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Optimal Reactive Power Planning using Firefly Algorithm

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***Abstract*—this article Firefly Algorithm is used as evolutionary technique for the best assignment of flexible AC transmission systems (FACTS) is a unified system. Reactive Power load taken base to 125% base loading and the system presence with FACTS devices. The lines and buses recognized to connect the FACTS devices using New Voltage Stability Index (NVSI).FACTS devices along with reactive generation of generators using Firefly algorithm. The test and Validation is performed on IEEE 30 bus and 72 bus Real time systems. Effectiveness of placement of FACTS devices is established by comparing the results reported in literature.**

***Keywords:* FACTS devices, Firefly algorithm, Differential Evolution algorithm, line power flow, Particle Swam Optimization.**

I. INTRODUCTION

Reactive power planning is a nonlinear optimization problem for a large scale system with lot of uncertainties. There has been a growing apprehension in the RPP problems for the safety and economy of power systems. The rapid development to fast acting and self-commutated power electronics converters, well known Flexible AC Transmission Systems (FACTS), introduced by Hingorani.[1]-[5],are useful in taking fast control actions to ensure the security of power system. FACTS devices are accomplished of governing the voltage angle and voltage magnitude at particular buses and line impedances of transmission lines.. FA distributed [6].Optimal power flow using GA is presented [7].GA types of FACTS devices [8]. Intelligence based algorithm [9] to limit location of FACTS. [10]-[16].

II. PROBLEM FORMULATION

The objective purpose [1] mathematically as follows.

$$W_C = h\sum d_1 p_{loss,1} \quad (1)$$

Where, (P_{loss}), denotes duration d_l:

$$P_{loss} = \sum gk\left(V_i^2 + V_j^{\,2} - 2V_iV_j\cos\theta_{ij}\right) \quad (2)$$

Installation cost is:

$$I_C = \sum\left(e_i + C_{Ci}\left|Q_{Ci}\right|\right) \quad (3)$$

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Using Data base [18], cost function for FACTS are developed.

$$C_{TCSC} = 0.0015s^2 - 0.173s + 153.75$$

$$C_{SVC} = 0.0003s^2 - 0.3051s + 127.38$$

$$C_{UPFC} = 0.0003s^2 - 0.2691s + 188.22$$

The third function is expressed as

$$\text{Min } F_C = W_C + C_{facts} \quad (5)$$

Constraints as follows

(i)Load Flow Constraints:

$$0 = Q_i - V_i\sum V_j\left(G_{ij}\sin\theta_{ij} + B_{ij}\cos\theta_{ij}\right) \quad (6)$$

$$0 = Q_i - V_i\sum V_j\left(G_{ij}\sin\theta_{ij} + B_{ij}\cos\theta_{ij}\right) \quad (7)$$

(ii) $Q_{gi}^{\min} \le Q_{gi} \le Q_{gi}^{\max}$ (8)

(iii) $V_i^{\min} \le V_i \le V_i^{\max}$ (9)

(iv) $-100 \le Q_{facts} \le 100$ (10)

(v) $-0.8X_{Line} \le 0.2 \le X_{facts}$ (11)

The following objective function [5]

$$\text{Min } F_C = F_C + \sum\alpha\left(V_i - V_i^{\lim}\right)^2 + \sum\beta\left(Q_{gi} - Q_{gi}^{\lim}\right)^2$$

$$i \in N_{Og\lim} \quad i \in N_{V\lim} \quad (12)$$

III. SIMULATIION

The simulation has been been studied. Case 1.is the light load, case 2 is heavy loads and whose load is 125%.

IV. INDEX FORMULATION

Considering [19].

$$I = \frac{V_1\angle 0 - V_2\angle\delta}{R + jX} \quad (13)$$

$$I^* = \frac{V_1^* - V_2^*}{R - jX} \quad (14)$$

Neglecting resistance

$$I^* = \frac{V_1^* - V_2^*}{-jX} \quad (15)$$

R.E. Power $= V_2 I^*$ (16)

in equation (13) in and solving

$$P_2 = \frac{V_1V_2}{X}\sin\delta \quad (17)$$

$$Q_2 = \frac{V_2^2}{X} + \frac{V_1V_2}{X}\sin\delta \quad (18)$$

Neglect δ above eqn

$$\left(V_2^2\right)^2 + \left(2Q_2X - V_1^2\right)V_2^2 + X^2\left(P_2^2 + Q_2^2\right) = 0 \quad (19)$$

Solution is

$$\left(2Q_2X - V_1^2\right) - 4X^2\left(P_2^2 + Q_2^2\right) \ge 0 \quad (20)$$

$$\frac{2X\sqrt{(P_2^2+Q_2^2)}}{2Q_2X-V_1^X} \le 1 \qquad (21)$$

$$NVSI_{ij} = \frac{2X\sqrt{(P_j^2+Q_j^2)}}{2Q_jX-V_i^2} \qquad \textbf{(22)}$$

V. FIREFLY ALGORITHM

A.OVERVIEW.

The (FA) is a met heuristic [21].

B.ATTRACTIVENESS.

$$\beta_{(r)} = \beta_0 * \exp(-\gamma_r^m), \text{ with } m \ge 1 \qquad (23)$$

C.DISTANCE

$$r_{ij} = \|x_i - x_j\| = \sqrt{\sum_{k=1}^{d} \|x_{ik} - x_{jk}\|^2} \qquad (24)$$

we have, for$d$ = 2; we have

$$r_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j{}^2)} \qquad (25)$$

The distance r calculated such as [12].

D.MOVEMENT

$$x_i = x_i + \beta_0 * \exp(-\gamma_{rj}^2) * (x_i - x_j) + \alpha * \left(ran - \frac{1}{2}\right) \qquad (26)$$

We use $\beta0$ = 0.1, $\alpha \in$ [0, 1], and the attractiveness or absorption coefficient γ = 0.2, optimal values of firefly parameters are No. of fire flies is 30, β_0 = 0.1, γ = 0.2, α=0.25, m=4, d=20 and minimum iteration is 100.

VII. Optimal Results And Comparison

Table 1 & 2 gives the bus voltage and power losses for Test systems. Table 3&4 shows the annual cost saving at 100% and 125 % load. Table 5&6 shows the Real power saving for 72 bus system at 100% and 125 % load. The FA based RPP gives more savings on the real power for the cases 1and2 respectively. Fig 1 shows the Bus voltage profile for 72 bus system. Figure2 and 3 show the Convergence Rate of FA with incorporating UPFC for, 1.25% loading.

Table 1.Voltage (Bus)

BUS	100%			125%		
	DE	PSO	FA	DE	PSO	FA
1	1.052	1.077	1.089	1.049	1.082	1.091
2	1.065	1.077	1.089	1.069	1.078	1.097
3	1.062	1.082	1.095	1.059	1.068	1.088
4	1.069	1.089	1.099	1.067	1.087	1.094
5	1.045	1.079	1.087	1.070	1.078	1.082
6	1.077	1.082	1.095	1.067	1.069	1.083
7	1.062	1.072	1.082	1.064	1.068	1.086
8	1.053	1.085	1.093	1.056	1.062	1.092
9	1.057	1.060	1.083	1.046	1.061	1.089
10	1.055	1.066	1.070	1.062	1.083	1.090
11	1.057	1.063	1.072	1.072	1.084	1.093
12	1.045	1.085	1.094	1.083	1.098	1.099
13	1.053	1.083	1.093	1.078	1.091	1.098

Table 2 Power losses and Generation

		P_g	Q_g	P_{Loss}	Q_{Loss}
Case 1	DE	3.0017	1.0994	0.1587	0.2954
	PSO	2.9895	1.3678	0.1614	0.2176
	FA	2.9876	1.1644	0.1608	0.2610
Case 2	DE	3.8965	1.8159	0.2925	0.7629
	PSO	3.8724	1.8043	0.2802	0.7023
	FA	3.8701	1.7975	0.2178	0.6793

Table 3 Performance Comparison (P_C save %) for Case-1

loading	FACT Devices	DE	PSO	FA
100%	SVC	8.4826	8.63616	8.83276
	TCSC	8.6473	8.72755	8.90755
	UPFC	9.0872	9.36894	9.66894

Table 4 Performance Comparison (P_C save %) for Case 2

loadin g	FACT Devices	DE	PSO	FA
125%	SVC	8.9458	9.03616	10.8403
	TCSC	12.8456	13.62755	15.3410
	UPFC	14.8620	15.76894	17.8511

Table 5 Performance Comparison (W_C save in \$) for Case 1

loadin g	FACT Devices	DE	PSO	FA
100%	SVC	8.42×10^6	8.76×10^6	8.82×10^6
	TCSC	9.07×10^6	9.21×10^6	9.37×10^6
	UPFC	10.25×10^6	10.3×10^6	10.54×10^6

Table 6 Performance Comparison (W_C save in \$) for Case 2

loading	FACT Devices	DE	PSO	FA
125%	SVC	1.55×10^7	1.58×10^7	1.59×10^7
	TCSC	2.29×10^7	2.34×10^7	2.48×10^7
	UPFC	3.06×10^7	3.12×10^7	3.59×10^7

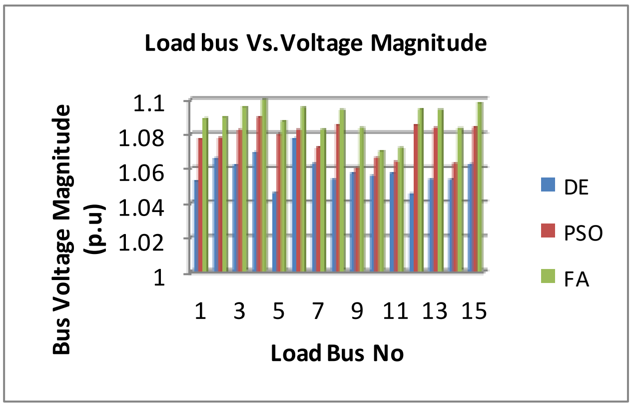

Fig.1.Bus voltage profile for 100% incorporating UPFC

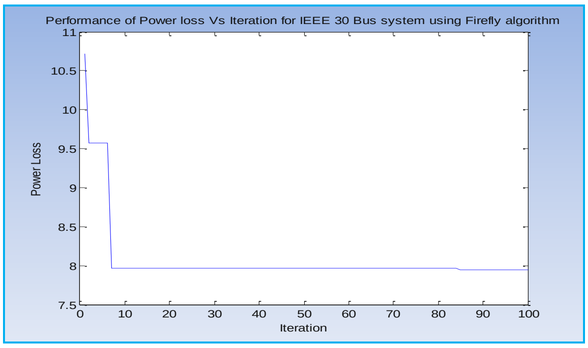

Figure 2.Convergence rate of Firefly algorithm for Test system for 125%

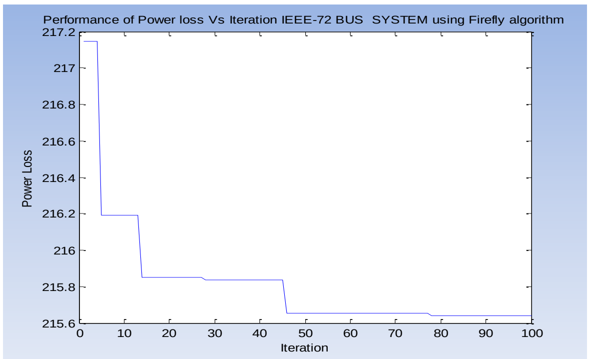

Figure 3.Convergence rate of Firefly algorithm for Indian utility 72 Bus system for case 2.

VI. CONCLUSION

NVSI has been built-up for solve the feeble bus VAR Dispatch. Using Index, the place of reactive power approaches for voltage control is firm. The separate maximum load ability obtains from the load buses will be arranged in increasing order with the smallest value being ranked highest. The uppermost rank suggests the feeblest bus in the system with low sustainable load. The purpose studies on the IEEE 30-bus system and Real Time approach shows that the FA based reactive power planning gives more savings on real power, annual and the total costs for unlike loading conditions reported in literature.

REFERENCES

1. G. O. Young, “Synthetic structure of industrial plastics (Book style with paper title and editor),” in *Plastics*, 2nd ed. vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 15–64.
2. W.-K. Chen, *Linear Networks and Systems* (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.
3. H. Poor, *An Introduction to Signal Detection and Estimation*. New York: Springer-Verlag, 1985, ch. 4.
4. B. Smith, “An approach to graphs of linear forms (Unpublished work style),” unpublished.
5. E. H. Miller, “A note on reflector arrays (Periodical style—Accepted for publication),” *IEEE Trans. Antennas Propagat.*, to be published.
6. J. Wang, “Fundamentals of erbium-doped fiber amplifiers arrays (Periodical style—Submitted for publication),” *IEEE J. Quantum Electron.*, submitted for publication.
7. C. J. Kaufman, Rocky Mountain Research Lab., Boulder, CO, private communication, May 1995.
8. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interfaces(Translation Journals style),” *IEEE Transl. J. Magn.Jpn.*, vol. 2, Aug. 1987, pp. 740–741 [*Dig. 9th Annu. Conf. Magnetics* Japan, 1982, p. 301].
9. M. Young, *The Techincal Writers Handbook.* Mill Valley, CA: University Science, 1989.
10. (Basic Book/Monograph Online Sources) J. K. Author. (year, month, day). *Title* (edition) [Type of medium]. Volume(issue). Available: http://www.(URL)
11. J. Jones. (1991, May 10). Networks (2nd ed.) [Online]. Available: http://www.atm.com
12. (Journal Online Sources style) K. Author. (year, month). Title. *Journal* [Type of medium]. Volume(issue), paging if given. Available: http://www.(URL)

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