ISSN:2321-1156

International Journal of Innovative Research in Technology & Science(IJIRTS)

Optimal Location of UPFC in Power System Using Gravitational Search Algorithm

[1]**Dr. E. NandaKumar, Associate Professor,** Sri Krishna College of Technology, Coimbatore, India. [2]**R.MANI,** PG Schoar, Sri Krishna College of Technology, Coimbatore, India.

Abstract

This paper presents a novel approach to the effective location of FACTS devices in power system by a gravitational search algorithm (GSA) technique. The ultimate aim is to improve the voltage profile of system as well as reduce real power losses. Among the various FACTS controllers, Unified Power Flow Controller (UPFC) considered. Gravitational search algorithm work based on the gravitational concept used to provide an optimal solution by solving multi objective optimization problem. The location and rating of the UPFC optimized in IEEE standard 39 bus systems. Simulation done by MATLAB software and Newton-Raphson method used for power flow.

Keywords- FACTS; GSA; Optimal location

1. Introduction

The power system is a complex network comprising of transmission lines interconnecting all the generator stations transformers and load. The important requirement of a reliable power system is to maintain the voltage within the possible range to ensure a high quality of customer service. The voltage collapse occurs in power system to supply the reactive power or by an excessive absorption of reactive power.

Therefore it is difficult to provide voltage stability even in normal condition. Voltage problem mainly associated with the reactive power imbalance. Voltage instability problem is being addressed in two different ways. The first approach is to mitigate the problem and the second approach is to enhance the voltage stability of the system for selecting the operating condition. The only way to save system from voltage collapse is to reduce reactive power load or add additional reactive power. To achieves secure and economic operation Flexible AC Transmission System devices are properly installed in the system. The function of FACTS devices is to control the transmission line power flow. There are various types of FACTS devices are used such as Static Series Compensator (SSSC), Static Synchronous Compensator (STATCOM), Static VAR Compensator (SVC), Unified Power Flow Controller (UPFC), and Interline Power Flow Controller (IPFC). The principle function of UPFC is to control the flow of real and reactive power by injecting voltage in series with transmission line.

2. Static Model of UPFC

Power flow through the transmission line depend on line reactance, bus voltage magnitudes, and phase angle between sending and receiving end buses .i.e.,$\delta_i - \delta_j$.

$$P_{ij} = \frac{V_i V_j}{X_{ij}} \text{Sin}\,(\delta_i - \delta_j) \quad \textbf{(1)}$$

UPFC is capable of both supplying and absorbing real and reactive power and it consists of two ac/dc converters. One converter is connected in series with the transmission line through a series transformer and the other in parallel with the line through a shunt transformer. The dc side of the two converters is connected through a common capacitor, which provides dc voltage for the converter operation. As the series branch of the UPFC injects a voltage of variable Magnitude and phase angle, it can exchange real power with the transmission line and thus improves the power flow capability of the line as well as its transient stability limit. The shunt converter exchanges a current of controllable magnitude and power factor angle with the power system.

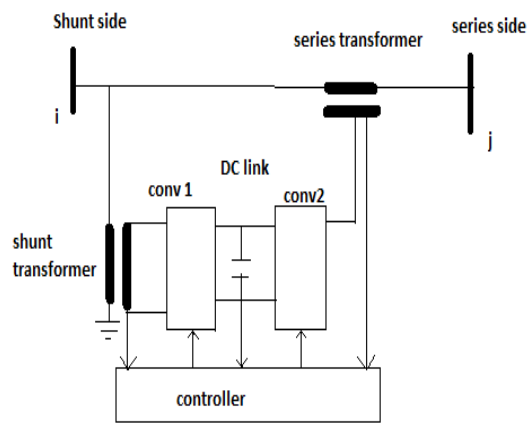

Fig. 1.1UPFC Power injected model

UPFC injected power for the from bus

$$upfiF = bs(fb,tb) * v(fb) * v(tb) * \sin(\theta+\delta) + (v(fb) * \cos(\delta)) \quad (2)$$

UPFC injected power for the to bus

$$upfiT = bs(fb,tb) * v(fb) * v(tb) * \sin(\theta+\delta) + \cos(\theta+\delta) \quad (3)$$

Where

fb=from bus

tb=to bus

bs=Ybus value

v(fb)=voltage value from bus

v(tb)=voltage value to bus

3. Calculation for Real Power Loss

The objective function of this problem is to find the optimal place and rating of the UPFC based on real power loss calculation. Hence, the objective function is expressed as in equation

Power loss = $P_{ij}F + P_{ij}T$ **(4)**

Real power loss=abs(sum(power loss)) **(5)**

Where,

$P_{ij}F$=real(complex power from bus)

$P_{ij}T$=real(complex power to bus)

3.1 Fitness Function

Considering the power loss as the objective function and the Fitness Function is expressed as in equation

$$fitfun = \min \sum_{j=1}^{N} V_i V_j Y_{ij} \cos(\delta_{ij} + \gamma_j - \gamma_i) \quad (6)$$

$$f(x) = fitnessfunc(variable) \quad (7)$$

$$f(x) = loss + sum((1.1 - abs(v)^2) \quad (8)$$

Equality constraints:

The Equality constraints represents load flow equation as

$$P_{Gi} - P_{Di} - \sum_{j=1}^{N_B} V_i V_{ij} Y_{ij} \cos(\delta_{ij} + \gamma_j - \gamma_i) = 0 \quad (9)$$

$$Q_{Gi} - Q_{Di} - \sum_{j=1}^{N_B} V_i V_{ij} Y_{ij} \sin(\delta_{ij} + \gamma_j - \gamma_i) = 0 \quad (10)$$

3.1.1 Inequality Constraints:

Bus voltage inequality constraint:

$$V_{Gi}^{min} \le V_{Gi} \le V_{Gi}^{max} \quad (11)$$

Bus Voltage angle inequality constraint:

$$\delta_{Li}^{min} \le \delta_{Li} \le \delta_{Li}^{max} \quad (12)$$

Real power inequality constraint:

$$Q_{Ci}^{min} \le Q_{Ci} \le Q_{Ci}^{max} \quad (13)$$

Reactive power inequality constraint:

$$p_{Gi}^{min} \le Q_{Gi} \le \quad (14)$$

4. Gravitational search algorithm

GSA is the stochastic search algorithm, which based on Newtonian Laws and mass interaction. The GSA technique, agents are taken as the consideration of the objects and the performances are measured by their masses.

Step 1. To determine the search space of the proposed method and initialize the starting location, voltage limit and the angle, which are assumed as the agents.

Step 2. Random generation of input values such as the voltage and the corresponding angle. From the input values fitness functions evaluate.

Step 3. Evaluate the fitness of the each agent and determine the solution.

Step 4. Update the gravitational constant G(t),best fitness F(B),worst fitness F(W) and mass of the agent $M_i(t)$ can be described as the following equation.

F(B)=Min Fitness **(15)**

F(B)=Max Fitness **(16)**

$$M(t) = \frac{mi(t)}{\sum_{j=1}^{N} mj(t)} \quad (17)$$

$$mi(t) = \frac{F(t) - W(B)}{F(B) - F(W)} \quad (18)$$

Step 5. To evaluate the total force of the agents at different direction, it can be described by the following equation.

$$TF(t) = \sum_{j \neq 1} random(force(t)) \quad (19)$$

$$Force = G(t) \frac{Mp(t) - Ma(t)}{Rij + E} (yi(t) - yj(t)) \quad (20)$$

Rij is the Euclidian distance between two agent, E is the small constant, Mp(t) and Ma(t) active and passive gravitational mass related agent.

Step 6. Find the acceleration of agent, which can be determine by the following equation

$$a(t) = \frac{TF(t)}{M(t)} \quad (21)$$

Step 7. Updating the agent's velocity and position using the following equation

V(t+1)=random(t)+a(t) **(22)**

X(t+1)=x(t)+V(t+1) **(23)**

Step 8. Repeat the procedure from step 3 to 7 until it reaches the stop criteria.

Step 9. Terminate the process.

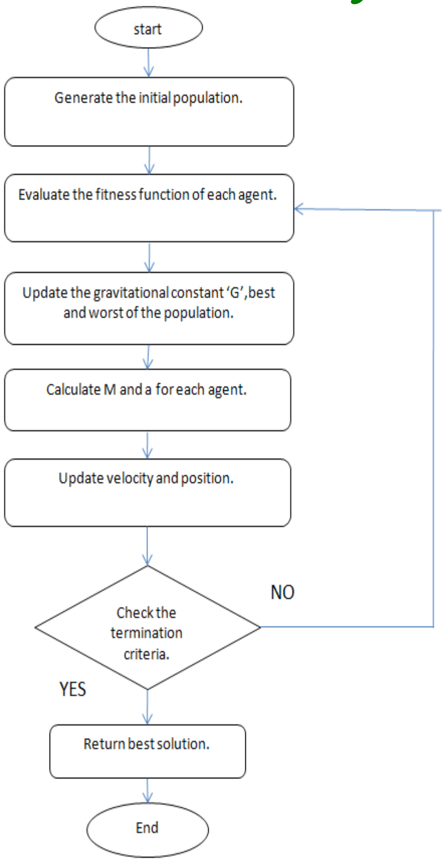

Fig. 2. GSA Flowchart

5. Simulation Results

IEEE 39 bus system was used for testing GSA and the results were obtained. In which location of the UPFC ware optimized and the objective such as minimizing real powerless and improvement of voltage in power system ware obtained. The optimal location of UPFC in IEEE 39 system is identified bus number 5-6 and series injection voltage 0.1200pu, series injected voltage angle 1.673676 obtained by. Hence UPFC placed between bus number 5 and bus number 6 and the real power loss --0.723883 p.u. calculated.. The voltage profile in IEEE 39 bus system shown in Fig. 3.

5.1 Voltage profile in IEEE 39 bus system after placing UPFC

The voltage profile in IEEE 39 bus system before and after placing UPFC is shown in Fig. 3.

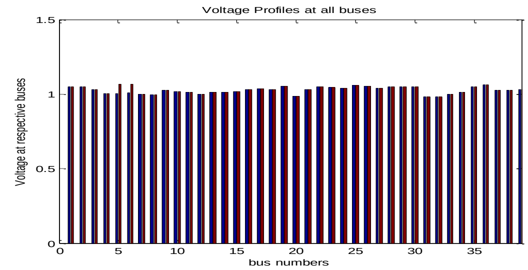

Fig.3. Voltage Profile after placing UPFC

5.2 Convergence speed of gravitational search algorithm

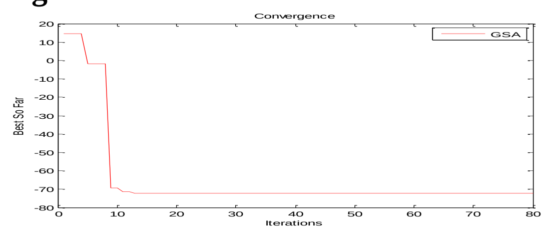

Fig. 4 Convergence speed

5.3 Comparison of Voltage before placing UPFC and after placing UPFC

Bus no	Before placing UPFC	After placing UPFC	Bus no	Before placing UPFC	After Placing UPFC
1	1.047	1.047	19	1.050	1.052
2	1.049	1.049	20	0.991	0.987
3	1.030	1.031	21	1.032	1.032
4	1.004	1.004	22	1.050	1.050
5	1.005	1.098	23	1.045	1.045
6	1.008	1.097	24	1.037	1.038
7	0.997	0.997	25	1.058	1.058
8	0.996	0.996	26	1.052	1.052
9	1.028	1.028	27	1.038	1.038
10	1.017	1.017	28	1.050	1.050
11	1.013	1.013	29	1.050	1.050
12	1.000	1.000	30	0.048	1.048
13	1.014	1.015	31	0.982	0.982
14	1.012	1.012	32	0.983	0.983
15	1.015	1.016	33	0.997	0.997
16	1.032	1.033	34	1.012	1.012
17	1.034	1.034	35	1.049	1.049
18	1.031	1.031	36	1.064	1.064

6. Conclusion

In this paper GSA algorithm used to improve the voltage stability of the power transmission system. The approach was implemented and the performance evaluated with IEEE 39 bus system. Initially voltage rating of the each buses calculated and the optimal location of the UPFC, injected voltage magnitude, voltage angle determined .The result shows that this stochastic algorithm quickly finds the optimal solution and size of the UPFC then other technique.

7. References

[1] A.K.M RezwanuarRahman,MdShahabulAlam, MdZakir Hossain and Md.Shahjahan "Localization of FACTS Devices for Optimal Power Flow Using Genetic Algorithm International Conference on Electronics and Communication Technology.978-1-4799-2299-4/2013 IEEE.

[2] AjamiAli,Armaghan Mehdi "A multi-objective gravitational search algorithm based approach of power system stability enhancement with UPFC" Springer(2013)20 1536-1544 DOI:10.1007/s1771-013-1645-1.

[3] Kiran Kumar Kuthadi, M. Suresh Babu, NagarajuTella, "Optimal Location And Parameter Settings Of Facts Devices For Enhancing Power System Stability And Minimization Of Power Losses", International Journal Of Engineering Science and Technology (IJEST), Vol. 4 No.06 June 2012.

[4] GayadharPanda, P.K.Rautraya" Gravitational Search Algorithm optimized SSSC Based Facts C ontroller to Improve Power System Oscillation Stability" International Journal of Electrical And Communication Engineering vol:8 No:2,2014.

[5] Purwoharjono,Muhammadabdillah, Ontosenopenangsang, adisoeprijanto "Optimal Placement and Sizing of Thyristor-controlled-series-capacitor using Gravitational Search Algorithm TELKOMNIKA Indonesian Journal of Electrical Engineering vol.10.no5,septemper 2012.

[6] MehradAhmadi KamarposhiMostafaAliezhad, "Comparison of SVC, STATCOM in static voltage Stability margin. "International journal of Electrical and Electronics Engineering,vol.4,No.5.323-328,2010.

[7] M.A.Perze,A.RMessina, C.R Fuerte Esquivel."Application of FACTS devices to improve steady state voltage stability", in proceeding the IEEE conference on power engineering society,vol.2, p112-1120,2000.

[8] Prof.C.UdhayaShankar,Nimmisreedharan, Dr.Rani Thottungal" Stability Enhancement Of Electrical Power System By Optimal Placement Of UPFC", International Journal Of Advanced Engineering Research And Studies, Ijaers/Vol. I/Issue Ii/January- March, 2012/146-151.

[9] KesineniVenkateswarlu,Ch.Sai Babu and Kiran KumarKuthadi,"Improvement of Voltage Stability and Reduce Power Losses by Optimal Placement of UPFC device by using GA and PSO", International Journal of Engineering Sciences Research-IJESR Vol 01, Issue 02, May, 2011.

[10] K.Y.Lee,Y.M.Park,J.L.Ortiz,"Aunited approach to optimal real and reactive power dispatch",IEEE transcationson power apparatus and systems, Vol.PAS-104, No.5, May 1985.

[11] P.Kundur,"1994 power system stability and control," New York, McGraw-Hill.

Biographies

First Author:

Dr. NandaKumar obtained his Bachelor degree (B.E) in Electrical and Electronics Engineering from the Bharathidasan University, Trichy, India in 1998 and the Master of Engineering (M.E) degree in Power Systems Engineering from the Anna University, Chennai, India in 2007. Also received his PhD. Degree under Faculty of Electrical Engineering from Anna University - Chennai in November 2014. He is currently working as an Associate Professor in the department of Electrical & Electronics Engineering at Sri Krishna College of Technology, Coimbatore. His research interests include Power System Optimization Techniques, Power Flow Analysis, Economic Load Dispatch and Power Quality Issues.

Second Author:

Mr. R. Mani is a PG Scholar in Power Systems Engineering in the department of Electrical & Electronics Engineering at Sri Krishna College of Technology, Coimbatore. His research interest includes Power System Optimization Techniques, Economic Dispatch and Power Flow.