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ATC enhancement by incorporating FACTS devices for deregulating scenario in present power market

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The cost based monopolistic power market rules are new fangled by the word deregulation. Trepidations in its conceptualisation and integrated operation in the impending scenario are transmission pricing, congestion management and Available Transfer Capability (ATC). Of this intriguing technical challenge, ATC is the one that needs to be interrogated and dogged to make open access a feasible obsession for private entity participation which is deregulation's intention.

This research work aims at calculating ATC using non iterative, simple, Power Transfer Distribution Factors (PTDF) based methodology, enhancing them using Flexible AC Transmission system (FACTS) devices like Static compensator (STATCOM) and Unified Power Flow Controller (UPFC). A proven alternative to overcome extravagance by erecting new transmission facility is incorporation of FACTS devices in the existing structure that indulge in reactive power compensation. These FACTS devices are modelled using the power flow equations and is placed optimally based on the slope of sensitivity factors.

The optimal settings of FACTS devices is obtained by a soft computing technique labelled as Particle Swarm Optimisation (PSO) to enhance the ATC for the assumed bilateral and multilateral power contracts. The voltage and angle of shunt and series FACTS devices are randomly generated as the population of PSO on sample 6 bus and standard IEEE 30 bus systems.

Keywords: *PTDF, linear slope of sensitivity factors, power flow modelling of facts, particle swarm optimisation, bilateral and multilateral transactions.*

1.0 INTRODUCTION

According to NERC report ATC is a measure of the transfer capability remaining in the transmission network for further commercial activity over and above already committed users [1]. Open access may cause overload in the multifaceted power network, so ATC calculation and enhancement gain its value. It helps the power system operation people to reduce the system sternness with better efficiency and improved system performance.

Optimal Power Flow (OPF) and Continuation Power Flow (CPF) have been used for evaluation of ATC in [2] and [3]. In deregulated market, the transactions in the open access market could be two types, either involving just one buyer-seller pair known as bilateral transactions, or bringing

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together a multiple buyers and sellers who group themselves together to enter into a multilateral transaction. ATC computation for bilateral and multilateral transaction is discussed in [4] and [5]. The linear ATC has been calculated using DC Power Transfer Distribution Factors (DCPTDF) [6].

To enhance ATC, reactive power compensation is provided by using FACTS devices that is included by altering existing real and reactive power equation that is dealt in [7] and [8].The UPFC modelling and its performance in transmission control is analysed in [9].Computation of TCSC reactance and location for attaining objective of enhancing ATC is discussed in [10].Enhancement of ATC using TCSC and SVC described in [11].A new methodology of ATC computation using Real Coded Genetic algorithm is analysed in [12]. Multi transaction determination of ATC using AC-PTDF factors is done by Kumar et al. in [13]. Comparing UPFC and SEN transformer for improving ATC is done in [14].The FACTS devices like STATCOM, SSSC and UPFC are used to enhance ATC using PTDF approach is done in [15].

Many heuristic algorithms like Genetic Algorithm (GA) and Particle Swarm Optimisation (PSO) have been used in [16] to compute ATC. Particle swarm optimization is motivated from the model of social behaviour and was introduced by Eberhart et al. in [17].To manipulate individuals,each individual in PSO flies in the search space with velocity that is dynamically adjusted according to its own and its companion's flying experience. The velocity of the particle that is updated according to its own previous best position and the previous best position of its companions and more information are available in previous research [18]. PSO is now applied for solving electrical engineering related problem like setting FACTS devices as used in [19]. The time varying acceleration, inertia weight method using modified Particle Swarm Optimisation method is introduced by Halgamuge et al. in [20].

This paper intended in enhancing ATC for bilateral and multilateral power contracts using FACTS devices such as STATCOM, UPFC. The control parameters voltage and angle of FACTS devices is optimally determined by employing standard and modified PSO algorithms. Multiple FACTS devices are incorporated and its performance in enhancing ATC is also investigated. The results are demonstrated on sample 6 bus and IEEE 30 bus system.

2.0 PROBLEM FORMULATION

In order to solve non linear power flow problem, the objective function tobe solved is formulated with all the equality and inequality constraints. This is given in the following sub sections.

2.1 Objective function

The objective function of ATC maximization is represented as,

$$MAX\left\{ATC_{mn}^{FACTS}\right\} \quad ....(1)$$

2.2 Constraints

The constraints includes power flow limits and security limits for executing power flow problem.

2.2.1 Equality constrains

The law of energy conservation is verified at all buses. The real and reactive power conservation at buses expressed mathematically as,

$$P_{Gi} - P_{Di} - \sum_{j=1}^{Nbus} |V_i||V_j||Y_{ij}|\cos(\theta_{ij} + \delta_j - \delta_i) = 0 \quad ....(2)$$

$$Q_{Gi} - Q_{Di} - \sum_{j=1}^{Nbus} |V_i||V_j||Y_{ij}|\sin(\theta_{ij} + \delta_j - \delta_i) = 0 \quad ....(3)$$

2.2.2 Inequality constraints

- Power flow Constraints
    - Voltage constraint of Load buses,

$$V_i^{min} \leq V_i \leq V_i^{max} \quad ....(4)$$

Where V_i^{min} and V_i^{max} are minimum and maximum voltage limit at bus *i* respectively.

- Active power generation limits

$$P_{gi}^{min} \leq P_{gi} \leq P_{gi}^{max} \quad ....(5)$$

Where P_{gi}^{min} and P_{gi}^{max} are minimum and maximum real power limit at bus *i* respectively.

- Reactive power generation limits

$$Q_{gi}^{\min} \leq Q_{gi} \leq Q_{gi}^{\max} \quad ....(6)$$

Where Q_{gi}^{min} and Q_{gi}^{max} are minimum and maximum reactive power limit at bus *i* respectively.

- Security Constraints

$$S_{gi} \leq S_{gi}^{\max} \quad ....(7)$$

Where S_{gi} is the thermal limits on line *i*.

3.0 FACTS MODELLING

The shunt and series type FACTS devices are modeled based on power flow equations. The FACTS devices are installed in a suitable location by changing the jacobian matrix in the N-R power flow. The STATCOM and UPFC are employed by adding and modifying suitable equations in the N-R power flow.

$$\begin{bmatrix} \Delta\delta^{FACTS} \\ \Delta V^{FACTS} \end{bmatrix} = \begin{bmatrix} J_1^{FACTS} & J_2^{FACTS} \\ J_3^{FACTS} & J_4^{FACTS} \end{bmatrix}^{-1} \begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} \quad ....(8)$$

3.1 STATCOM

Static compensator is a vital shunt type FACTS device, which controls the voltage magnitude i.e., is a regulating device used on alternating currents electricity transmission networks, at bus where it is added to, by injecting/absorbing the reactive power at that bus.

The shunt voltage, shunt angle, and shunt impedance are made as control parameter for the power flow model. The value of X_{sh} is set to 0.1 p.u. The schematic representation of STATCOM is shown in Figure 1.

$$\left.\begin{array}{l} 1 < V_{sh} < 1.1\text{p.u} \\ -0.0843 < \delta_{sh} < 0 \text{ rad)} \end{array}\right\} \quad ....(9)$$

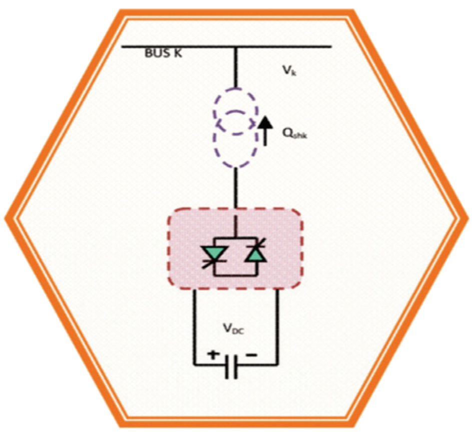

FIG. 1 SCHEMATIC REPRESENTATION OF STATCOM

Let *K* be the bus where STATCOM is added. The real and reactive power are modelled in equations (10 and 11). The Jacobian matrix after incorporating STATCOM get transformed in respective places which is mathematically formulated in equations (12 and 13).

$$P_K^{STATCOM} = V_K^2 G_{sh} + V_K V_{sh}[G_{sh}\cos(\delta_K - \delta_{sh}) + B_{sh}\sin(\delta_K - \delta_{sh})] \quad ....(10)$$

$$Q_K^{STATCOM} = -V_K^2 B_{sh} + V_K V_{sh}[G_{sh}\sin\delta_K - \delta_{sh}) - B_{sh}\cos(\delta_K - \delta_{sh})] \quad ....(11)$$

$$J_{3,statcom}(K,K) = J_3(K,K) + V_K V_{sh}[G_{sh}\cos(\delta_K - \delta_{sh}) + B_{sh}\sin(\delta_K - \delta_{sh})] \quad ....(12)$$

$$J_{4,statcom}(K,K) = J_4(K,K) + V_{sh}[G_{sh}\sin(\delta_K - \delta_{sh}) - B_{sh}\cos(\delta_K - \delta_{sh})] \quad ....(13)$$

Where $1/Z_{sh} = G_{sh} + jB_{sh}$.

3.2 UPFC

The UPFC is a combination of a Static Compensator (STATCOM) and a Static Synchronous Series Compensator (SSSC) coupled via a common DC voltage link shown in Figure 2. The main advantage of the UPFC is to control voltage. The shunt voltage, shunt angle, and shunt impedance, series voltage, series angle and series impedance are made as control parameter for the power flow model. The X_{sh} and X_{se} are set to 0.1 p.u.

The real and reactive power modelling equations are given in (15 and 16).

$$\left.\begin{array}{l} 1<V_{sh}<1.1 \text{ p.u} \\ -0.0843<\delta_{sh}<0 \text{ rad} \\ 0.45<V_{se}<0.55 \text{p.u} \\ \delta_{se}=-1.576 \text{rad} \end{array}\right] \quad ....(14)$$

Let UPFC is added in line *K-M*. The Jacobian matrix after incorporating UPFC get transformed in respective places which are mathematically formulated using equations (17, 18, 19 and 20).

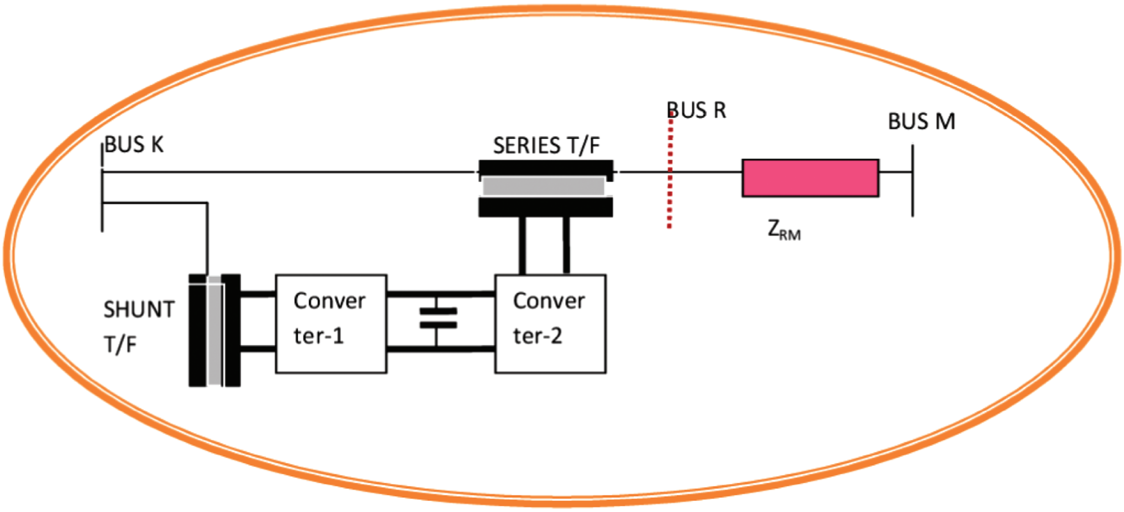

FIG. 2 SCHEMATIC REPRESENTATION OF UPFC

$$P_{KM}^{upfc} = V_K^2(G_{KK}+G_{sh}) + V_K V_M[G_{KM}\cos(\delta_{KM}) + B_{KM}\sin(\delta_{KM})] + V_K V_{se}[G_{KM}\cos(\delta_K-\delta_{se}) + B_{KM}\sin(\delta_M-\delta_{se})] + V_K V_{sh}[G_{KM}\cos(\delta_K-\delta_{sh}) + B_{sh}\sin(\delta_K-\delta_{sh})] \quad ....(15)$$

$$Q_{KM}^{upfc} = -V_K^2(B_{KK}+B_{sh}) + V_K V_M[G_{KM}\sin(\delta_{KM}) - B_{KM}\cos(\delta_{KM})] + V_K V_{se}[G_{KM}\cos(\delta_K-\delta_{se}) - B_{KM}\cos(\delta_K-\delta_{se})] + V_K V_{sh}[G_{KM}\sin(\delta_K-\delta_{sh}) + B_{sh}\cos(\delta_K-\delta_{sh})] \quad ....(16)$$

$$J_{1,upfc}(M,M) = J_1(M,M) + V_M V_{se}[-G_{KM}\sin(\delta_M-\delta_{se}) + B_{KM}\cos(\delta_M-\delta_{se})] \quad ....(17)$$

$$J_{2,upfc}(M,M) = J_2(M,M) + V_{se}[G_{KM}\cos(\delta_M-\delta_{se}) + B_{KM}\cos(\delta_M-\delta_{se})] \quad ....(18)$$

$$J_{3,upfc}(K,K) = J_3(K,K) + V_K V_{se}[G_{KM}\cos(\delta_K-\delta_{se}) + B_{KM}\sin(\delta_K-\delta_{se})] + V_K V_{sh}[G_{sh}\cos(\delta_K-\delta_{sh}) + B_{sh}\sin(\delta_K-\delta_{sh})] \quad ....(19)$$

$$J_{4,upfc}(K,K) = J_4(K,K) - 2V_K[G_{KM}\cos(\delta_K-\delta_{se}) + B_{KM}\sin(\delta_K-\delta_{se})] + V_M[G_{KM}\sin(\delta_M-\delta_{se}) - B_{KM}\cos(\delta_{KM})]V_{se}[G_{KM}\sin(\delta_M-\delta_{sh}) - B_{KM}\cos(\delta_K-\delta_{se})]V_{sh}[G_{sh}\sin(\delta_K-\delta_{sh}) + B_{sh}\cos(\delta_M-\delta_{sh})] \quad ....(20)$$

Where, $1/Z_{sh} = G_{sh} + jB_{sh}$ and

$1/Z_{se} = G_{se} + jB_{se}$.

4.0 ATC EVALUATION

4.1 ACPTDF Computation

Linear sensitivity factors offer a great potential for real time calculation of ATC. Use of these factors offers an approximate but extremely fast model for the ATC determination. It is given as,

$$ACPTDF_{km,ij} = \Delta P_{km} / P_{ij} \qquad ....(21)$$

Where, P_{ij} is transacted real power between seller and buyer buses for particular contracts made.

$$\Delta P_{km} = \left[\frac{\partial P_{km}}{\partial V_k}\right]\Delta V_K + \left[\frac{\partial P_{km}}{\partial V_m}\right]\Delta V_m + \left[\frac{\partial P_{km}}{\partial \delta_k}\right]\Delta\delta_K + \left[\frac{\partial P_{km}}{\partial \delta_m}\right]\Delta\delta_m \qquad ....(22)$$

Where,

ΔV_K and ΔV_m - voltage sensitivity

$\Delta \delta_K$ and $\Delta \delta_m$ - angle sensitivity.

4.2 ATC COMPUTATION

The power transfer in the line *k-m* due to transaction *i-j* is calculated using,

$$T^{FACTS}{}_{km,ij} = \begin{bmatrix} \dfrac{(P_{km}^{\max} - P_{km}^{0})}{PTDF_{km,ij}^{FACTS}}; PTDF^{FACTS}{}_{km,ij} > 0 \\ \inf; PTDF_{km.ij} = 0 \\ \dfrac{(P_{km}^{\max} - P_{km}^{0})}{PTDF_{km.ij}^{FACTS}}; PTDF^{FACTS}{}_{km,ij} < 0 \end{bmatrix} \qquad ....(23)$$

ATC for transaction *i-j* is found by,

$$ATC_{ij}^{FACTS} = min\left\{T_{km,ij}^{FACTS}\right\},\ km \in N_L \qquad ....(24)$$

5.0 OPTIMAL LOCATION OF FACTS DEVICES

For placement of FACTS, the lines can be identified where power flow sensitivity variations are of lower magnitude but with higher variations. Although the slope of curves may be higher at some other lines but PTDF values may be higher. These lines with higher PTDFs will not result in considerable increase in ATC. Hence lines with high slope and lower magnitude are considered good to place FACTS device, accordingly the FACTS devices such as STATCOM and UPFC are placed. The optimised placement of FACTS devices plays an important role in enhancement of ATC. The slope of the PTDF is an important deciding factor.

5.1 PSO

Particle swarm optimisation technique is an Evolutionary heuristic algorithm. It Particle Swarm Optimization (PSO) is population based optimization method first proposed by Kennedy and Eberhart [17] inspired by social behaviour bird flocking or fish schooling. The PSO was applied to different areas of electric systems [18]. It is population based search procedure in which individuals called particles change their position (state) with time. In a PSO system, particles fly around in a multidimensional search space. During flight, each particle adjusts its position according to its own experience (P_{best}), and according to the experience of a neighbouring particle (G_{best}), made use of the best position encountered by itself and its neighbour.

5.2 Standard PSO

The value of the inertia weight W and acceleration co-efficient C_1 and C_2 are made fixed for all the time intervals.

The following equations are utilized, in computing the position and velocities, in the X-Y plane:

$$\begin{aligned} V_i^{k+1} &= W \times V_i^k + \left[C_1 \times rand_1 \times (P_{best_i} - S_i^k)\right] \\ &+ \left[C_2 \times rand_2 \times (G_{best} - S_i^k)\right] \end{aligned} \qquad ....(25)$$

$$S_i^{k+1} = S_i^k + V_i^{k+1} \qquad ....(26)$$

The first part known as cognitive part of the (25) represents the earlier velocity, which provides the needed momentum for particles to rove across the search space. The second part known as social part (26), represents the previous personal thinking of each particle. The cognitive component encourages the particles to move towards their own best positions found so far.

The mechanism for PSO algorithm is shown in the Figure 3.

5.3 Modified PSO

The acceleration co-efficient C_1 and C_2 and inertia weight W are made time varying using the equations below,

$$W = W_{max} - \left[(W_{max} - W_{min}) * \left(\frac{\text{current iteration}}{\text{Max iteration}} \right) \right] \quad ....(27)$$

$$C_1 = C_{max} - \left[(C_{min} - C_{max}) * \left(\frac{\text{Current iteration}}{\text{Max iteration}} \right) \right] \quad ....(28)$$

$$C_2 = C_{min} - \left[(C_{max} - C_{min}) * \left(\frac{\text{Current iteration}}{\text{Max iteration}} \right) \right] \quad ....(29)$$

The number of iterations is the stopping criteria. C_{max} and C_{min}, W_{max} and W_{min} are the acceleration co-efficient and inertia weights corresponding minimum and maximum values. It usually rises for every iteration. The PSO is employed here to attain optimal settings of FACTS devices.

6.0 RESULTS AND DISCUSSIONS

6.1 Sample 6 BUS

The ACPTDF values are calculated using equation (21) for the assumed bilateral (BT) and multilateral (MT) transactions BT_1 (1-6), BT_2 (1-5), BT_3 (3-4), MT (2, 3-4, 5) in the sample 6 bus system [22] and they are given in Table 1.

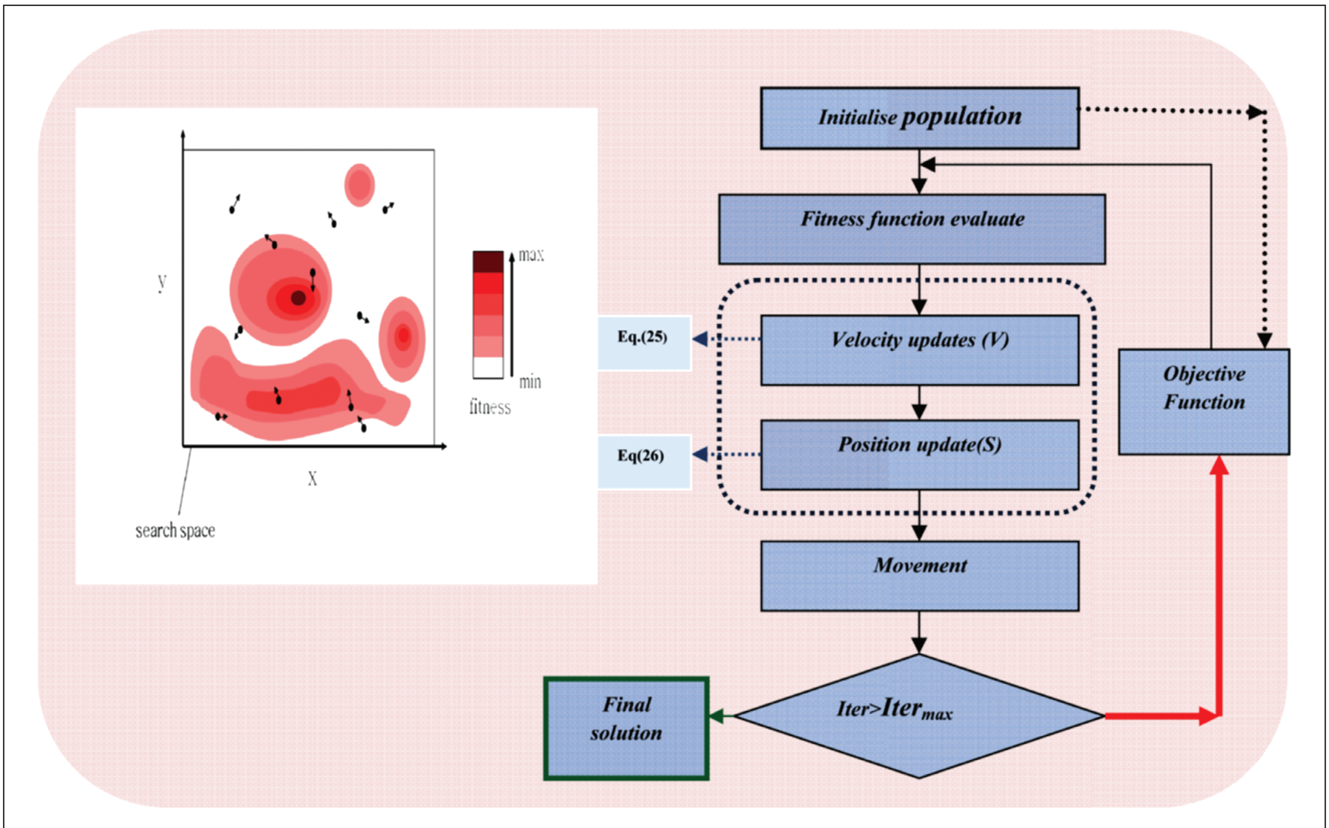

FIG. 3 MECHANISM OF PSO

The ATC value for base case is calculated using equation (24) and is provided in the Table 2. The FACTS devices are located using linear slope of sensitivity factors by analysing Figure 4. In this system, the slope is higher in the line no. 2 (1-4) but the value of PTDF is higher so it is preferable to have FACTS device in the line 10 (4-5) where the slope is higher but magnitude is lower. The line 11 (5-6) is also preferable to place FACTS device it is taken into consideration for circumstances employing multiple FACTS devices in same bus. So the STATCOM is placed in the bus 4 and

UPFC in the line 4-5. The change of ACPTDF values after incorporation of FACTS devices is recorded in Figure 5 comparing with base case values for BT_1 the transactions.

TABLE 1				
ACPTDF VALUES FOR TRANSACTIONS				
LINE	**BT_1**	**BT_2**	**BT_3**	**MT_1**
(1-2)	0.42681	-0.0888	0.3410	-0.2229
(1-4)	0.32425	0.2266	0.2968	0.1883
(1-5)	0.32386	-0.1239	0.4406	0.0842
(2-3)	0.2153	-0.3889	0.1189	-0.2079
(2-4)	-0.246	0.6216	-0.12406	0.8172
(2-5)	0.0161	-0.0552	0.19667	0.2478
(2-6)	0.4152	-0.2606	0.12823	-0.0662
(3-5)	-0.148	0.2451	0.13223	0.4439
(3-6)	0.3627	0.3675	-0.0137	0.3489
(4-5)	0.0977	-0.4792	0.1485	-0.377
(5-6)	0.2106	-0.1442	-0.3461	-0.557

Since, this is the measure of sensitivity of line MW to the power transfer. Typically PTDF are the factors relating the active power injections and branch flows.

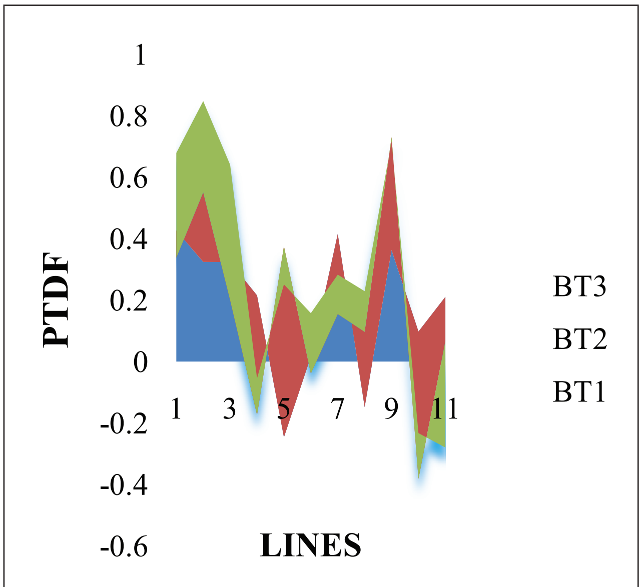

FIG. 4 PLACEMENTS OF FACTS

The standard PSO is employed to optimise the parameter settings of FACTS devices and the ATC value after incorporation of FACTS devices is given in Table 2. The ATC value rises about 2.5 MW for BT_1 and 3 MW for BT_2 which is 9% that of base case. The optimal settings of voltage and angle for STATCOM and UPFC achieved using standard PSO in accordance with equation (9) and (14) and they are given in Table 2. While employing UPFC for the same transaction the value rises up to 11% to that of base case. The performance of UPFC is superior in all the transactions considered compared to STATCOM for employing single FACTS devices. The convergence graph plotted between Iteration and ATC is obtained for BT_1 using STATCOM is shown in Figure 6.

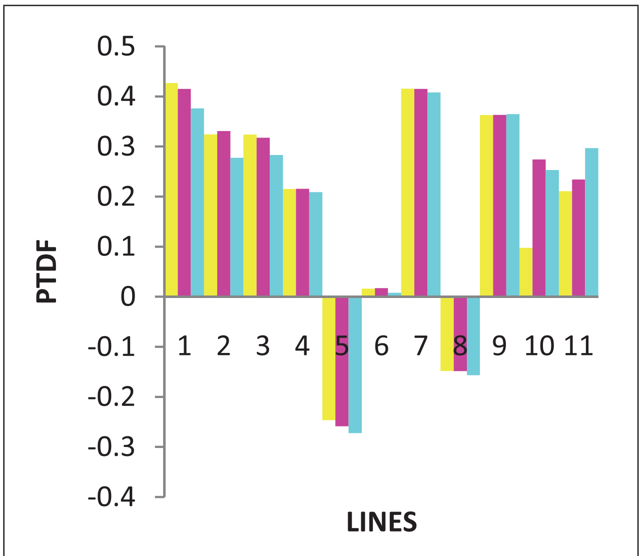

FIG. 5 COMPARISON OF PTDF VALUES WITH BASE CASE AND AFTER FACTS INCORPORATION

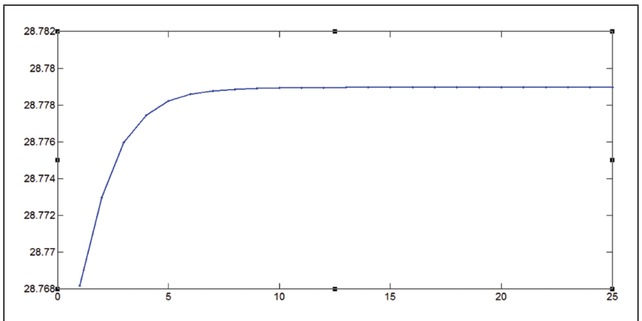

FIG. 6 CONVERGENCE GRAPH FOR BT1 USING STATCOM

While employing multiple FACTS devices, the enhancement of ATC is elevated to notable amount of power compared to enhancement using single devices. The settings of multiple FACTS devices are also optimised using standard PSO employing the limits accordingly using equation

(9 and 14) and are recorded accordingly in Table 3. The Figure 7 and 8 shows the difference in ATC enhancement for single and multiple FACTS devices STATCOM and UPFC. For MT the performance of multiple UPFC [21] is far better i.e., the ATC value rises up to 3 MW compared to single UPFC which is 5% boosted compared to base case. The performance of multiple UPFC is better compared to multiple STATCOM enhancements in all the transactions.

TABLE 2

ENHANCED ATC VALUES WITH SINGLE FACTS DEVICE

Transaction	ATC-Base case (MW)	STATCOM			UPFC		
		ATC (MW)	Ratings		ATC (MW)	Ratings	
			V_{sh} (p.u)	$delta_{sh}$ (rad)		V_{sh} (p.u)	$delta_{sh}$ (rad)
BT_1	26.5	28.78	1.0142	-0.002062	28.995	1.0068	-0.05333
BT_2	33.164	36.029	1.0327	-0.001832	37.012	1.0466	-0.004192
BT_3	43.289	44.774	1.0339	-0.001599	46.508	1.0113	-0.045905
MT	32.927	33.961	1.0128	-0.005072	34.622	1.0346	-0.00312

TABLE 3

ENHANCED ATC VALUES USING MULTIPLE FACTS

Transaction	Base Case ATC (MW)	STATCOM				UPFC			
		ATC (MW)	Placement - Bus	V_{sh} (p.u.)	$delta_{sh}$ (rad)	ATC (MW)	Placement - Lines	V_{sh} (p.u.)	$delta_{sh}$ (rad)
BT_1	26.5	29.688	4	1.0142	-0.00206	32.732	4-5	1.0068	-0.05333
			5	0.99829	-0.02613		5-6	1.0466	-0.0126
BT_2	33.164	37.174	4	1.0327	-0.00183	45.599	4-5	1.0466	-0.00419
			5	1.0238	-0.00354		5-6	1.0262	-0.00775
BT_3	43.289	44.112	4	1.0339	-0.00159	44.097	4-5	1.0113	-0.0459
			5	1.0411	-0.00048		5-6	1.0144	-0.0119
MT	32.97	37.442	4	1.0128	-0.00507	37.452	4-5	1.0346	-0.00312
			5	1.008	-0.00119		5-6	1.0256	0.0009

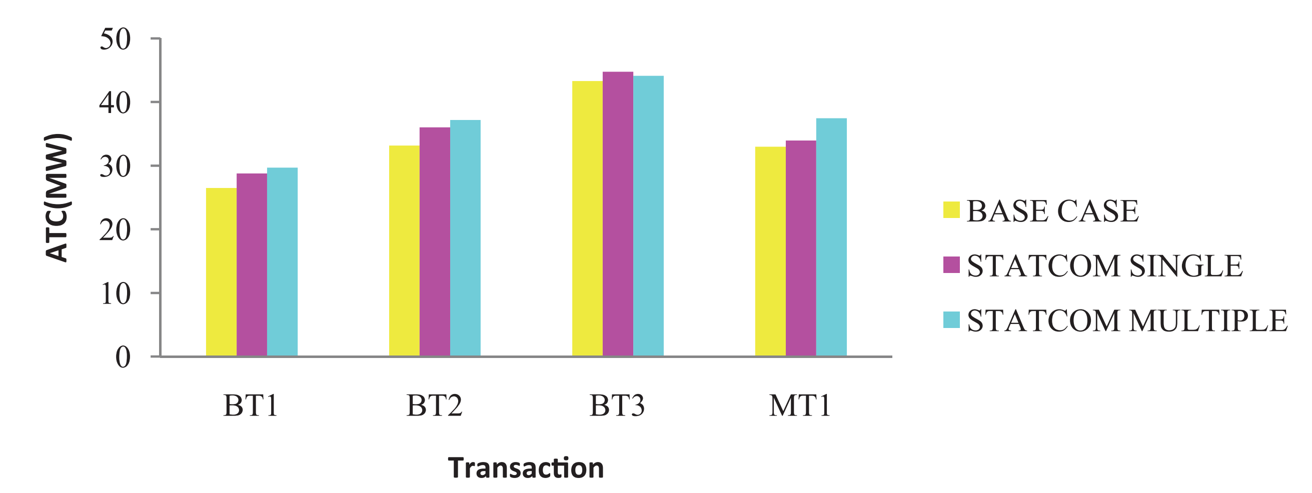

FIG. 7 PERFORMANCE COMPARISON OF SINGLE AND MULTIPLE STATCOM

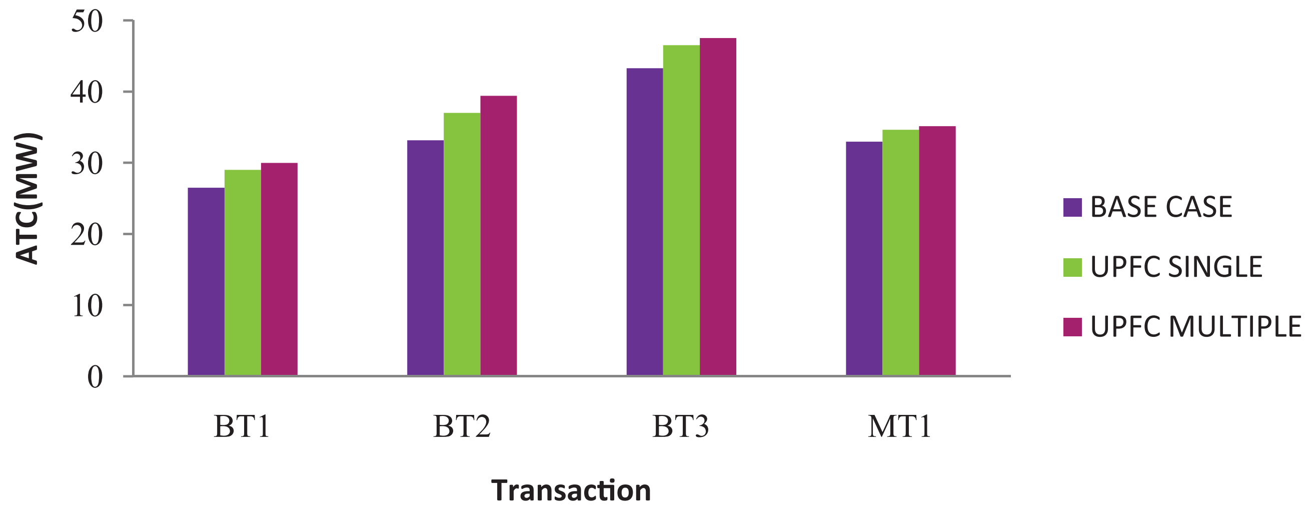

FIG. 8 PERFORMANCE COMPARISON OF SINGLE AND MULTIPLE UPFC

6.2 IEEE 30 BUS

The ATC enhancement for the considered three bilateral transactions BT_1 (1-12), BT_2 (5-23), BT_3 (2-12), and a multilateral transaction MT (2, 11 - 28, 26) by incorporating STATCOM and UPFC is given in the Table 4. The modified PSO algorithm is employed for optimising the parameters settings of FACTS devices [23-26].

In this system, the slope of sensitivity is higher with lower magnitude of PTDF in the line 27(15-18), 33(22-24), etc., line 27(15-18) is chosen for this work. So the STATCOM is placed in the bus 18 and UPFC is placed in between the bus 15-18. This conclusion is made based on the Figure 9.

The enhancement of ATC for BT_1 using STATCOM is 3.45 MW and for UPFC is 5.14 MW. The greatest enhancement is achieved for BT_3 where the improvement is 9 to 12% to that of base case. The value rises up to 21.2% to that of base case while utilizing UPFC for the same power contracts considered. It is recorded in Table 4 with the optimised settings of its voltage and angle. The graph illustrating the improvement of ATC is shown in Figure 10.

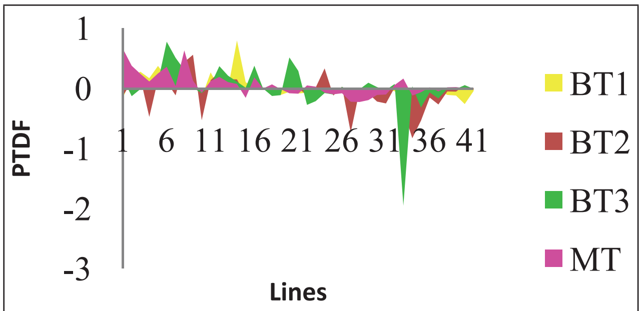

FIG. 9 LINEAR SLOPE SENSITIVITY FACTOR

TABLE 4

ENHANCED ATC VALUES AND CORRESPONDING FACTS RATING OPTIMISED USING MODIFIED PSO

Transaction	ATC-Base case (MW)	STATCOM			UPFC		
		ATC (MW)	Ratings		ATC (MW)	Ratings	
			V_{sh} (p.u)	$delta_{sh}$ (rad)		V_{sh} (p.u)	$delta_{sh}$ (rad)
BT_1	60.855	64.303	1.093	-0.007608	65.996	1.0068	-0.05333
BT_2	23.901	24.019	1.0327	-0.005324	25.285	1.0466	-0.004192
BT_3	58.83	61.083	1.0936	-0.007608	71.765	1.0932	-0.00765
MT	11.367	11.509	1.0128	-0.008789	11.62	1.0346	-0.00312

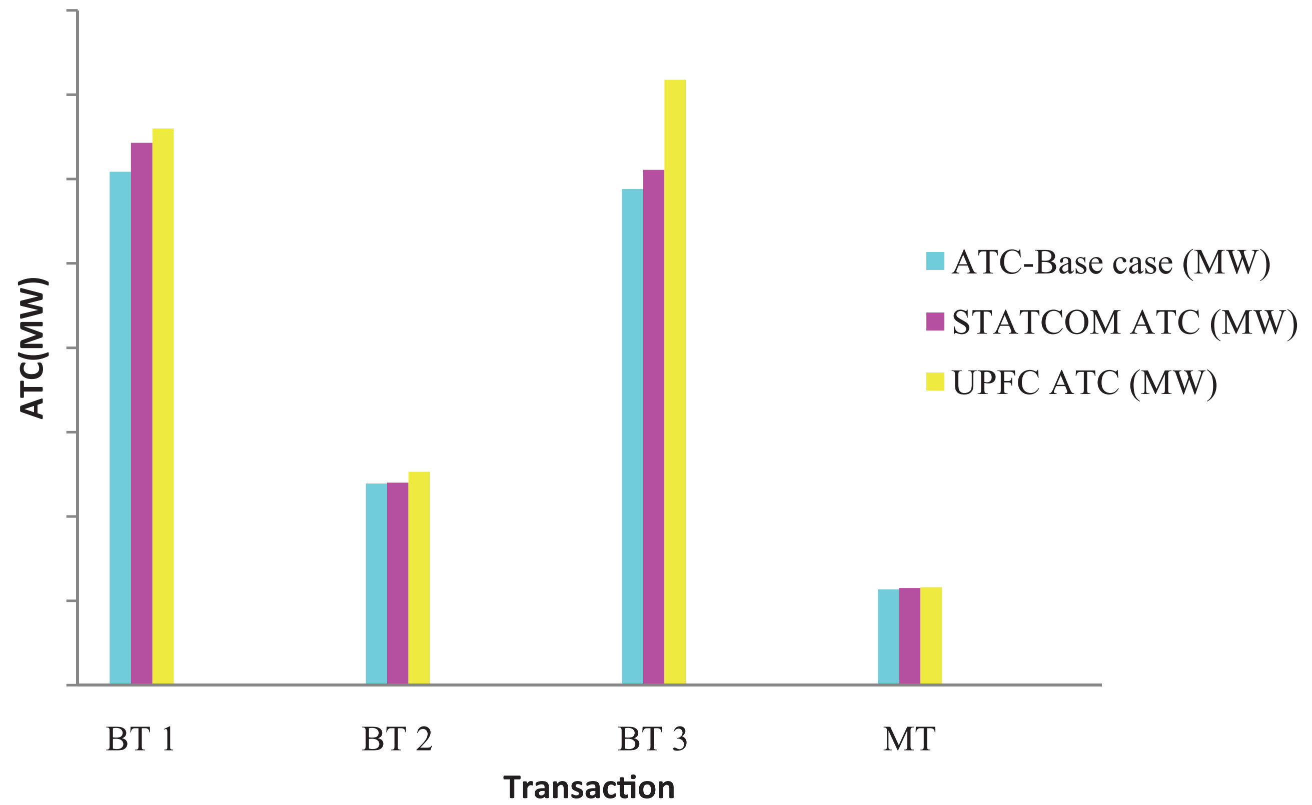

FIG. 10 COMPARISON OF PERFORMANCE OF FACTS DEVICES-PARAMETER OPTIMISED USING MODIFIED PSO

7.0 CONCLUSION

ATC a vital issue in the field of deregulation is unravelled by calculating it using linear sensitivity factor AC-PTDF method and it is enhanced using FACTS devices like STATCOM, UPFC whose optimal settings of the FACTS parameters like shunt voltage and its angle are attained using standard PSO with and without multiple FACTS devices for sample 6 bus and modified PSO for 30 bus system. Thus open access of transmission system is made feasible and disassembly of existing structure for attaining better efficiency and private sector partaking in finance is encouraged. Thus, an important objective of deregulation task is accomplished by considering any combinations of bilateral and multilateral transactions. The proposed methodology is tested in a sample 6 bus system and IEEE 30 bus system. The results are fairly convincing.

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