Strategic Position and Tuning of UPFC using Multiple Indices and Flower pollination Algorithm for Contingency Management

Sravana Kumar Bali, B.Durgaprasad, A.Jagadeesh, V.Raj Kumar

Abstract: In this paper, a technique was proposed in the presence of UPFC to optimize the sizing of generators with Flower Pollination algorithm. The UPFC is based on an index incorporating both the L-index and the LUF index. For tuning the generators, a multi objective function has been selected. The multi-objective feature consists of deviation of voltage, cost of active generation of power and loss of transmission line. This approach was tested and implemented for regular loading and extreme network conditions due to line failure (contingency situation) on an IEEE 30 test bus system.

Keywords:Optimal Reallocation; UPFC; Flower Pollination Algorithm; Voltage Stability

I. INTRODUCTION

Optimalpower flow or optimal generator reallocation consists of optimizing an objective function when operational constraints are present. To solve the OPF problem, a lot of methods have been developed so far. In [1] Zhang et al. suggested a revised method for solving OPF based on multi-objective evolutionary algorithms. For obtain a uniformly distributed pareto-optimal solution, an adapted Tchebycheff decomposition approach was used. A solution to the power system's optimum energy flow problem was obtained using various methods such as Colliding Bodies Optimization algorithm [2], PSO optimization with aging manager and challenger [3], adaptive group search optimization [4].

FACTS components have very important role in further enhancing the impact of the power systems solution on the OPF problem. Mahdad and Srairi [5] used the adaptive flower pollination algorithm combined with SVC to resolve the OPF in the case of failures in the generating units. UPFC is a better FACTS tool that has been used to mitigate transmission losses and network operating costs [6-7], power system loadability, congestion management and various other applications. For the optimum power flow with UPFC, the Flower Pollination Algorithm was used in this article. UPFC has been put in the process using LUF and L-index. For a poly-objective feature, specifically decreasing deviation of voltage Cost of active power generation and loss of transmission line, the optimal tuning of generators was achieved. True and imaginary generation of power results and bus voltage restrictions are taken as optimization requirements. To prove the validity of the novel procedure, the results of optimum tuning without and with UPFC were compared.

II.INDEX FOR PLACEMENT OF UPFC

A. L-index: The expression for L- index is given in Equation (1). F_{pq} indicates complex parameters, V_q indicates magnitude of voltage at bus q andV_j indicates magnitude of voltage at bus p.

$$Lindex = \left| 1 - \sum_{q=1}^{g} F_{pq} \frac{V_q}{V_p} \right| \quad (1)$$

B. Line Utilization Factor (LUF): LUF is an index indicated for formative the congestion of the transmission lines as given in equation 4.

$$LUF = \frac{MVA_{pq}}{MVA_{pq}^{\max}} \quad (2)$$

Objective function is presented by Equation (3).

$$\text{Min O} = \text{Min}\,(W_1 * O_1 + W_2 * O_2 + W_3 * O_3) \quad (3)$$

Where, O_1 is the Fuel cost given by

$$O_1 = \min\left(\sum_{i=1}^{ng} [a_i + b_i P_{Gi} + c_i P_{Gi}^2] \right) \quad (4)$$

O_2 is the Real power loss

(5)

O_3 is the deviation of voltage

$$O_3 = \min(VD) = \min\left(\sum_{k=1}^{Nbus} \left| V_k - V_k^{ref} \right|^2 \right) \quad (6)$$

$$O_2 = \min\left(\sum_{i=1}^{ntl} real(S_{pk}^{q} + S_{kp}^{q}) \right)$$

II. FLOWER POLLINATION ALGORITHM

Algorithm represented in the form flow chart as shown below

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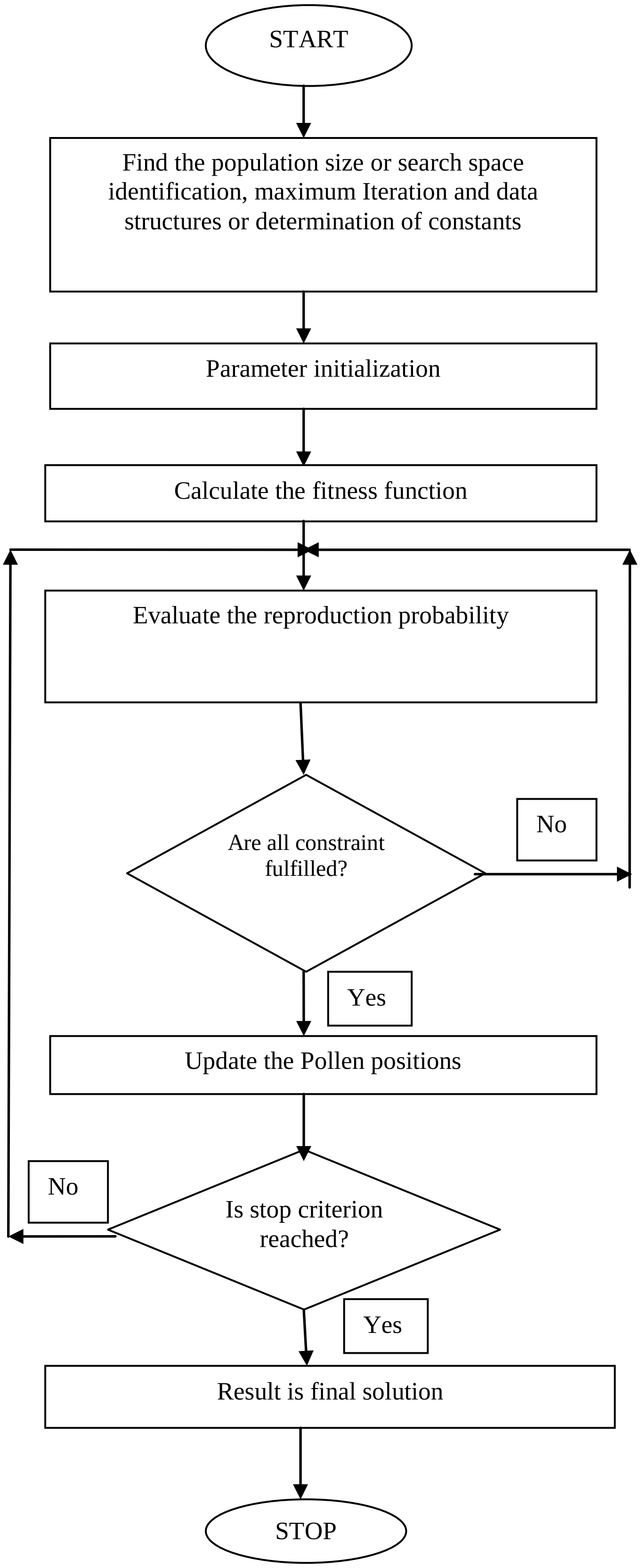


Fig.1 Flower Pollination Algorithm Flowchart

III. PROPOSED METHODOLOGY

The process for the projected technique mentioned in Fig. 2

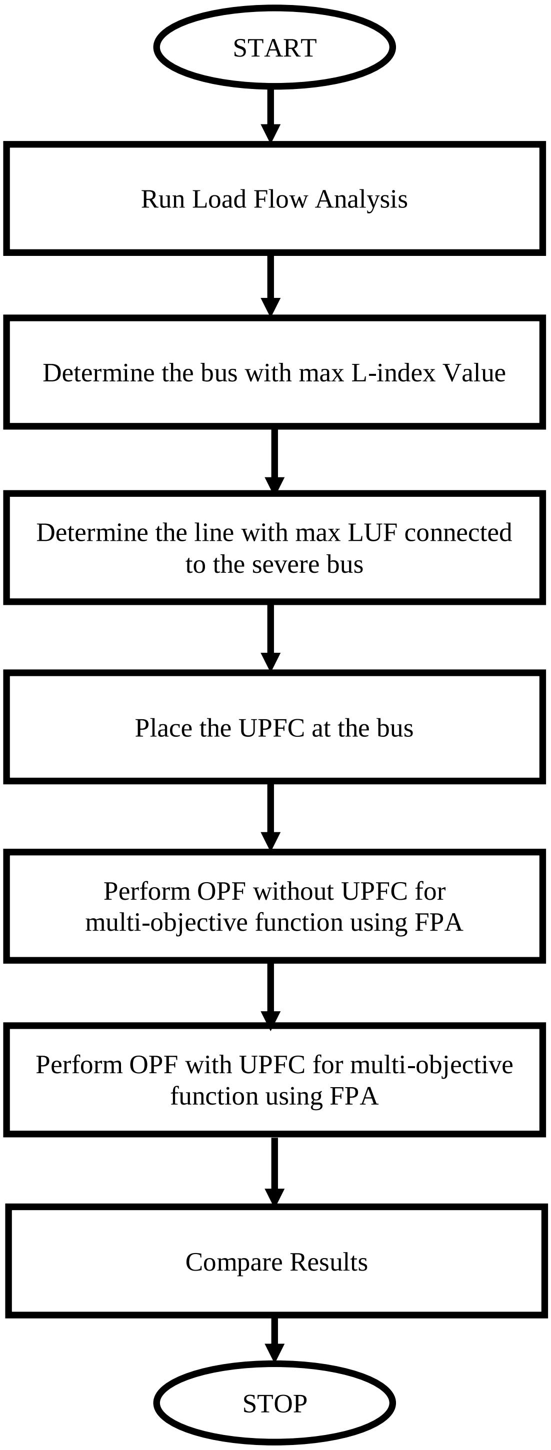


Fig.2 Flow Chart for the illustration of the proposed methodology

IV. RESULTS AND DISCUSSION

Contingency study for the IEEE 30 bus scheme is done and it is seen that outage of 27-28 results in more damage to the network, reflected in L-index value of 0.4522 p.u (max) as presented in Table 1. It is seen from Fig. 3 that line 27-30 is the severe-most line for line 27-28 contingency.

Therefore, Single linecontingency for 27-28 and UPFC at bus 30 and line 27-30 has been considered for the study.

Table-I: Feeble Bus in IEEE 30 Structure

RANK	BUS NO	Line Outage	L-Index
1	30	27-28	0.4522
2	19	9-10	0.1918
3	30	27-30	0.1793
4	29	27-29	0.1613
5	14	4-12	0.1591
6	21	10-21	0.1416
7	26	25-27	0.1375
8	20	10-20	0.1341
9	30	6-28	0.1298
10	19	19-20	0.117
11	17	10-17	0.1167
12	30	29-30	0.1163
13	30	3-4	0.1151
14	30	4-6	0.1041
15	26	10-22	0.102
16	26	22-24	0.102
17	30	6-10	0.0938
18	30	12-15	0.0938
19	30	23-24	0.0934
20	30	21-23	0.0921
21	30	12-14	0.0907
22	30	12-16	0.0904
23	30	15-18	0.0902
24	30	14-15	0.0898
25	30	18-19	0.0898
26	30	15-23	0.0898
27	30	16-17	0.0894
28	30	6-7	0.0867
29	30	6-9	0.0857
30	30	24-25	0.0823

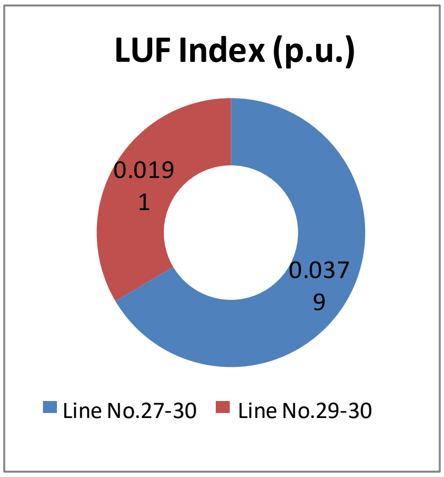
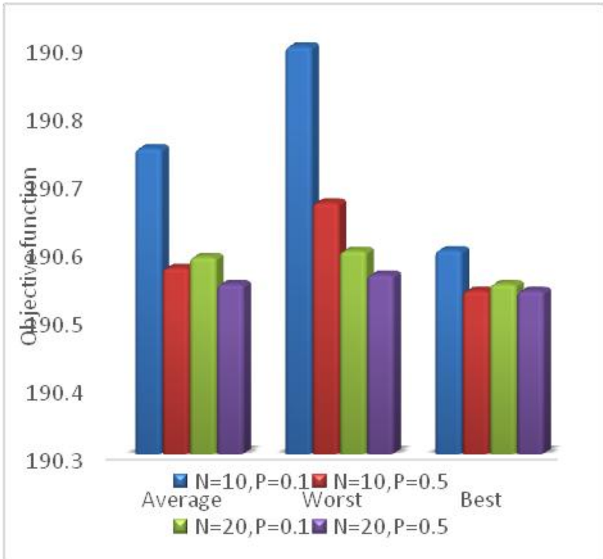


Fig.3 Severe Line at 27-28 contingency condition is 27-30



N = No. of pollens (Population size)

P = Probability switch

Fig.4Analysis of Objective Function value by varying Flower Algorithm Parameters

A number of values of N and P have been checked and the results are presented in Fig. 4. It is noted that for N = 20, P = 0.5 indicates the least average and best result of the objective function.

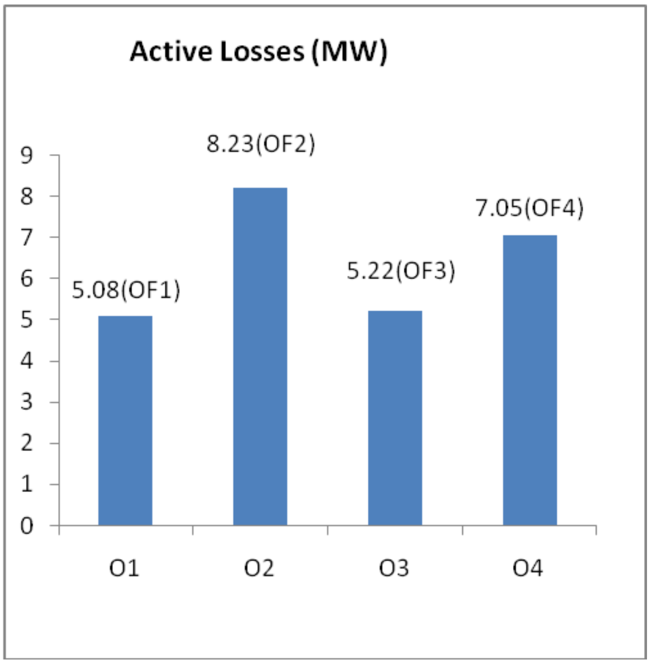


Fig.5 Real power loss vs. objective function

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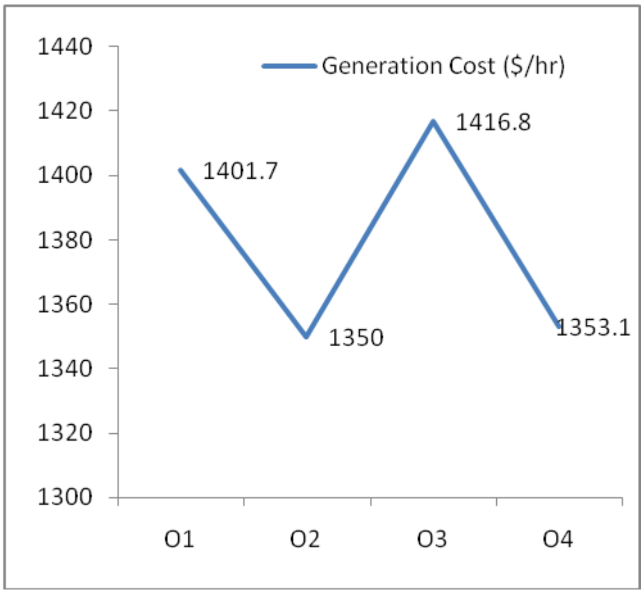

Fig. 6 Generation cost vs. objective function

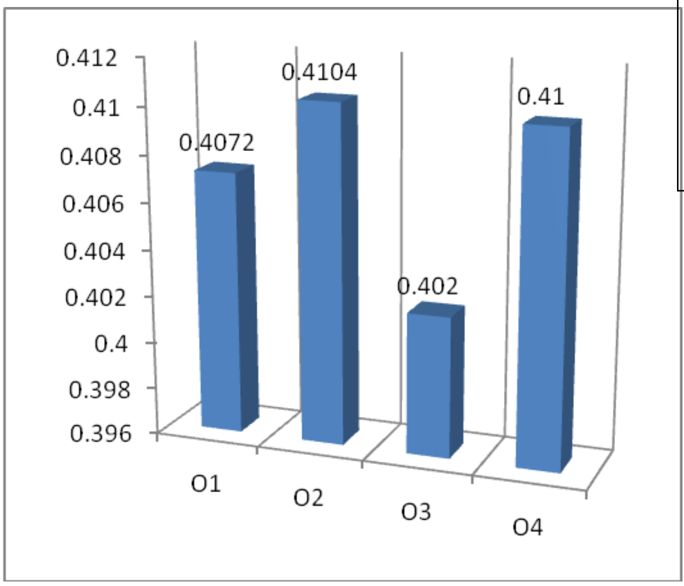

Fig.7 Voltage deviation vs. objective function

O1 – merelyTransmission losses

O2- merely cost of Generation

O3- merelydivergence of voltage

O4 – multi objective function

The network elements for single objective and multi-objective function are shown in Figures 5, 6, and 7. Multi objective function is seen to be apt for network elements.

Table-II:ASSESSMENT OF NETWORK ELEMENTS FOR WITHOUT CONTINGENCY & CONTINGENCYWITH UPFC PLACED AT 27-30

Loading Condition	Parameter		FPA: FPA-OPF without UPFC	FPA: FPA-OPF with UPFC
		PG1	115.517	87.0542
		PG2	50	50
Without Contingency	Real power generation (MW)	PG5	37.37	20.8158
		PG8	37	39.24574
		PG11	40.124	41.46105
		PG13	10	50
	Total Active generation of power (MW)		290.011	288.5768
	Total cost of Active power Generation ($/hr)		1365.33	1220.2
	Deviation of Voltage (p.u.)		1.835553	0.30956
With Contingency 27-28	Real power generation (MW)	PG1	104.14	108.1
		PG2	29.35	22
		PG5	36.287	26.71
		PG8	49.88	49.08
		PG11	63.45	74.54
		PG13	9.936	10
	Total Active generation of power (MW)		293.043	290.43
	Total cost of Active power Generation ($/hr)		1369.1	1353.1
	Deviation of Voltage (p.u.)		3.4022	0.41

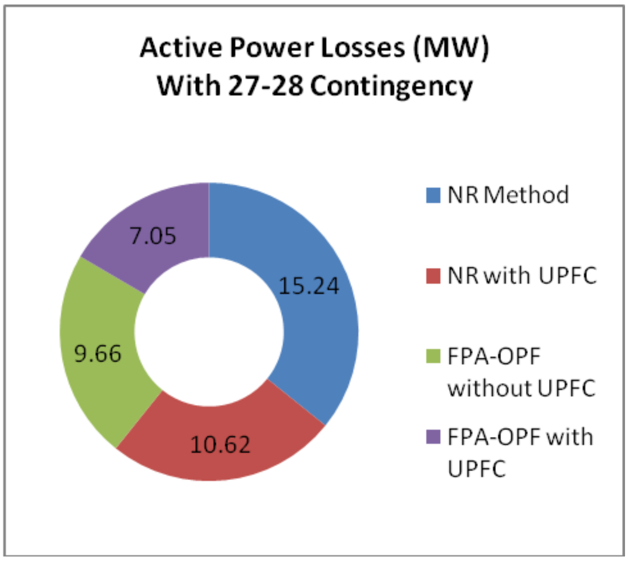

Fig.8 Assessment of Active Power Losses

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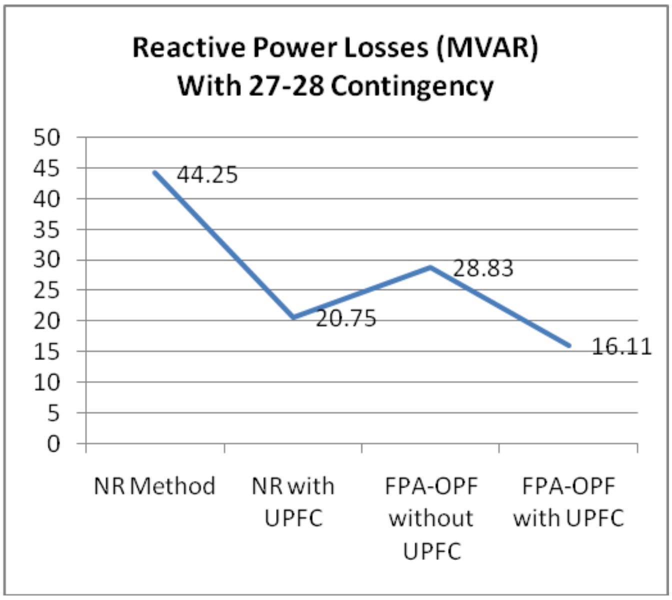

Fig.9 Assessment of Reactive Power Losses

Real power generation and cost of generation of the network have been evaluated for ordinary and faulty situation for OPF in absence and presence of UPFC in Table 2.OPF in the presence of UPFC reduces these parameters to a good extent. Contrast of Active and reactive power losses in various methods are presented in figures 8&9. The OPF with UPFC is found to be the better result in ordinary and faulty situation. The voltage summary of the 30 bus structure for OPF in absence and presence of UPFC has been assessed in Fig.10. The convergence characteristics presented in Fig. 11.

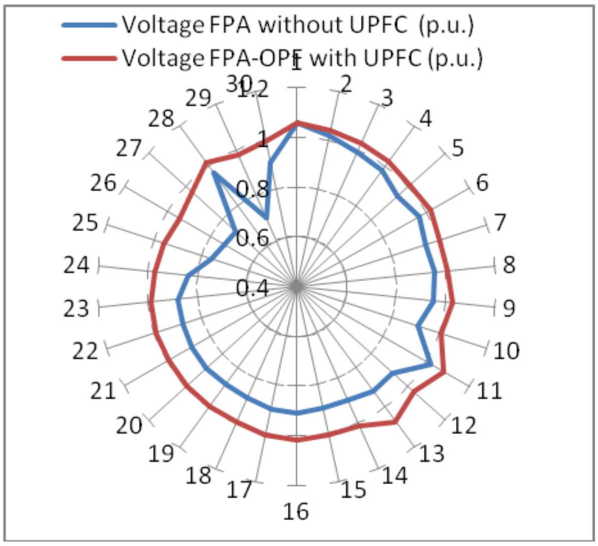

Fig.10 Assessment of bus voltages using FPA- OPF without and with UPFC

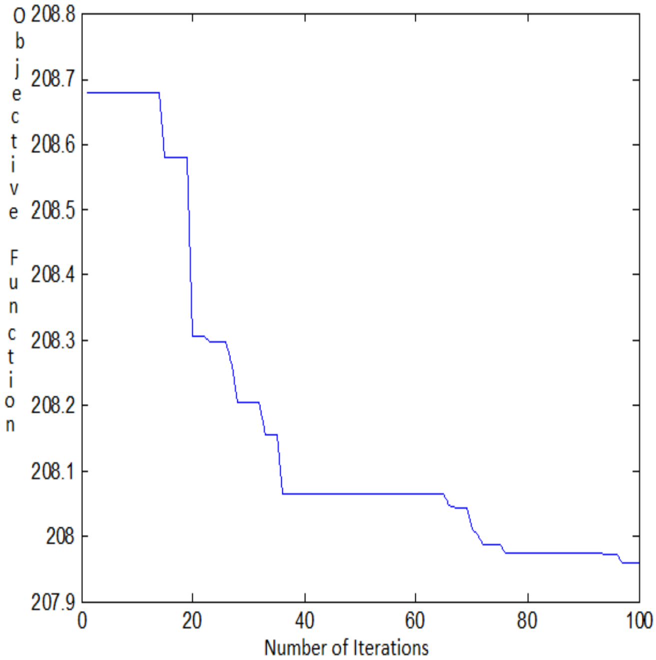

Fig.11Multi Objective function value Vs iterations FPA-OPF with UPFC

V. CONCLUSION

- Optimal power flow using UPFC is observed in reduction of the contingency issues.
- The UPFC has been optimally placed in the system depending on L-index and LUF.
- Flower pollination algorithm has been used for the optimization of the UPFC and generator parameters.
- The projected technique applied for an IEEE 30 bus system for n-1 contingency situation.
- OPF using UPFC is observed to be an effective solution for enhancement of the system operation as seen in the values of the power system elements like decrease in Active power loss, deviation of voltage and fuel cost.

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