Optimal Allocation of UPFC to Minimize Real Power Losses using NSPSO Algorithm

N.Kalpana, M.Venu Gopala Rao

Abstract: ***This paper presents the optimal location of UPFC in Transmission system by implementing a new methodology called NSPSO. With this we can achieve two objectives one is reduction of Real Power loss (RPL) and the other one is improving the bus voltages. In order to identify the optimal location of the UPFC, L-Index strategy is utilized. Moreover the effectiveness of the method is tested on the IEEE 14 bus & IEEE 30 bus system by considering 125%, 150%, 175% and 200% overloading cases. Finally, we can prove that the NSPSO algorithm is the optimal technique for finding the rating and location of UPFC and also improving the system stability.***

Index Terms: PSO, NSPSO, UPFC, Optimal Location, Power system stability, Power flow algorithms.

I. INTRODUCTION

The significance of energy is very vital in the 21st century with the growing demands specially for the developing countries like India. Though many countries generate energy, but unable to transmit and distribute the power due to real, reactive power losses and environmental limitations. There are several methods to overcome these limitations. FACTS devices will manage steady state power flow also as system parameters in a dynamic state by putting them in proper areas without changing the generation constraints [1] -[5]. With this merit there is an expanded enthusiasm for FACTS devices in present day control, non linear loads [6] joined with mitigation of intensity industry. Moreover the conrol of power flow is a practical method for dispatching indicated control exchanges and there is an immense increment in the power flow exchanges because of intensity system rebuilding. Along with this high cost and environmental constraints are significant obstacles for expansion of power transmission network [7] -[8], All the above issues were solved by using the FACTS devices, which improves power transfer capability, reduce system losses and improves stability.

Revised Manuscript Received on October 30, 2019.

* Correspondence Author

N.Kalpana*, Department of Electrical &Electronics Engineering, Matrusri Engineering College, Osmaniya University, Hyderabad, Telangana, India.

M.Venu Gopala Rao, Professor & HOD, Electrical and Electronics Engineering, PVP Siddartha Institute of Technology, Vijayawada. Email:venumannam@gmail.com

There are many propelled strategies proposed in the literature for the upgrading enhancing area of FACT devices and their parameter settings.FACTS devices can calm the system from blockage and help in using the greatest limit of the transmission network without compromising the stability and network security.

In this paper, UPFC is one of the most fascinating and conceivably the flexible class of FACTS devices. The key component of UPFC is that it offers up to three power system parameters. For example, line active power, line reactive power, and bus voltage. Accordingly, it can give important useful adaptability to the consolidated use of power angle control with controlled arrangement of back to back converter compensation. This component makes it the most skilled individual from the FACTS family. This paper is identified with the examination of an enduring steady-state performance of a UPFC utilizing mathematical model.Optimal UPFC may be used to control the line power flow through converting their parameters to accomplish the above goals.

Steady state execution examination of UPFC includes power flow studies about which incorporate the estimation of bus bar voltages, branch loadings, real and reactive power flows, real and reactive transmission lossess in an power system and the effect of UPFC on the previously mentioned system parameters. To assess UPFC generally steady state performance, a sufficient model is required for reproduction considers. An UPFC model utilizing the power injection idea is changed to meet these necessities. Figure 1 delineates a voltage sourced equal circuit of UPFC in which two voltage sources are utilized to speak to the crucial segments of the beat width regulated controlled yield voltage waveforms of the two branches (arrangement and shunt). The impedances of the two coupling transformers are incorporated into the proposed model and lossess of UPFC (lossess of exchanging power converters) are mulled over.

In association with this, the new control scheme dependent on Non-Sorting Dominated Particle Swarm Optimization NSPSO Algorithm has been presented for better multiobjective optimization[9]. NSPSO broadens the essential type of PSO by utilizing components individual bests and posterity for progressively viable nondomination examinations. Rather than a solitary correlation between a component's close to home best and its posterity, NSPSO analyzes all elements close to home bests and their posterity in the whole population[11].

This demonstrates to be compelling in giving a proper determination strain to push the swarm populace towards the Pareto-Optimal front. NSPSO which can increment such "sharing" among all components in a swarm populace particularly concerning how to enable the populace overall to advance towards the genuine Pareto-Optimal front

The main ideology is to limit Real Power Losses (RPL) and to improve Bus Voltages to accomplish better stability performance. For this purpose L-index is utilized to locate the heavy loss bus in the system to put the UPFC device and furthermore for Voltage Stability investigation. In this context to find the rating of the UPFC, NSPSO algorithm is used.

II. PROBLEM FORMULATION

As indicated, It is desired in the power system network to limit RPL and to increase the power transfer capability of line.To achieve this, we need to locate the optimal rating of UPFC. This objective function at different constraints is expressed as [10]

$$\text{Minimize } C=[c1,c2,c3] \qquad (1)$$

Where c1 gives the Real Ppower Losses(RPL) as

$$c1=\sum_{k\in Ni} g_k\left(V_i^2=V_j^2-2V_iV_j\cos\theta_{ij}\right)=P_{activeloss} \qquad (2)$$

c2 gives the total voltage profile of load buses from expected value of 1 p.u.

$$c_2=VD=\sum_{k=1}^{N\ PQ}\left(V_K-Vrefk\right)^2 \qquad (3)$$

and c3 gives the k^{th} bus L-index[12] :

$$c_3=L_k=\left|1\pm\frac{V_{ok}}{V_k}\right|=\frac{S_k^*}{Y_{kk}V_k^{\ 2}} \qquad (4)$$

The minimization issue is liable to the accompanying different Constraints:

i) Load Flow Constraints:

$$P_k-V_k\sum_{j=1}^{Ng}V_j\left(G_{kj}\cos\theta_{kj}+B_{kj}\sin\theta_{kj}\right)=0, \qquad (5)$$

$k=1,2,\ldots N_B-1$

$$Q_k-V_k\sum V_j\left((G_{kj}\cos\theta_{kj}-B_{kj}\sin\theta_{kj}\right)=0 \qquad (6)$$

$k=1,2,\ldots N_{PQ}-1$

(ii) Voltage constraints:

$$V_i^{\min}\le V_i\le V_i^{\max}, i\in N_B \qquad (7)$$

(iii) Reactive Power Generation(RPG) Limit:

$$Q_{gi}^{\min}\le Q_{gi}\le Q_{gi}^{\max}, i\in N_g \qquad (8)$$

(iv) Generation of Reactive Power (RP) at capacitor banks:

$$Q_{ci}^{\min}\le Q_{ci}\le Q_{ci}^{\max}, i\in N_c \qquad (9)$$

(v) Limits of Transformer Tap setting are:

$$t_p^{\min}\le t_p\le t_p^{\max}, p\in N_t \qquad (10)$$

(vi)Transmission line power flow limit:

$$S_i\le S_i^{\max}, i\in N_t \qquad (11)$$

III. MODELING OF UPFC

A.Modelling Of UPFC

In 1991 Gyugyi proposed the UPFC concept[16], UPFC is a mix of the series and shunt compensator joined with a normal DC interface through a capacitor. The series compensator connected in series with a line transformer in a transmission line and shunt compensator connected in shunt with a transmission line Both compensators controls all the parameters in a transmission system. for instance, voltageregulation and phase angle conrol. The active and reactive power control of the transmission line is controlled by injecting the voltage [7] in series through series converter. Hence in a transmission line active and reactive power control is done by using series converter only.

UPFC is a special device, which control the voltage at the bus on transmission system, and at a time it controls the active and reactive power flow [17-18]. The series converter (converter 2) gives the capacity of the UPFC which depends upon the injecting voltage and phase angle of the series converter(converter 2). The converter 1 (shunt) is to supply the required real power of the converter2 throgh a DC link.[17]

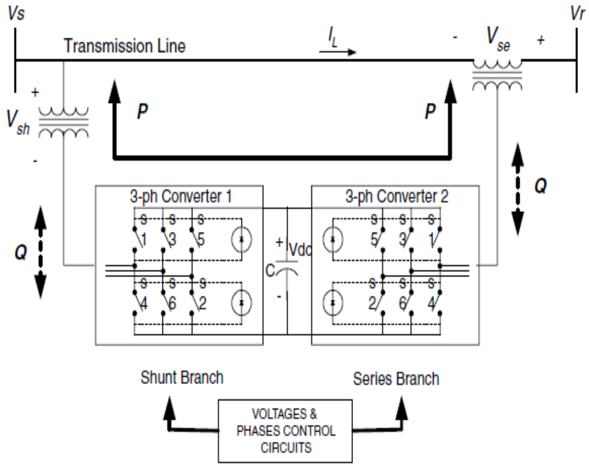

Fig.1 Power flow model of UPFC

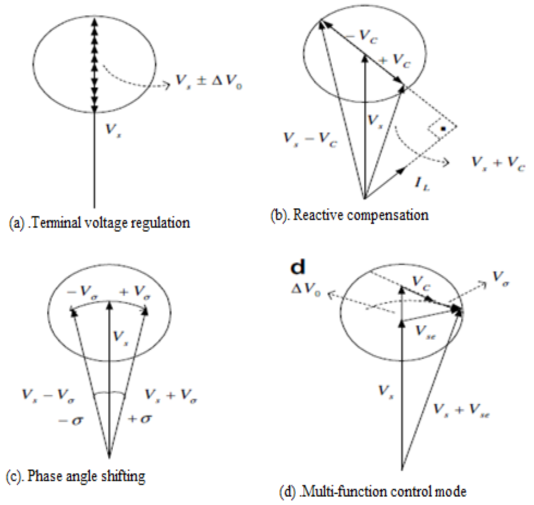

Fig. 2. Operational modes of UPFC

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-12, October 2019

B. Mathematical Modeling of UPFC

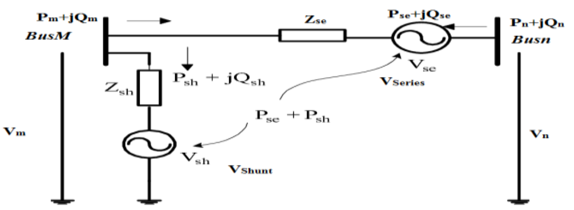

Fig3:Mathematical modeling of UPFC

In the modeling of UPFC, firstly design the converter2 (series Converter) and then converter1(shunt), as converter2 performs the main task of the UPFC

The mathematical model of the UPFC in steadt state is designed interms of current source.[9]

Where $b_s = \frac{1}{x_s}$ (12)

$I_s = -jb_s V_s$ (13)

Figure 4 dipicts The current source modeling.

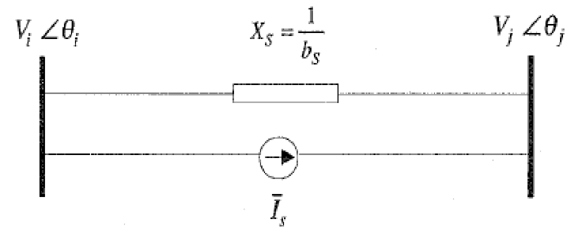

Fig4: Illustrates transmission line system interms of current sourse(I_s)

The Injected powers $S_{iseries}$,and $S_{jseries}$, interms of current sources are

$S_{iseries}=V_i(-I_s)^*$ (14)

$S_{jseries}=V_j(I_s)^*$ (15)

The injection power $S_{iseries}$ and $S_{jseries}$ can be simplified as

$S_{iseries}=V_i[jb_s r v_i e^{jr}]^*$ (16)

By using the Euler Identity equation (16) becomes

$S_{iseries}=V_i[e^{j(\gamma+90)} b_s r v_i^*]$ (17)

$S_{iseries}= V_i^2 b_s r[\cos(-\gamma-90)+j\sin(-\gamma-90)]$ (18)

By utilizing trigonometric identies, Equation (18) becomes

$= b_s r\ V_i^2 \sin\gamma - j\ b_s r\ V_i^2 \cos\gamma$ (19)

If we define $\theta_{ij}=\theta_i-\theta_j$

Comparative adjustments can be applied to Equation (15)

$S_{jseries}=V_j[-jb_s r V_j e^{j\gamma}]^*$

$=b_s r V_i V_j \sin(\theta_{ij}+\gamma)+ b_s r V_i V_j$ (20)

From eq.(19) and (20), separate real and imaginary terms which represents the real and reactive powers interms of series injected voltage sources are given by

$P_{iseries}= b_s r V_i^2 \sin\gamma$

$Q_{iseriesi} = b_s r\ V_i^2 \cos\gamma$

$Pjseries = -b_s r V_i V_j \sin(\theta_{ij}+\gamma)$

$Qjseries= -b_s r V_i V_j \cos(\theta_{ij}+\gamma)$ (21)

Where

In eq.(21) the Pseries indicates the required active power, which is supplied by converter 2. To that converter2 active power is provided from converter1 via dc link. And Qseries indicates the injected reactive power by converter2.

Shunt converter model

Now equating the active power suppliaed by converter1 and converter2(interms of associated voltage sources). Assume negligible converter losses

$P_{conv1}=P_{conv2}$ (22)

Eq.(23) is equipped by the series voltage source device

$$S_{conv2} = V_s I_{ij}^* = re^{j\gamma} V_i \left(\frac{\bar{v}_i{}^1 - v_j}{jX_s} \right)^* = \textit{Apparent power} \qquad (23)$$

$$= re^{j\gamma} v_i \left(\left(re^{j\gamma} V_i + V_i - V_j \right) / \ jX_s \right)^* \qquad (24)$$

After Comparative adjustments, the Active and Reactive Powers provided by converter2 are

$$P_{conv2} = rb_s V_i V_j \sin(\theta_i - \theta_j + \gamma) - rb_s V^2{}_i \sin\gamma \qquad (25)$$

$$Q_{conv2}=-rb_s V_i V_j \cos(\theta_i-\theta_j+\gamma)+rb_s V^2{}_i \cos\gamma+r^2 b_s V^2{}_i \qquad (26)$$

At last, after injecting the series and shunt power combinly at each bus(I,j), mathematical model of UPFC in steady state is obtained and its equations are as follows

'i' and bus 'j'

$P_{iupfc} = rb_x V^2 \sin\gamma - rb_2 V_i V_j \sin(\theta i - \theta j + \gamma)$ (27)

$P_{jupfc} = rb_x V_i V_j \sin(\theta i - \theta j + \gamma)$ (28)

$Q_{iupfc} = -\ rb_s V^2{}_i \cos\gamma$ (29)

$P_{jupfc} = rb_s V_i V_j \cos(\theta i - \theta j + \gamma)$ (30)

General nodal power flow equations and linearized power system model are often expressed in rectangular structure by the subsequent equations:

$$\begin{bmatrix} \Delta P^1 \\ \Delta Q^1 \end{bmatrix}^n = \begin{bmatrix} H^1 & N^1 \\ J^1 & L^1 \end{bmatrix}^n \begin{bmatrix} \Delta\theta \\ \Delta V/V \end{bmatrix}^n \qquad (31)$$

where P^1 and Q^1 are active and reactive nodal power injection vectors, that are operate of nodal voltages, (V\h), and network conductance and susceptance, (G and B), severally. (ΔP^1 = Pspef _ Pcalt) is that the active power mismatch vector and (ΔQ^1 = Qspef _ Qcalt) is the reactive power mismatch vector. (ΔV and Δh) are vectors of progressive changes in nodal voltages. H^1, N^1, J^1, and L^1 mean the fundamental components in the Jacobean matrix. Inferred infused power model can be consolidated into a general NR power flow calculation by changing the related components in the typical Jacobean grid and the comparing force.

IV. VOLTAGE STABILITY INDEX

To control the event of voltage Collapse, it is imperative to illuminate the working requirement regarding a power system. For this Kessel presented a voltage stability index as an answer for the power flow condition in the method for L-index[13].The L-index is a quantitative measure for the valuation of the separation of true state of the system stability limit.

The L-index represents the quality of the whole system. With this for a given system operating condition, load flow results are going to be initiated wherever it consists of load characteristics and generator characteristics. For a K-bus power system network, buses are separated as transferrable all load buses to the pinnacle and treat them as α M and place the PV buses to the bottom and term them as α N i.e., α M ={1,2,…,k M} and α N ={ kL+1, kL+2,……k k}
Here- k M is the number of load buses.
The accompanying hybrid system equation is then acquired [13]

$$L_j = \left| 1 \pm \frac{V_{xj}}{V_j} \right| = \frac{S_j^*}{Y_{jj} V_j^{\,2}} \qquad (32)$$

(32) Where $V_{xj} = -\sum_{i \in \alpha G} F_{ji} V_I$

Where the L-index changes between zero (no-load) and 1(voltage collapse) and it provides scalar range to every load bus. Voltage stability is guaranteed once when the L-index value close to zero.[12].

V. OPTIMAL LOCATION OF UPFC USING NSPSO

A. PSO Algorithm

Over the most recent two decades, Particle Swarm Optimization (PSO) has increased fast prominence as an amazing improvement method, which was created by Eberhart and Kennedy [17]; PSO is generally an ongoing stochastic heuristic system, it depends on the relationship of swarm of feathered creatures(birds) and school of fish [17]. In PSO, every element settles on its choice utilizing its own experience together with other elements' understanding. PSO has an extensible and well-adjusted system to enable and adjust to the worldwide and neighborhood investigation and abuse capacities inside a short calculating time.[17]
However, these extensive qualities make PSO a profoundly practical system to be utilized for solving multi-objective optimization problems.
The following equation represents the fundamental PSO

$$S_p^{k+1} = S_p^{k} + V_p^{k+1} \qquad (33)$$

$$V_p^{k+1} = w\, V_p^{k} + c_1\, rand_1(\ldots) \times (p\,best_p - s_p^{k}) + c_2\, rand_2(\ldots) \times (gbest - s_p^{k}) \qquad (34)$$

Where,
S_p^k: p^{th} element position at generation k
V_p^k: p^{th} element velocity at generation k
c_p : Weighting factor,
wt : Weighting function,
$pbest_p$: Pbest of particle p,
rand : Random number between 0 and 1,
gbest: Gbest of the group.
The following weighting function is usually utilized [19]:

$$wt = wt_{\max} - \frac{wt_{\max} - wt_{\min}}{itera_{\max}} Xiter \qquad (35)$$

where,
· itera: current iteration number,
· wt_{min}: final weight,
· wt_{max}: initial weight.

B. NSPSO

NSPSO is the extended version of the PSO, which utilizes elements individual bests and offspring for progressively successful non- domination comparisons [20]. NSPSO thinks about all elements of individual bests and their offspring in the whole populace instead of a solitary examination between components individual best and its offspring. NSPSO algorithm performs dependent on the non-commanded arranging idea utilized in NSGA-II [20], where the whole populace is put away into various non-dominated levels.
The main cons of PSO is that dominance comparisons are not fully utilized while updating the personal best of each particle. In order to eliminate the above cons and increase the sharing level between elements in the swarm, NSPSO combines the entire population of *N* pbest and *N* of these elements' offspring to form a temporary population of 2*N* elements. Then domination comparisons among all the 2*N* individuals are thoroughly verified. The principle cons of PSO are that dominance correlations are not completely used while refreshing the individual best of every particle. So as to dispense with the above cons and increment the sharing level between elements in the swarm, NSPSO consolidates the whole populace of N pbest and N of these elements' offspring to shape a brief populace of 2N elements. At that point domination comparisons among all the 2N individuals are thoroughly verified. This methodology will yield more non-dominated arrangements through the mastery correlation tasks and permit the arranging of the whole populace into various non-control levels as utilized in NSGA-II[19].

C. Algorithm to find the UPFC sizes using NSPSO method

NSPSO Algorithm:[19]
The strategy associated with the algorithm is as per the following [19]:

1. Input the population and save in *PSOLIST*:
   a) With in the prescribed limits, Every element of the swarm is selected arbitrarily. And its starting velocity is adjusted zero.
   b) Find every element in the populace ;
   Iteration Counter(IC): *=0.*
2. IC=IC+1.
3. From PSOLIST, distinguish all elements which gives non-dominated solutions , save those elements in *NONDOMPSOLIST*.
4. For every element of the swarm, find out Crowding Distance(CD) .
5. Based on Crowding Distance(CD), resort the *NONDOMPSOLIST*.
6. For (p=0; p < *num* element *p*++)
   a) Out of the sorted *NONDOMPSOLIST,which is mentioned in the upper part* (e.g. top 5%),select n^{th} element global best i.e. Gbest arbitrarily
   b) Depending on (34)& (33),update the velocity V_p and the position S_p

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-12, October 2019

c) For a temporary populace,add *Pbest$_p$*, *S$_p$ of the pth* element and saved in *NEXTPOPLIST*.
d) Add the *pth* element's *Pbest$_i$* and *Xi* to a temporary populace, stored in *NEXTPOPLISt*.
   if *p* < *num elements*, go to a).
7. From *NEXTPOPLIST* update elements which Provide non-dominated solutions,these are moved to *NONDOMPSOLIST*. The *NEXTPOPLISTREST* contains remaining elements.
8. For the next iteration, clear the *PSOLIST*.
9. From a *NONDOMPSOLIST*, choose elements arbitrarily and add it to *PSOLIST*(with out exceeding *num elements*).
10. If *PSOLIST* size < *num elements*, repeat.
a) From *NEXTPOPLISTREST* distinguish the non-dominated elements and save these to *NEXTNONDOMLIST*.
b) Until *size<num elements*, put elements of NEXTNONDOMLIST to PSOLIST
c) Clear *NEXTPOPLISTREST* after riplication *NEXTPOPLISTREST* to *EXTPOPLISTRESTCOPY*.
d) From *NEXTPOPLISTRESTCOPY*, Allot the empty *NEXTPOPLISTREST* by remaning elements apart from non-dominated ones.
e) If *PSOLIST* size > *num elements*,go to a)
11. Go to 2.If *IC* > *maxIterations*.

VI. RESULTS AND ANALYSIS

The adequacy of the proposed NSPSO tried with two standard test systems, they are IEEE 30 bus & 14 bus systems. In a 14 bus system [22], 1,2,3,6 and 8 are the generator buses, 4,5,7,9,10,11,12,13 and14 are the load buses and 20 transmission lines. And in 30 bus system [22] 1,2,5,8,11 and 13 are the generator buses, 3, 4, 6, 7, 9, 10, 12, 14 ,15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30 are the load buses and 41transmission lines. The load has expanded into 5 cases. Case1-Full loading, Case2-125% of loading, Case3-150% of loading, Case4-175% of loading and Case5-200% of loading. The simulation results of the two test systems for the above cases are examined below.

A. Simulation results for 14 bus system

Table I shows RPL before and after placement of UPFC , Optimal location & rating of UPFC for above mentioned 5 cases utilizing NSPSO

Table I. Result for 14 bus system.

Cases	Losses without UPFC(MW)	Optimal location of UPFC	UPFC injection in series with line (MVAr)	UPFC injection in shunt with the bus (MVAr)	Losses with UPFC (MW)
Case 1	13.3934	4-9 9-14	7.4204 10.6444	6.0000 7.0000	13.3355
Case 2	22.7259	4-9 9-14	9.9246 0.0506	15 10	22.219
Case 3	35.5578	4-9 9-14	24.1683 14.7925	43 6	34.639
Case 4	51.61	4-9 9-14	14.7639 30.6572	61 15	49.804
Case 5	70.8595	4-9 9-14	3.0375 65.2245	92 0	69.2677

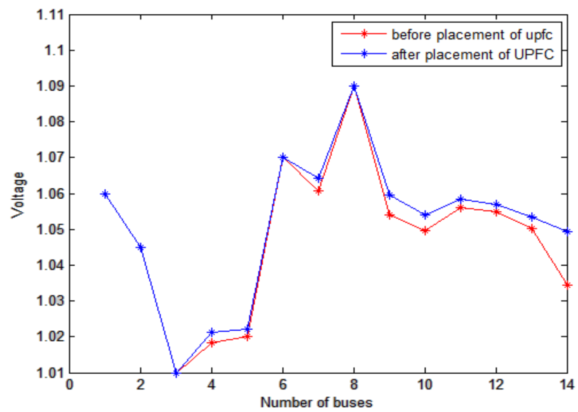

Figure 5: Voltage profile when with & without UPFC for Normal loading

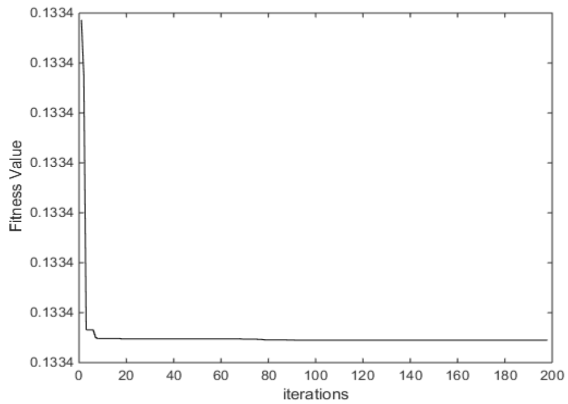

Figure 6: Convegence of 14 bus system at base case

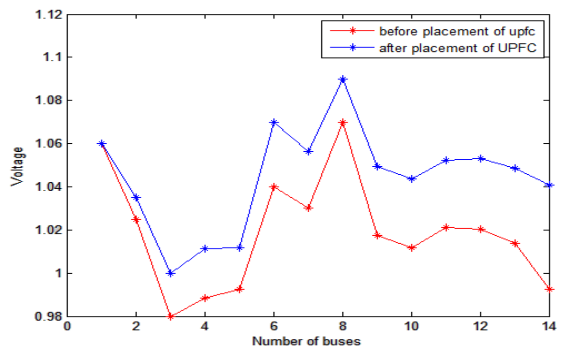

Figure 7: Voltage profile with & without UPFC for 125% of loading

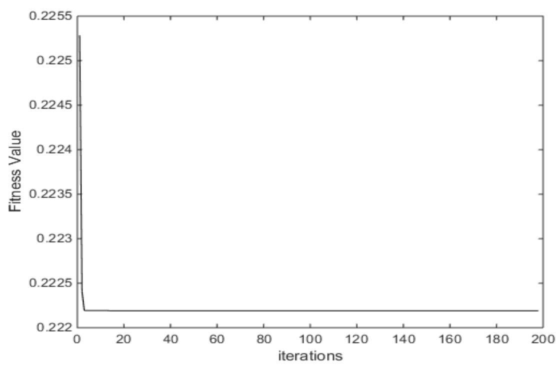

Figure 8:Convergence characteristics of IEEE 3of 14 Bus system at 125% of loading

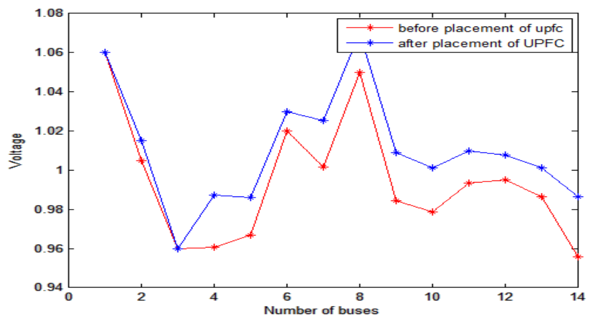

Figure 9: Voltage profile when with & without UPFC for 150% of loading

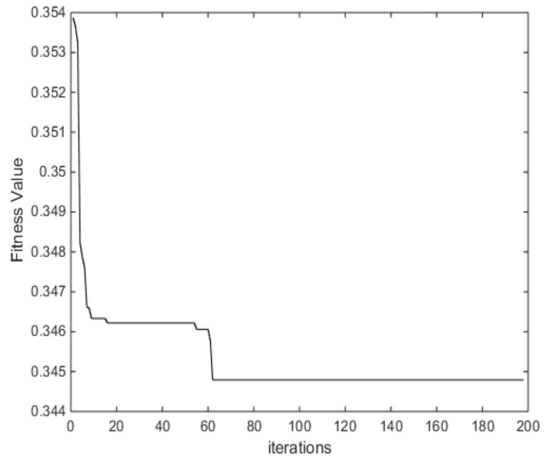

Figure 10: Convergence of 14 Bus system at150% of loading

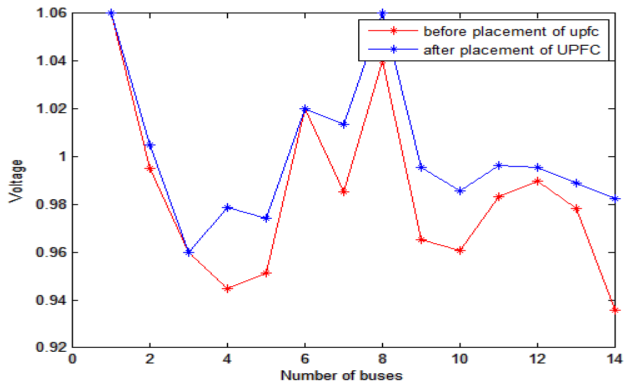

Figure 11: Voltage profile with & with out UPFC for 175% of loading

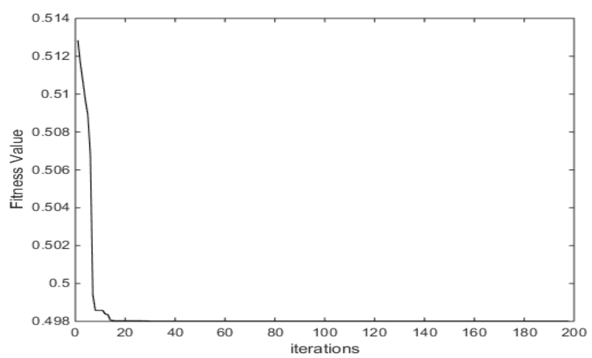

Figure 12:Convergence of 14 Bus test system at175% of loading.

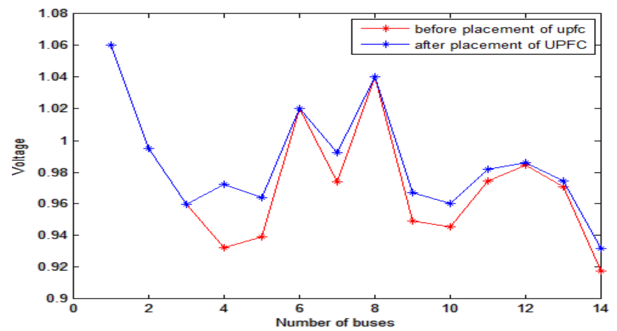

Figure 13: Voltage profile with & with out UPFC for 200% of loading.

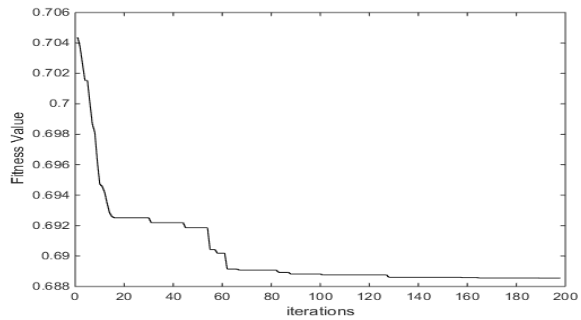

Figure 14:Convergence of 14 Bus system at 200% of loading.

B. Simulation results for 30 bus system

Table II shows RPL with and with out UPFC,rating and optimal location of UPFC for different load cases utilizing NSPSO.

Table II. Result of 30 bus system.

cases	Losses without UPFC (MW)	Optimal location of UPFC	Reactive power injection in series with line (MVAr)	Reactive power injection in shunt with the bus (MVAr)	Losses with UPFC (MW)
Case1	17.5985	7-6 24-25 25-26 27-30	5.3819 2.0481 3.7225 0.8623	3 3 12 12	17.42 11
Case2	30.3738	7-6 24-25 25-26 27-30	0.4385 35.8415 26.3520 0.4954	5 3 17 16	29.33 85
Case3	47.2228	7-6 24-25 25-26 27-30	5.9475 0.9505 2.0367 3.9949	8 5 37 31	45.51 48
Case4	69.3379	7-6 24-25 25-26 27-30	23.6606 13.2037 0.4842 0.6595	9 5 38 29	66.97 04
Case5	96.5636	7-6 24-25 25-26 27-30	8.3091 49.7435 0.5101 14.6994	12 6 50 47	92.92 82

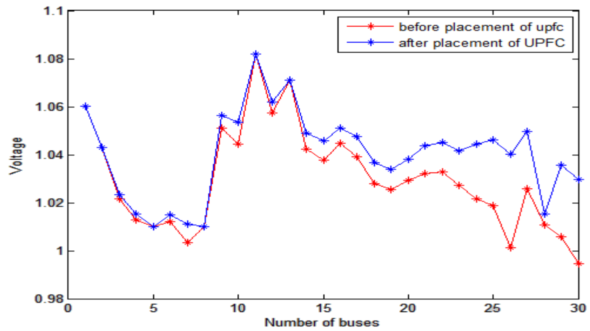

Figure 15: Voltage profile with & with out UPFC for Normal loading

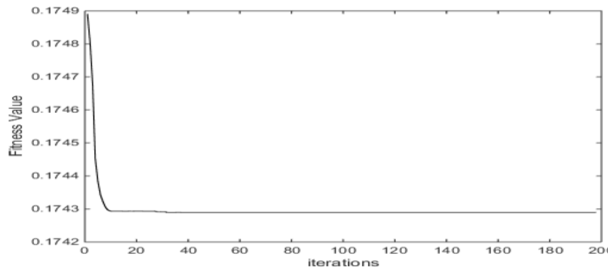

Figure 16:Convergence of 30 Bus system for case1

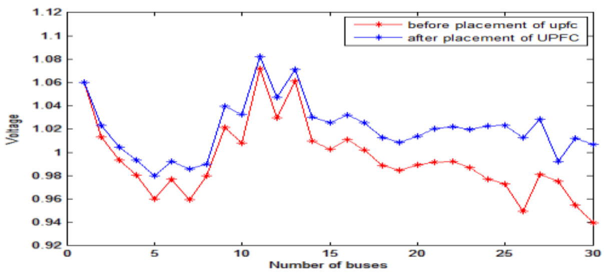

Figure 17: Voltage profile with & with out UPFC for 125% of loading

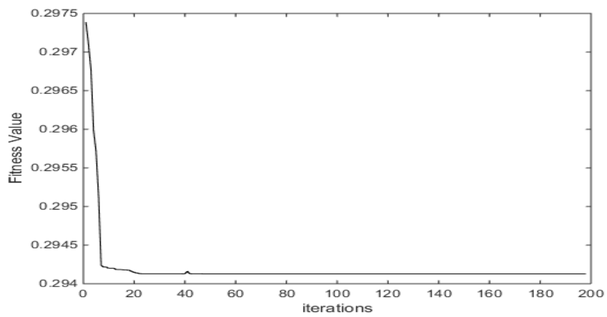

Figure 18:Convergence of 30 Bus system for125% of loading

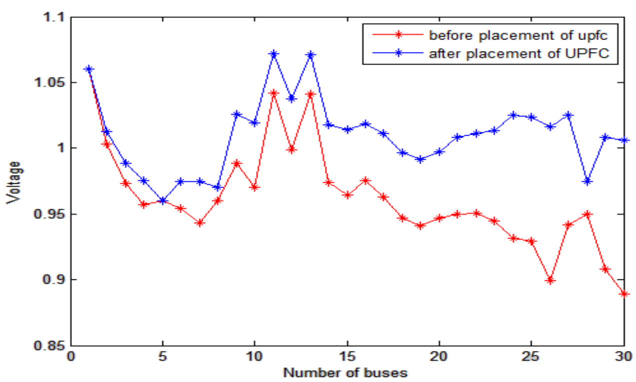

Figure 19: Voltage profile with & with out UPFC for 150% of loading(case3)

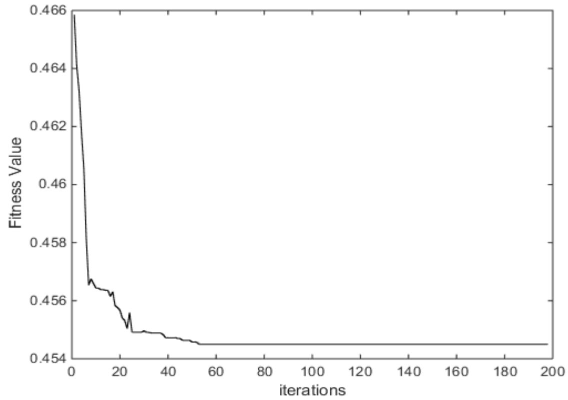

Figure 20:Convergence of 30 Bus system at 150% of loading

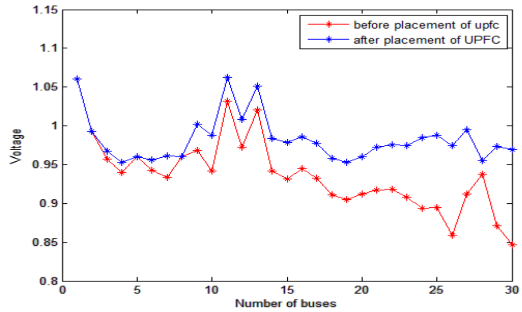

Figure 21:Voltage profile with & with out UPFC for 175% of loading

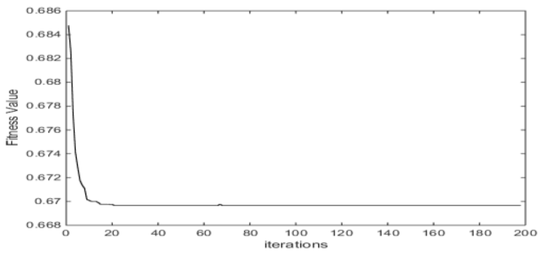

Figure 22:Convergence of 30 Bus system at 175% of loading

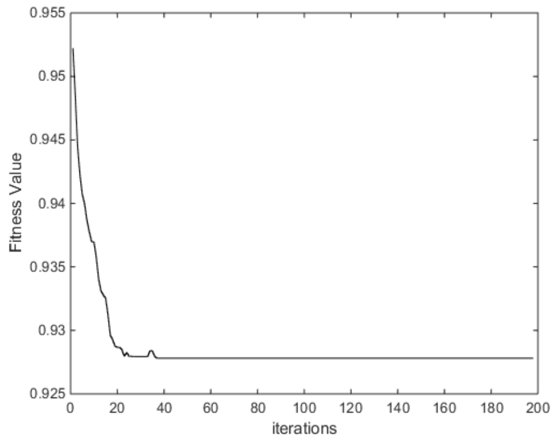

Figure 23:Convergence of 30 Bus system at 200% of loading.

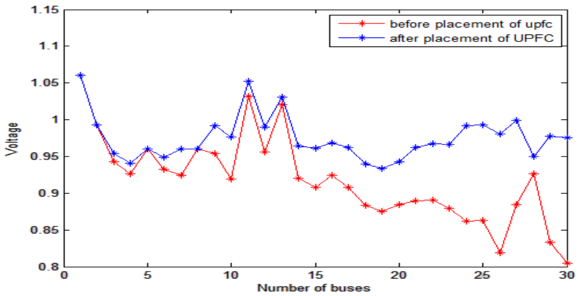

Figure 24:Voltage profile with & with out UPFC for 200% of loading

VII. CONCLUSION

In This Paper Two Approaches Are Executed For Finding Sizes And Optimal Locations Of Upfc Devices. In Order To Find The Optimal Upfc Locations, L Index Approach Is Used And To Find The Optimal Upfc Sizes, Non Sorting Daminated Particle Swarm Optimization(Nspso) Algorithm Is Implemented. Based On The Simulation Results, The Total System Real Power Loss(Rpl) Has Been Diminished And Bus Voltages Are Improved In All Overload Conditions I.E. 125%, 150%, 175% And 200% And System Stability Is Also Maintained.

REFERENCES

1. Hingorani NG, Gyugyi L. "Understanding FACTS: concepts and tech. of flexible AC transmission systems." New York: Wiley IEEE Press; 2000.
2. Verma KS, Singh SN, Gupta HO. "Location of unified power flow controller for congestion management." Electric Power Sys. Res 2001;58(2):89–96.
3. Gyugyi L. "A unified power flow control concept for flexible AC transmission syst." IEE Proc Part C 1992;139(4):323–31.
4. Galiana GD et al. "Assessment and control of the impact of FACTS devices on power system performance." IEEE Tran. Power Sys. 1996;11(4):1931–6.
5. Singh SN, Erlich I. "Locating unified power flow controller for enhancing power system loadability." In: International conference on future power system. Amsterdam, Netherlands; Nov. 2005, p. 162–66.
6. Larsen E, Miller N, Nilsson S, Lindgren S. "Benefits of GTO Based compensation systems for electric utility applications." IEEE Tran Power Del 1992;7(4):2056–64.
7. Nabavi-Niaki A, Iravani MR. "Steady-state and dynamic models of unified power flow controller (UPFC) for power system studies." IEEE Tran Power Syst 1996; 11(4):1937–43.
8. Gyugyi L, Shauder CD, Williams SL, Rietman TR, Torgerson DR, Edris A. "The unified power flow controller: a new approach to power transmission control." IEEE Tran Power Del 1995; 10(2):1085–97.
9. T.V.cutsem, "Voltage instability: phenomena, counter measures and analysis methods", proc of IEEE, Vol.88, pp.208- 227,Feb, 2000.
10. Xiaodong Li: "A non-dominated sorting particle swarm optimizer for multi-objective optimization" (2003)
11. M. Noroozian l. Angquist, m. Ghandhari g. Anderson "Use of upfc for optimal power flow control." Ieee trans on power delivery, vol. 12, no. 4, october 1997
12. Huang G.M. and Nair N.K.C. (2001) "Detection Of Dynamic Voltage Collapse," Power System Engineering Research Centre,www.pserc.wise.edu/ecow/get/publication/2002public/dynamic_summer.pdf.
13. P.Kessel, H.Glavitsch "Estimating the Voltage Stability of a Power System" IEEE, Trans on Power Delivery, Vol.PWRD-1, N3, July 1986
14. M. Noroozian, L. Angquist, M. Ghandhari and G. Anderson "Use of UPFC for optimal power flow control" in IEEE Trans on Power Delivery, Vol. 12, No. 4, October 1997
15. Lashkar Ara A, Kazemi A, Gahramani S, Behshad M. Optimal reactive power flow using multi-objective mathematical programming. Sci Iranica Tran D: Comput Sci Eng Electr Eng 2012; 19(6):1829–36.
16. N.G. Hingorani and L. Gyugyi, " Understanding FACTS: concepts and technology of Flexible ac transmission systems", IEEE Press, NY, 1999 .
17. R. Eberhart, and J. Kennedy, "Particle Swarm Optimization," *Proc. Of IEEE International Conf. on Neural Networks*, Vol. 4, pp. 1942–1948, 1995.
18. R. Z. Mi˜nano, "Optimal power flow with stability cnstraints," Ph.D. dissertation, Universidad e Castilla - La Mancha, 2010.
19. K. Deb, A. Pratap, S. Agarwal, T. Meyarivan, "A fast and elitist multiobjective genetic algorithm: NSGA-ll," iEEE Trans on Evolutionary Computation 6,2002, pp. 182-197.
20. Xiaodong Li: "A non-dominated sorting particle swarm optimizer for multi-objective optimization," (2003)
21. http://www.ee.washington.edu/research/pstca/.

AUTHORS PROFILE

N.KALPANA received the B.Tech. degree in Electrical and Electronics Engineering f Engineering from J.N.T.U.,Hyderabad, India, in 2004. She received M.Tech. degree in 2009 from JNTU college of Engineering,Kukatpalli, Hyderabad, India, in the field of Electrical Power Engineering. She is presently working as Assistant Professor in the Department of Electrical and Electronics Engineering, MECS, Hyderabad, and she is pursuing her Ph.D. from Acharya Nagarjuna University,Guntoor. Her research interests are power system stability and control, voltage stability, FACTS devices, optimization techniques and evolutionary algorithms. He has published.

Dr.Venu Gopala Rao.M, FIE, Senior Member IEEE at present is Professor & Head,department of Electrical & Electronics Engineering, PVPSIT, Kanuru, Andhra Pradesh, India. He received B.E degree in Electrical &Electronics Engineering from Gulbarga University in 1996, M.E.(Electrical Power Engineering) from M S University, Baroda, India in 1999, M.Tech.(Computer Science) from JNT University, India in 2004 and Dactorial Degree in Electrical &Electronics Engineering from JNT University, Hyderabad, India in 2009. He published more than 35 papers in various National, International conferences and Journals. His research interests accumulate in the area of Power Quality, Distribution System, High Voltage Engineering, Condition Monitoring of Electrical Machines and Signal Processing.