$$

$$Pg_i^{\min} \le Pg_i \ge Pg_i^{\max} i = 1, 2, ..., ng$$

$$Qg_i^{\min} \le i = 1, 2, ..., nt$$

$$Qc_i^{\min} \le Qc_i \ge Qc_i^{\max} i = 1, 2, ..., nc$$

$$V_{se}^{\min} \le V_{se} \ge V_{se}^{\max}$$

$$\theta_{se}^{\min} \le \theta_{se} \ge \theta_{se}^{\max}$$

Where

a, b, c - coefficient of fuel cost

g - number of generating bus

$Pgi \& Qgi - generatedrealandreactivepower$

$Pdi \& Qdi - realandreactivepowerdemand$

$Pgi^{\min}, Pgi^{\max},$
$Qgi^{\min}, Qgi^{\max} - generating \lim its$

$Vi^{min} \& Vi^{\max} voltage \lim its$

$Qci^{\min} \& Qci^{\max} - injectingreactivepower \lim its$

EVOLUTIONARY ALGORITHM OVERVIEW

The Evolutionary algorithm has been developed by Price and Storn, based on the population generated which is similar to GA. The DE depends on mutation operation as a search mechanism and selection operations to direct the search toward the prospective regions in the search space. The idea behind DE is generation of trial vectors and in all the step the vector updates by summing weights and randomizing the vector differentially. If the obtained fitness value of the present vector is better than that of the decided vector, then the decided value is replaced by present vector in the next generation. The DE algorithm is described as

Initialization: The initial population is generated randomly within the specified constraints

$$U_i^{(G)} = U_{ij} + rand[0,1]*(U_{ij}^{(h)} - U_{ij}^{(l)})$$

$where\ rand[0,1]$ - indicates the random value of uniform distribution between [0,1]

$U_{ij}^{(l)}\ \& U_{ij}^{(h)}$ - lower and upper boundary

Mutation: In this algorithm the process of mutation is to avoid the breaking up of search by the introduction of new parameters into the generation

$$V_i^{(h+1)} = U_{r3}^{(h)} + f_m*(U_{r2}^{(h)} - U_{r1}^{(h)})$$

$U_{r3}^{(h)}, U_{r2}^{(h)}\ and\ U_{r1}^{(h)}$ - Selected vectors randomly among the generated population

If $r_1 \neq r_2 \neq r_3$, calculate the vectorial difference between them, adjustment factor selected between the range[0,2] such that $f_m > 0$ is a real parameter due to the possibility of creating new generations. Cross Over: It creates the trial vectors, by combining the parent vector with mutant vector based on the probability distribution. For each of the mutation vector, $V_i^{(h+1)}$ choosing of index number is followed based on uniform distribution $snrb(i)\{1,2,....n\}$ and trial value, $x_i^{(h+1)} = [x_{i1}^{(h+1)}, x_{i2}^{(h+1)}, ...x_{in}^{(G+1)}]^T$ is generated using the equation

$$x_{ij}^{(h+1)} = v_{ij}^{(h+1)} if\ (rand[0,1] \leq MR) or (j = snrb(i))$$
$$= U_i^{(G)} else$$

Selection: The selection operator identifies the particular vector that is going to decide the next generationvector. These vectors are selected from the trial value and the current population. In this stage each of the present value is compared with previous value using the equation.

$$U_i^{(h+1)} = x_i^{(h+1)} if\ (f(x_i^{(h+1)}) < f(U_i^{(h)}))$$

$$= U_i^{(h)} else$$

where f - value of fitness.

RESULTS AND DISCUSSION

Proposed DE algorithm has been implemented for IEEE 30 bus system in the working platform of MATLAB 6.5. Total system demand is 2.834 p.u at 100 MVA base and the voltage limit of all load buses are considered to be 1.1-0.90 in p.u. In the testing stage all the lines are checked for reduction of cost and increase in power flow, location for installing UPFC and amount of voltage and angle to be injected in the bus is obtained using DE based OPF.

Initially the OPF i.e, real power, setting of transformer tap, added reactivepower, economic fuel cost and loss of power for standard IEEE bus system are predicted excluding and including the compensating device such as UPFC. It is identified that there is reduction in the loss of power and the requirement of real power generation by the addition of the compensating device and also significant reduction in the cost and improvement in voltage profile for increased number of buses. The operating costs of the best solution in the normal operation without and with UPFC is $807.157 and $803.031 per hour respectively. Similarly the power loss has decreased from 10.525 MW to 9.331 MW due to the involvement of the FACTs device.

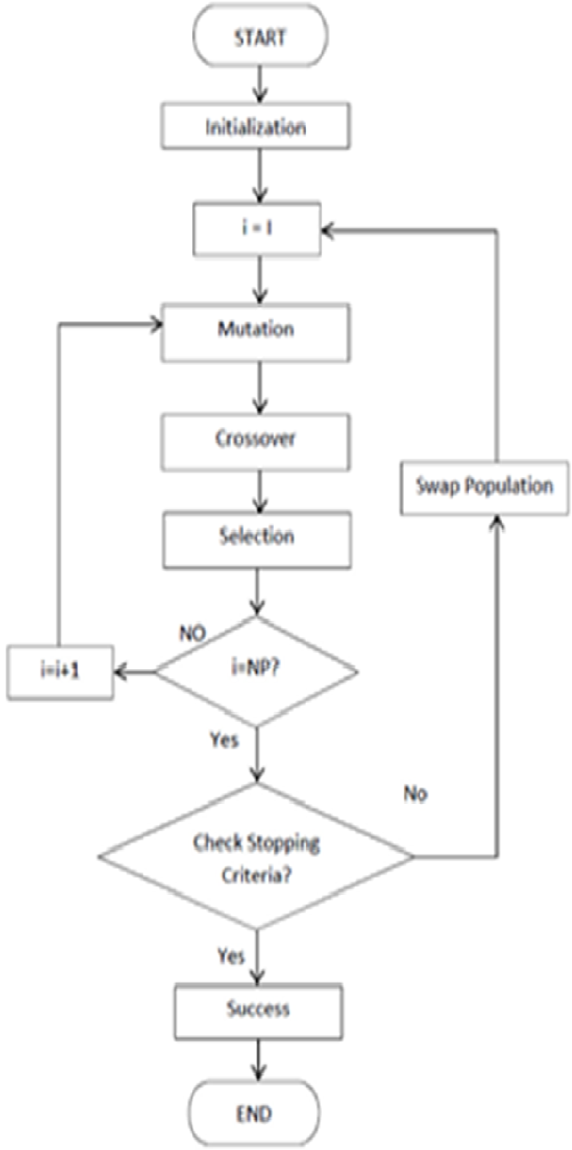

Figure No.1.Flowchart

Table.1DE controlParameters

S.No	DEParameter	Value
1.	PopulationSize	30
2.	Maximum Generations	500
3.	CrossoverRatio	0.5

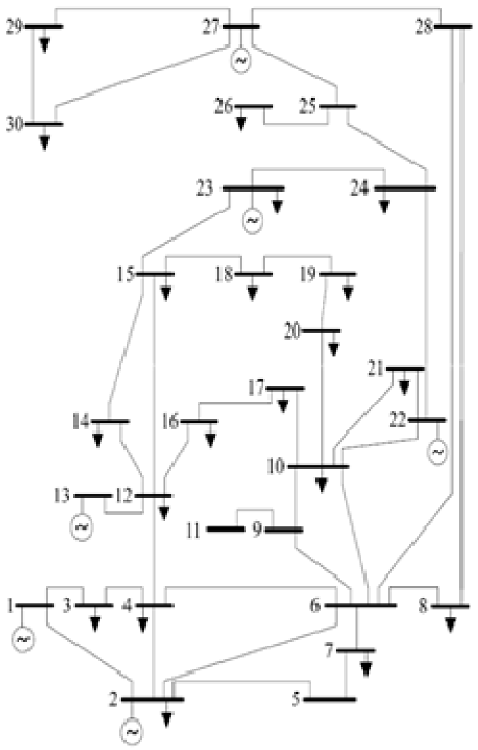

Figure No.2. Standard Test Systems

Table 2. Comparison of result with and without UPFC

Quantity	Without UPFC	With UPFC
Pg1(MW)	173.976	172.7683
Pg2(MW)	47.79856	48.61468
Pg3(MW)	21.90069	*21.79669*
Pg4(MW)	25.16695	*24.69203*
Pg5(MW)	12.84381	12.54689
Pg6(MW)	12.23936	12.31197
TotalGeneration Cost($/hr)	807.8546	802.9464
Power Loss(MW)	10.52537	9.330555

Table 3. Comparison of OPF Solution

S.No	Parameter	With IPFC	With UPFC
1.	Real Power Generation(MW)	164.678	172.768
		48.372	48.6147
		23.795	21.7967
		22.431	24.692
		15.735	12.5469
		16.569	12.312
2.	Generator Voltages(p.u)	1.043	1.049
		1.032	1.035
		1.012	1.007
		0.987	1.017
		1.019	1.026
		1.070	0.981
3.	Transformer Tap Setting (p.u)	1.028	1.035
		1.008	1.006
		1.009	0.983
		0.959	0.9928
4.	Total Real PowerGeneration (MW)	291.678	292.703

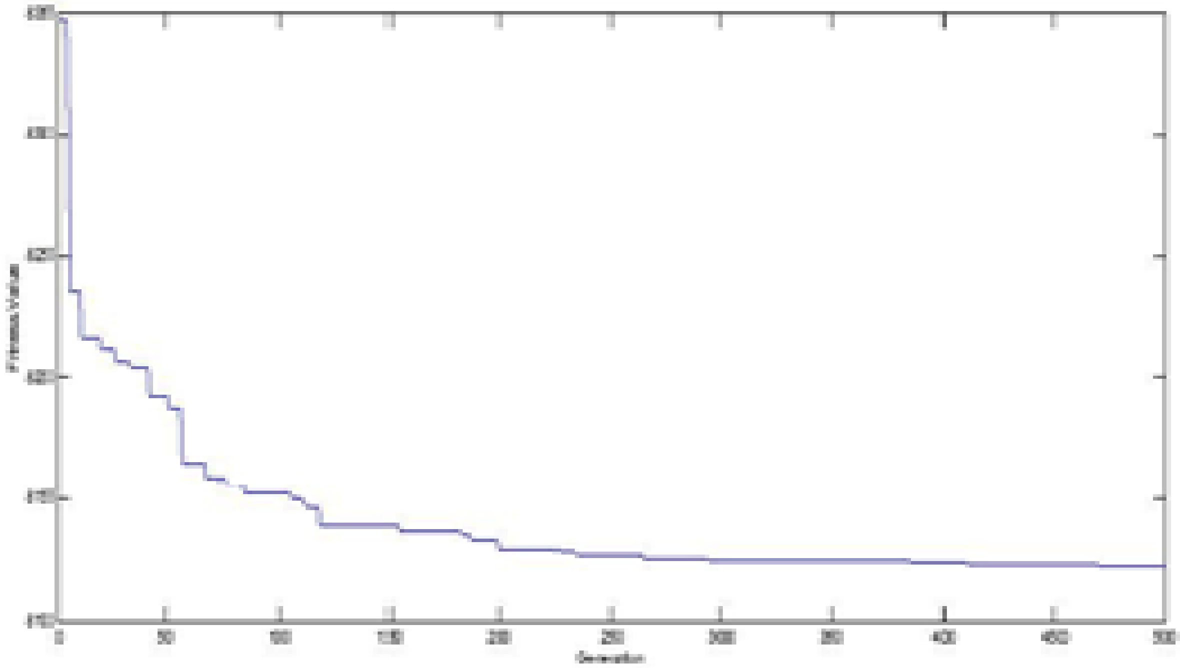

Figure No.3. Characteristics of Convergence for iterations of 500

CONCLUSION

In this paper, DE algorithm has been implemented to identify the optimal location for UPFC to reduce the overall operating cost and power loss in the power system. Here the steady state power injection model of UPFC has been incorporated into the OPF to exploit the new characteristics of FACTS devices. The result obtained shows the effectiveness and robustness of the proposed DE technique and also demonstrates the feasibility of loss minimization in other power system network.

REFERENCE

[1] Zhang X, Chen W, Dai C, Cai W. "Dynamic Multi-group self-adaptive differential evolution algorithm for reactive power Optimization", *Elect Power and Energy Syst*, **2010**, 32,351-357.

[2] N.G.Hingorani and L. Gyugyi, "Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems," *IEEE Press*, First Indian Edition,**2001**.

[3] M.A.Abido. "A Novel Multi objective evolutionary algorithm for Environmental/Economic Power Dispatch " *Elect Power Syst Res*, **2003**, 65, 71-81.

[4] K.P.Wang, J.Yurevich and A.Li,"Evolutionary Programming based Load Flow algorithm for system containing UPFC", *IEE Proc-Gener. Transm. Distrib*, **2003**,150(4),441-446.

[5] Devaraj D, Yeganarayana b, "Genetic Algorithm based optimal power flow for security Enhancement", *IEE Proc. Gener. Transm. Distrib*. **2005**,152(6),899-905.

[6] Varadarajan M, Swarup KS, "Solving Multiobjective optimal power flow using differential evolution", *IET Gener. Trans. Distrib*. **2008**,2(5),720-730.

[7] Kessel P, Glavitsch H, "Estimating the Voltage Stability of a power systems ", IEEE Trans. Power Delivery, PWRD **1986**,1(3),346-54.

[8] Y.Lue and A.Abur, "Improving System Security via Optimal Placement of Thyristor Controlled Series Capacitors (TCSC)", *IEEE Power Engineering Society Winter Meeting*,**2001**,2,516-521,2001.

[9] H.I.Shaheen, G.I.Rashed, and S.J.Cheng,"Optimal Location and Parameters setting of Unified power Flow controller Based on Evolutionary Optimization Techniques", *IEEE PES 2007 General Meeting*, **2007**, 1-8.

[10] P.Chen, H.Chang, "Large Scale Economic Dispatch by Genetic Algorithm", *IEEE Trans. On Power Systems, Nov.* , **1995**,10(4),1919-1926.

[11] J.A.Momoh, J.Z.Zhu,"Improved Interior Point based OPF Problems", *IEEE Trans. On Power Systems*, **1999**,14(3),1114-1120.

[12] P.Somasundaram, K.Kuppuswamy, R.P.KumidiniDevi,"Evolutionary Programming Based Security Constrained Power Flow", *Electric Power Systems Research, July* ,**2004**,72,137-145.

[13] DervisKaraboga, SelcukOkdem, "A Simple and Global Optimization Algorithm for Engineering Problems: Differential Evolution Algorithm", *Turk J Elec. Engin*.,**2004**,12(1),53-60.

[14] Chung TS, Li YZ, "A hybrid GA approach for OPF with consideration of FACTS devices", *IEEE Power Engineering Rev* **2001**,2,47-50.

[15] Ge SY, Chung TS, "Optimal active power flow incorporating power flow control needs in Flexible AC transmission systems", *IEEE Trans. On Power systems* **1999**,2.