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OPTIMAL PLACEMENT AND CO-ORDINATION OF UPFC WITH DG USING CUTTLE FISH ALGORITHM (CFA)

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***Abstract*— In modern power systems, there has been sizeable growth on integration of various renewable sources and multi sorts of flexible ac transmission system (FACTS). Here for the term renewable, the Distributed Generation (DG) is used. The power produced from DG ought to be regulated by up its voltage and minimize the ability losses within the system. For this purpose, the FACTS devices like UPFC is put in within the installation during this work, the matter thought-about is that the best placement and coordination of Unified Power Flow Controller (UPFC) and Distributed Generation (DG) using Cuttlefish Algorithm (CFA). The most downside thought of during this work are reduction of fuel price and power loss reduction. The quality IEEE thirty bus system is employed to ascertain the quality of the planned system. Additional the results are compared with PSO. Comparison shows that the CFA algorithmic rule had superior options than PSO.**

Keywords— Distributed generation (DG), Unified Power Flow Controller (UPFC), Cuttlefish Algorithm (CFA), Flexible AC Transmission System (FACTS).

I. INTRODUCTION

In restructured power market, electrical utilities area unit subjected to varied new technologies to ensure the quality of supply to the consumers and also to achieve the larger economical benefits. Increasing electricity demand necessitates the correct utilization of the transmission lines. Because of hyperbolic electricity demand it's essential to extend the usable power distribution capability distribution generation technology (DG) and Flexible AC Transmission system are developed.

Distributed generation plays vital role in improvement of system potency by providing needed power. DGs area unit made from varied sources like star, wind, fuel cells, small turbines so on. The ability made by these ways that ought to be regulated by raising its voltage and minimizes the ability losses within the system. For this purpose, the FACTS devices like UPFC are put in within the installation. Optimum placement and size of DGs ends up in minimizing operational prices, improved voltage regulation, power loss reduction and power issue correction.

In power grid, the installation of DG unit with FACTS needs some necessary considerations:

(1) which type of weight unit and FACTS devices to be put in,
(2) Location to be placed,
(3) a way to estimate the appropriate size and variety of the devices economically,
(4) a way to coordinate the multiple devices and network.

Depends on real and reactive power delivering capability, the DGs are generally classified into four sorts. They are:
(i) DGs capable of generating solely real power. Some samples of this sort are PV, small turbines, fuel cells etc.
(ii) DGs capable of generating each real and reactive power.
(iii)DGs capable of generating solely reactive power.
(iv)DGs capable of generating active power however over whelming reactive power.

FACTS devices play a serious role in transmission. FACTS devices provide the way for optimum utilization of existing transmission facilities. There are 2 styles of FACTS devices, one is thyristor based mostly} devices and also the alternative is voltage supply electrical converter based devices. Examples for Thyristor primarily based devices are Static power unit Compensator and thyristor controlled series electrical condenser. Examples for Voltage supply electrical converter primarily based devices are the Static Synchronous Compensator, Static Synchronous Series Compensator and Unified Power Flow Controller.

The present day analysis is directed to know the performance of VSI primarily based FACTS devices as a result of its harmonic performance, dynamic response and easy operation. The importance of VSI primarily based controllers are it uses dc-ac inverters to exchange shunt or series reactive power with the transmission rather than separate electrical condenser or reactor banks. FACTS devices play a serious role in transmission. FACTS devices provide the way for optimum utilization of existing transmission facilities. There are 2 styles of FACTS devices, one is thyristor based mostly devices and also the alternative is voltage supply electrical converter based devices. Examples for Thyristor primarily based devices are Static power unit Compensator and thyristor controlled series electrical condenser. Examples for Voltage supply electrical converter primarily based devices are the Static Synchronous Compensator, Static Synchronous Series Compensator and Unified Power Flow Controller.

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The UPFC consists of 2 VSCs coupled employing a common dc link. One is connected in shunt and also the alternative is connected serial with the cable employing a coupling electrical device.

The dc voltage for each converter is provided by a typical electrical condenser bank. The UPFC configuration has each STATCOM and SSSC that shares a typical dc link electrical condenser. Depends on management strategies, the UPFC will operated as an influence flow controller, a transformer or a phase shifter.

To determine the optimum weight unit size, CFA is employed. CFA relies on distinctive looking behavior of whales. The optimum siting is finished for loss reduction in distribution system. The potency of CFA is additionally tested [1]. To boost the voltage profile in distribution network and conjointly to reduce the facility loss victimization optimum placement of weight unit with SVC supported voltage stability index [2].

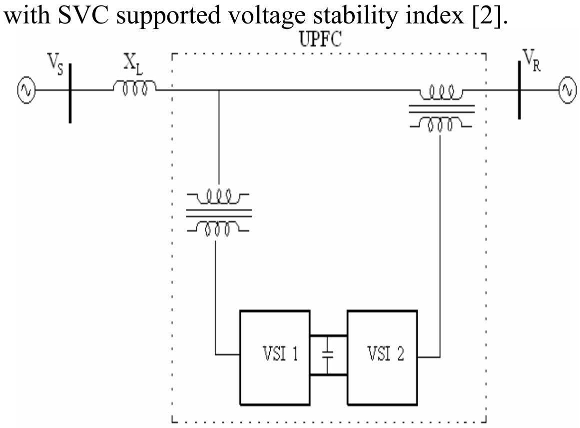

Figure 1: Schematic diagram of UPFC

The optimum allocation of UPFC was exhausted conductor victimization the hybrid reaction optimization algorithmic program [3]. The best placement of UPFC across a conductor was done to beat the soundness issues within the facility by considering technical and economical views is explained [5]. The congestion is eased and the value is reduced by acceptable allocation of UPFC device [10].

To determine the UPFC location supported voltage quality, active and reactive power losses and therefore the value of installation. The best location of UPFC is set victimization hybrid CSA-CRO algorithmic program [7].

For congestion relief in conductor, DGs area unit optimally siting and size. This will be done by developing a brand new algorithmic program [8]. To work out the generation capability and optimum placement of decigram, a brand new management theme has been projected. Conjointly coefficient factors area unit calculated for locating optimum decigram placement [9].

In this work, the optimal placement and co-ordination of DG with UPFC is done using Cuttlefish Algorithm. Using MATLAB software, CFA technique is tested in IEEE 30 bus system.

II. POWER FLOW PROBLEM FORMULATION

$$F = w_1 * F_G + w_2 * P_L \quad (1)$$

Where w_1,w_2 and w_3 are the weighting functions or penalty functions

$$Minimize \quad F_G = \sum_{i=1}^{N_G} (a_i P_{g_i}^2 + b_i P_{g_i} + c_i) \quad (2)$$

$$Minimize \quad P_L = F(P_{Loss}) \quad (3)$$

$$where \quad P_{Loss} = \sum_{L=1}^{NL} (P_{ij} + P_{ji}) \quad (4)$$

Where P_{ij} and P_{ji} are the real power flows from bus *i* to j and from bus j to i respectively.

Constraints

Power system constraints may be categorized into equality constraints and inequality constraints.

1. Equality constraints

The equality constraints reveal the physical behavior of the system. These constraints are:

Active power constraints

$$P_{Gi} - P_{Di} - V_i \sum_{j=i}^{NB} V_j [G_{ij} \cos(\delta_{ij}) + B_{ij} \sin(\delta_{ij})] = 0 \quad (5)$$

Reactive power constraints

$$Q_{Gi} - Q_{Di} - V_i \sum_{j=i}^{NB} V_j [G_{ij} \cos(\delta_{ij}) + B_{ij} \sin(\delta_{ij})] = 0 \quad (6)$$

$$where \quad \delta_{ij} = \delta_i - \delta_j$$

Where, NB= No. of buses, P_G = the output of active power, Q_G = the output of reactive power, P_D = real power load demand, Q_D = reactive power load demand.

2. Inequality constraints

The inequality constraints show the bounds on electrical devices existing in the power system plus the bounds formed to surety system safety.

a) Generator constraints

For every generator together with the reference bus: voltage, real and reactive generations should be constrained by the minimum and maximum bounds as follows:

$$V_{Gi}^{lower} \le V_{Gi} \le V_{Gi}^{upper}, i = 1 \quad (7)$$

$$P_{Gi}^{lower} \le P_{Gi} \le P_{Gi}^{upper}, i = 1 \quad (8)$$

$$Q_{Gi}^{lower} \le Q_{Gi} \le Q_{Gi}^{upper}, i = 1 \quad (9)$$

b) Transformer constraints

Transformer tap positions should be constrained inside their stated minimum and maximum bounds as follows:

$$T_{Gi}^{lower} \leq T_{Gi} \leq T_{Gi}^{upper}, i = 1, \ldots, NTr \quad (10)$$

c) Shunt VAR compensator constraints

Shunt reactive compensation devices need to be constrained by their minimum and maximum bounds as given below:

$$Q_{Ci}^{lower} \leq Q_{Ci} \leq Q_{Ci}^{upper}, i = 1 \quad (11)$$

III. CUTTLEFISH ALGORITHM

Chromatophores cells contain red, orange, yellow, black, and brown pigments. Besides, a group of mirror-like cells "iridophores and leucophores" enable decapod skin to own all the made and varied colors of its atmosphere. The look of the decapod so depends on that skin components have an effect on the light incident on the skin. Light could be mirrored by either chromatophores or by reflective cells "iridophores" or "leucophores" or a mixture of each and it's the physiological quality of the chromatophores and reflective cells that alter the decapod to provide such a wide view of optical effects.

Fig. 2denotes decapod skin particularization the 3 main skin structures (chromatophores, iridophores and leucophores) with 2example states (a, b) and 3 distinct ray traces (1,2,3) that show the modification reflective color.

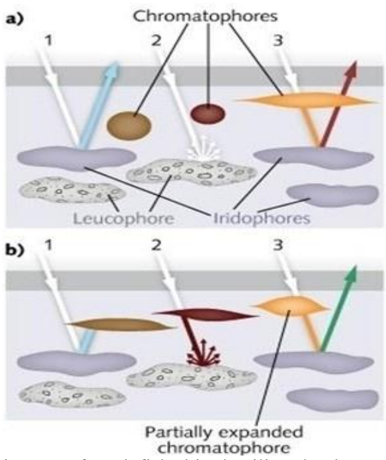

Fig. 2 Diagram of cuttlefish skin detailing the three main skin structures and three distinct ray traces

The proposed algorithm mimics the work of these three cell layers by reordering the six cases shown in Fig. 2 to be as shown in Fig. 3.

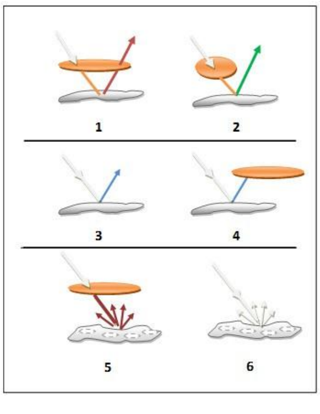

Fig. 3 Reorder of the six cases shown in Fig. 2

The algorithm considers two main processes: reflection and visibility. Reflection process simulates the light reflection mechanism, while visibility simulates the visibility of matching patterns of the cuttlefish. These two processes are used as a search strategy to find the global optimal solution. The formulation of finding the new solution (newP) by using reflection and visibility is described in (12).

$$New\ p = reflection + visibility \quad (12)$$

In order to simulate the stretch and shrink processes in chromatophores cells cases one and a couple of in Fig. 2, we have a tendency to outlined (13). This Equation is employed to provide AN interval that the chromatophores cells will use it to stretch and shrink their saccule. Whereas the visibility of the matching background that employed by decapod is developed in (14). This represents the regardful between best answer and current solutions.

$$Reflection_j = R * G_1[i].Points[j] \quad (13)$$

$$Visibility_j = V * (Best.Points[j] - G_1[i].Points[j]) \quad (14)$$

Where, G_1 is a group of cells. i, is the ith cell in G_1. Points[j] represent the jth point of ith cell. Best.Points represents the best solution points. R is a parameter that used to find the stretch or shrink interval of the saccule when the muscles of the cell is in contract or relax. V represents the visibility degree of the pattern. R and V are found as follows:

$$R = random() * (r_1 - r_2) + r_2 \quad (15)$$

$$V = random() * (v_1 - v_2) + v_2 \quad (16)$$

Where, random() function is used to generate a random numbers between (0, 1). r_1, r_2, v_1, v_2 are four constant values specified by user such as (r_1=1, r_2=-1) and (v_1=0.5, v_2=-0.5).

These cases work as a global search uses the value of the current point to found new area around it. While the deference between the best point and the current point is used to gravitate produced point to the best solution.

In case (3 and 4), iridophores cells are light reflective cells and that they are helping in organs concealment. That's means that the mirrored color from iridophores cells round the organs is terribly the same as the color of organs. Therefore the deference between the organs colors and therefore the around cells color presents the visibility. Now the visibility can be used to calculate and simulate the interval of the stretch and the shrink processes. The simulation relies on the parameter V and therefore the deference between the organs colors (Best points) and therefore the current colors (current points).Therefore the formulation of finding the visibility is remaining because it is just in case (1 and 2).

As a mirrored image, iridophores cells can replicate incoming lightweight to cancel the organs. Since organs drawn by the best resolution, we tend to assumed that the incoming color and therefore the mirrored color are identical, and that they are drawn by the simplest resolution. Therefore the formulation of finding the reflection is rewritten as in (17), and R is about to one.

$$reflection_j = R * Best.Point[j] \quad (17)$$

Case (3 and 4) is used as a local search uses the difference between the best solution and the current solution to produce an interval around the best solution as a new search area.

In case 5, Leucophores cells are work as a mirror. In this way, the cells will reflect the predominant wavelength of light in the environment. In white light they will reflect the white, in brown light they will reflect brown and etc., In this case the light is coming through chromatophores cells with specific color. The reflected light is very similar to the light that is coming from the chromatophores cells. In order to cover the similarity between the incoming color and the reflected color, we assumed that the incoming color is the best solution (*Best*), and the reflected color could be any value around the Best. The interval that is used around the *Best* is produced by the visibility using the parameter *V* and the deference between the *Best* and the average value of the *Best*. The modification of finding the visibility is rewritten as follows:

$$Visibility_j = V * (Best.Points[j] - AV_{Best}) \quad (18)$$

Best. Thus the formulation of finding the reflection is remaining as it as in (17).

The algorithm uses case 5 as a local search, but this time the difference between the best solution points and the average value of Best points is used to produce a small area around the best solution as a new search area.

Finally, incase 6 the leucophores cells will just reflect the incoming light from the environment. This operator allows the cuttlefish to blend itself into its environment. As a simulation, one can assume that any incoming color from the environment will be reflected as it and can be represented by any random solution.

IV. IEEE 30 BUS SYSTEM

With the aim of explaining the utilization of the instructed CFA technique, it's analyzed for the quality IEEE 30-bus system. The quality IEEE 30-Bus system has six PV buses, 24 PQ busses and xli interconnected branches. The load consists of solely static load.

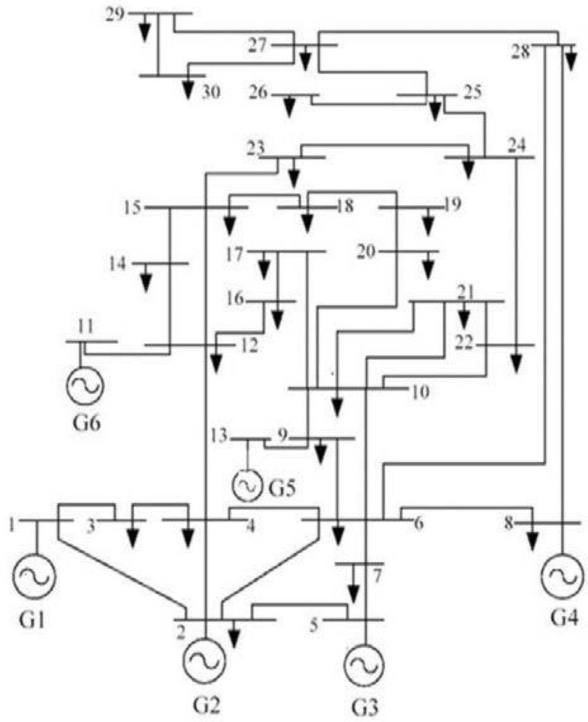

Figure 3: Single line diagram of IEEE 30 bus system

V. RESULTS AND DISCUSSIONS

CFA technique is enforced to resolve the UPFC-DG placement and co-ordination downside. The package program accustomed to check the IEEE thirty bus system is MATLAB 2014a.

The best values of power losses for various strategies area unit shown in Table 1. From the table it's discovered that with DG-UPFC placement the facility loss is reduced.

TABLE 1: OPTIMAL VALUES OF POWER LOSSES FOR DIFFERENT METHODS

CASES	POWER LOSS(MW)
normal loss(NR)	10.8856
Load time loss	12.6167
With DG-UPFC placement	10.3616
Without DG-UPFC placement	12.9345
Without UPFC/ DG placement	12.9345

The fuel cost for different methods are shown in table 2. The fuel cost obtained for the case with DG-UPFC placement is compared with without DG/ upfc placement and without upfc/DG placement. From the comparison it is observed that the optimal fuel cost is obtained with DG-UPFC placement.

TABLE 2: OPTIMAL VALUE OF FUEL COST FOR DIFFERENT METHODS

CASES	FUEL COST(RS/HR)
Without DG/ upfc placement	837.5197
With DG-upfc placement	832.0689
Without upfc/DG placement	832.6545

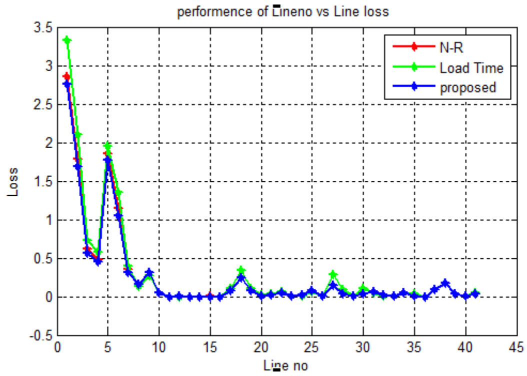

Figure 4: Line losses for different cases

The figure 4 shows the line losses for different cases. The figure 6 shows the voltage profile for normal load flow, load time and with DG-UPFC placement. The minimum bus voltage is 0.95 p.u. and maximum bus voltage is 1.05 p.u.

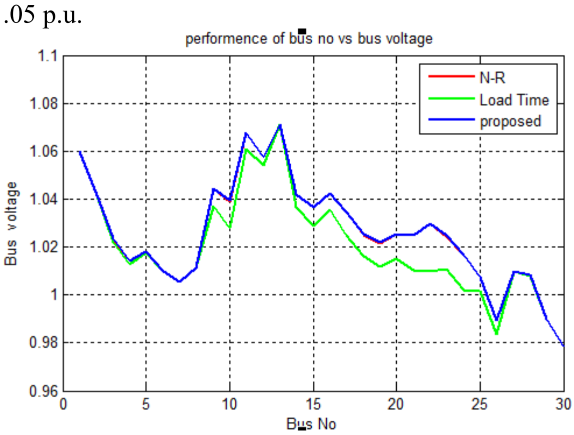

Figure 5: Voltage profile for different cases

The optimal UPFC location is shown in table 3. From the table it is observed that optimal location is from bus 8 to bus 28 .

TABLE 3: UPFC LOCATION

FROM BUS NO.	**TO BUS NO**
8	28

The optimal generation of 30 bus system is shown in table 4. The table shows the optimal generation with DG placement and with DG-UPFC placement.

TABLE 4: OPTIMAL GENERATION 30 BUS SYSTEM

DG BUS NO.	DG LIMIT MIN (MW)	DG LIMIT MAX (MW)	DG PLACE MENT (MW)	DG-UPFC PLACEME NT (MW)
1	50.00	200.0	194.0000	182.000
2	20.00	80.00	37.0000	40.0000
5	15.00	50.00	21.0000	30.0000
8	10.00	35.00	14.0000	19.0000
11	10.00	30.00	16.0000	10.0000
13	12.00	40.00	15.0000	16.0000

The performance comparison of DG is shown in figure 5. The performance of DG for three cases shown in figure 6 is with DG placement, with DG-UPFC placement and with UPFC placement respectively.

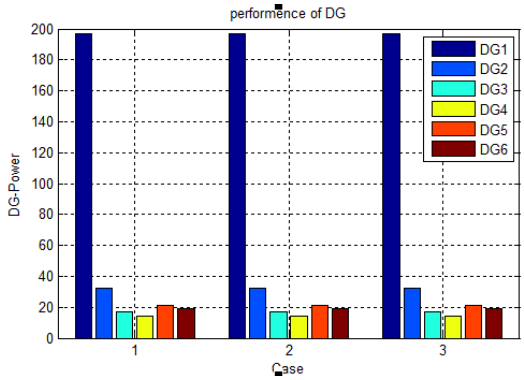

Figure 6: Comparison of DGs performance with different cases

COMPARISON OF CFA WITH PSO

The figure 8, shows the fuel cost comparison between PSO and CFA. From the table 5, it is observed that fuel cost is reduced with DG-UPFC placement using CFA than optimal placement using PSO.

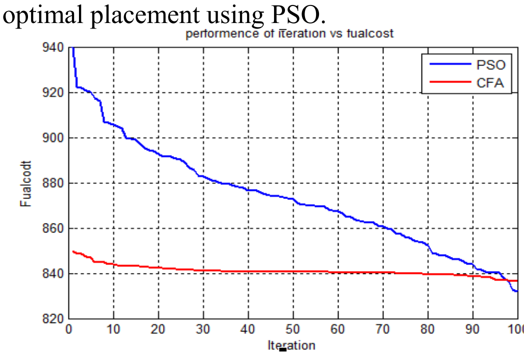

Figure 7: Fuel cost comparison between PSO and CFA

TABLE 5: FUEL COST COMPARISON BETWEEN PSO AND CFA

CASES	CFA	PSO
Without DG/ upfc placement	837.5197	861.0858
With DG-upfc placement	832.0689	855.6522
Without upfc/DG placement	832.6545	858.0657

The figure 8 shows the performance comparison of DG using PSO and CFA. The optimal generation of various DGs are shown in figure 9 .

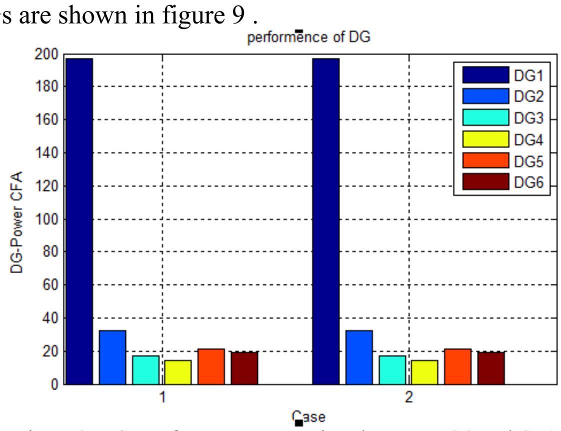

Figure 8: DGs performance comparison between PSO and CFA

TABLE 5: OPTIMAL GENERATION COMPARISON BETWEEN CFA AND PSO

DG BUS NO.	**CFA**	**PSO**
1	182.000	177.000
2	40.0000	40.0000
5	30.0000	21.0000
8	19.0000	18.0000
11	10.0000	10.0000

13	16.0000	35.0000

From the figures and tables shown above, it is proved that CFA is more efficient than PSO.

VI. CONCLUSION

The optimal placement and co-ordination of UPFC with DG is done using Cuttlefish Algorithm (CFA). The results obtained with DG-UPFC placement is compared with other cases such as without DG-UPFC placement and with DG/UPFC placement. From the above result discussions it is observed that the fuel cost and the power loss is minimized with optimal placement of DG-UPFC. CFA technique is used to resolve the problem of DG-UPFC optimal placement and co-ordination. Also the optimal generation and fuel cost of CFA is compared with PSO. From the results it is observed that the efficiency of CFA is better than PSO.

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Authors biography

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