Optimal Location of Multi-Types of Facts Devices Using Particle Swarm Optimization

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Abstract: In this paper the problem of improving the voltage profile and reducing power loss in electrical networks is a task that must be solved in an optimal manner. Therefore, placement of FACTS devices in suitable location can lead to control in-line flow and maintain bus voltages in desired level and reducing losses is required. This paper presents one of the heuristic methods i.e. a Genetic Algorithm to seek the optimal location of FACTS devices in a power system. Proposed algorithm is tested on IEEE 30 bus power system for optimal location of multi-type FACTS devices and results are presented.

I. INTRODUCTION

In the present day scenario private power makers are increasing rapidly to take care of the expansion demand of power. In this procedure, the current transmission lines are over-loaded may also be due to transfer of cheap power from generator bus to load bus. New transmission lines or FACTS devices on the current transmission system can dispose of transmission over-loading, however FACTS devices are favored in the present day power systems in view of it's by and large execution. The advantages achieved FACTS incorporate change of system element conducts furthermore, improvement of system unwavering quality. Certainties devices give vital advantages to enhanced transmission system administration through: better usage of existing transmission resources; expanded transmission system dependability and availability; expanded element also, transient matrix dependability and empowering natural benefits. However their primary capacity is to control the power by controlling the parameters, for example, transmission line impedances, terminal voltages and voltage edges. Power stream is electronically controlled also, it streams as requested by control focus and subsequently the expense and losses will be enhanced. It has been watched that establishment of FACTS devices expands the system's controllability yet the current ordinary OPF calculations must be adjusted such that power system investigation is feasible for present day power industry with FACTS devices. For last two decades scientists create calculations to illuminate OPF fusing FACTS devices. Still research is in advancement to meet the present blockage administration issue with help of FACTS devices proficiently. Have proposed deterioration technique to take care of OPF dispatch issue joining FACTS devices. This strategy manages the representation of arrangement compensators and stage shifters yet this technique did not consider the predefined line stream imperatives. Straight Programming (LP) based security obliged. OPF strategy has been effectively used to decide the FACTS parameters to control the power stream in the particular lines .have fathomed OPF issue consolidating FACTS devices utilizing Newton's strategy, prompting exceedingly strong iterative arrangements. Chung have exhibited GA to decide the parameters of FACTS devices.Ongsakul and, Bhasaputra have proposed cross breed Tabu Seek and Simulated Annealing (TS/SA) system to take care of OPF issues with FACTS devices. For Ideal area of various sorts of FACTS devices in the power system has been endeavored utilizing distinctive methods, for example, GA, half and half tabu methodology and Mimicked Annealing (SA). The best area for a set of stage shifters was found by GA to reduce the flow in vigorously stacked lines bringing about an expanded load ability of the system and diminished expense of creation. The best ideal area of FACTS devices with a specific end goal to decrease the creation cost along with the device's cost utilizing genuine power stream execution list was accounted for. In this paper, an way to deal with locate the ideal area of thyristor controlled arrangement compensator (TCSC), static var compensator (SVC) and brought together power stream controller (UPFC) in the power system to enhance the load ability of the lines and minimize the total loss utilizing GA is displayed. Examination of the proposed methodology is completed on IEEE 30-bus system. The Genetic Algorithm tool (ga-tool) of MATLAB is implied to solve the problem.

II. FACTS DEVICES MODEL

A. FACTS Devices

In this paper, three distinct FACTS devices have been chosen to put in appropriate area to make strides security edges in power system. These are: TCSC (Thyristor Controlled Series Compensators), SVC (Static VAR Compensator) and UPFC (Unified Power Stream Controller). These are appeared in Fig. 1.Power course through the transmission line i-j to be specific Pij is relied on upon line reactance Xij, bus voltage extents Vi, Vj, and stage point amongst sending and getting buss δi-δj. This is communicated by Eq.1.

$$Pij = \frac{Vi * Vj \sin(\delta\iota - \delta j)}{Xij} \qquad \text{(Eq.1)}$$

TCSC can change line reactance and SVC can be used to control receptive power in system. UPFC is the most adaptable individual from FACTS devices family and can be connected with a specific end goal to control all power stream parameters. Power stream can be controlled and streamlined by changing power system parameter utilizing Certainties devices. Thus, ideal decision and distribution of Certainties devices can bring about reasonable usage in power system.

An adaptable substituting current transmission system (FACTS) is a system made out of static hardware utilized for the AC transmission of electrical vitality. It is intended to upgrade controllability and increment power exchange capacity of the system. It is by and large a power hardware based system.

A FACT is characterized by the IEEE as "a power electronic based system and other static gear that give control of one or more AC transmission system parameters to upgrade controllability and increment power exchange capacity."

As indicated by Siemens "Certainties Increase the unwavering quality of AC lattices and lessen power conveyance costs. They enhance transmission quality and productivity of power transmission by supplying inductive or responsive energy to the network.

B. Mathematical Model of FACTS Devices

In this paper enduring state model of FACTS devices are created for power stream concentrates on. So TCSC is demonstrated basically to simply change the reactance of transmission line. SVC and UPFC are demonstrated utilizing the power infusion models. Models incorporated into transmission line for TCSC and UPFC and SVC is displayed and joined into the bus as shunt component of transmission line. Scientific models for Actualities devices are executed by MATLAB programming dialect.

TCSC: TCSC goes about as the capacitive or inductive compensator by altering reactance of transmission line. This progressions line stream because of progress in arrangement reactance. In this paper TCSC is displayed by evolving transmission line reactance as below:

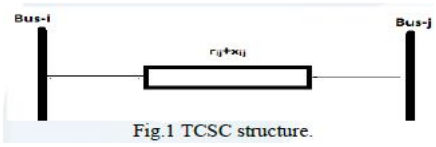


Fig.1 TCSC structure.

$$X_{ij} = X_{line} + X_{t\,csc} \qquad \text{(Eq.2)}$$

$$X_{t\,csc} = r_{t\,csc} * X_{line} \qquad \text{(Eq.3)}$$

Where $Xline$= reactance of transmission line,

$rTCSC$=compensation factor of TCSC.

TCSC reactance is chosen between -0.7$Xline$ to 0.2 $Xline$.

SVC:- SVC can be used for both inductive and capacitive compensation.

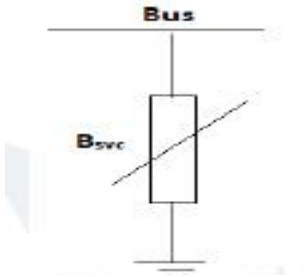


Fig.2 SVC structure

In this paper SVC is modeled as an ideal reactive power injection at bus i:

$$\Delta Q_i = Q_{svc} \qquad \text{(Eq.4)}$$

Static var systems are connected by utilities in transmission applications for a few purposes. The basic role is normally for quick control of voltage at powerless focuses in a system. Establishments might be at the midpoint of transmission interconnections or at the line closes. Static Var Compensators are shunt connected static generators/safeguards whose yields are changed in order to control voltage of the electric power systems. In its basic structure, SVC is connected as Fixed Capacitor-Thyristor Controlled Reactor (FC-TCR) design as appeared in The SVC is connected with a coupling transformer that is connected specifically to the air conditioner bus whose voltage is to be controlled. The powerful reactance of the FC-TCR is fluctuated by terminating point control of the counter parallel thyristors. The terminating point can be controlled through a PI (Proportional + Integral) controller in a manner that the voltage of the bus, where the SVC is connected, is kept up at the reference esteem.

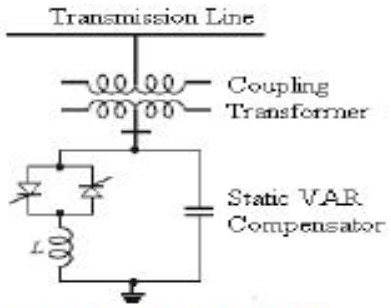


Fig. 1 Configuration of SVC

UPFC:- Two sorts of UPFC models have been Reported. One is coupled model and other is decoupled model. In the main sort, UPFC is displayed with arrangement mix of a voltage source and impedance in the transmission line. In decoupled model, UPFC is displayed with two isolated buss. To start with model is more perplexing contrasted and the second one in light of the fact that adjustment of Jacobian system in coupled model is inescapable. While decoupled model can be effectively actualized in traditional power stream calculations without alteration of Jacobian lattice components, in this paper, decoupled model has been utilized for demonstrating UPFC in power stream study (Fig. 3) UPFC controls power stream of the transmission line where is introduced. To get UPFC model in load stream study, it is spoken to by four variables: Pu1, Qu1, Pu2, Qu2.Assuming UPFC to be lossless, and genuine power stream from bus i to bus j can be communicated as

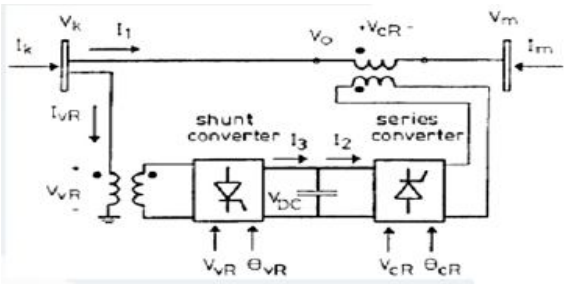


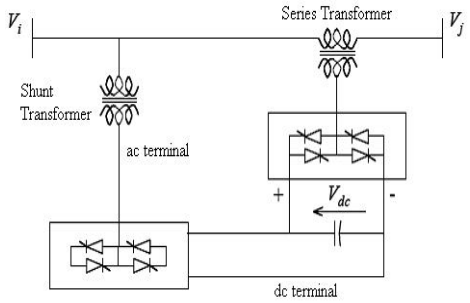
Fig.3 Modelling of UPFC

$$P_{ij} = P_{u1} \qquad \text{(Eq.5)}$$

Although UPFC can control the power flow, but cannot generate the real power. So:

$$P_{u1} + P_{u2} = 0 \qquad \text{(Eq.6)}$$

Among the accessible FACTS devices, the Unified Power Flow Controller (UPFC) is the most adaptable one that can be utilized to improve unfaltering state steadiness, dynamic solidness and transient dependability. The UPFC is equipped for both supplying and engrossing genuine and receptive power and it comprises of two air conditioning/dc converters. One of the two converters is connected in arrangement with the transmission line through an arrangement transformer and the other in parallel with the line through a shunt transformer. The dc side of the two converters is connected through a typical capacitor, which gives dc voltage to the converter operation. The power equalization between the arrangement and shunt converters is an essential to keep up a steady voltage over the dc capacitor. As the arrangement branch of the UPFC infuses a voltage of variable size and stage edge, it can trade genuine power with the transmission line and in this way enhances the power stream ability of the line and in addition its transient solidness limit. The shunt converter trades a current of controllable size and power variable edge with the power system. It is regularly controlled to adjust the genuine power consumed from or infused into the power system by the arrangement converter in addition to the losses by managing the dc bus voltage at a coveted quality.



Configuration of UPFC

III. GENETIC ALGORITHM

The GA is a hunt calculation in light of the system of characteristic choice and regular hereditary qualities. In a basic GA, people are rearranged to a chromosome that codes for the variables of the issue. The quality of an individual is the target capacity that must be streamlined. The number of inhabitants in competitors advances by the hereditary administrators of transformation, hybrid, and choice. The attributes of good competitors have more opportunities to be acquired, since great competitors live more. So the normal quality of the populace ascends through the eras. At last, the populace balances out, in light of the fact that no better individual can be found. At that stage, the calculation has met, and the vast majority of the people in the populace is for the most part indistinguishable, and speaks to an imperfect answer for the issue. A GA is represented by three components: the

transformation rate, the hybrid rate, and the populace size. The usage of the GA is definite in. GAs is one of the successful techniques for improvement issues particularly in non-differential target capacities with discrete or constant choice variables. Figure 4 demonstrates the way that the hereditary calculation works. A brief portrayal of the segments of Figure 4 is as below:

1. Initialize a population of chromosomes.

2. Evaluate each chromosome in the population.

3. Create new chromosomes by mating current chromosomes.

4. Apply mutation and recombination as the parent chromosomes mate.

5. Delete a member of the population to accommodate room for new chromosomes.

6. Evaluate the new chromosomes and insert them into the population.

7. If time is up, stop and return the best chromosomes; if not, go to 3.

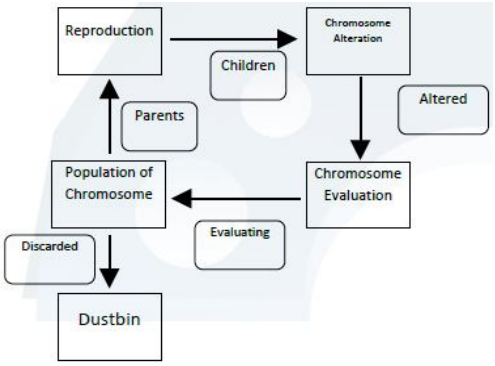


Fig.4 Working of Genetic algorithm

Similarly as with any inquiry algorithm, the ideal arrangement is acquired simply after much emphasis. The rate of the cycles is dictated by the length of the chromosome and the span of the populaces. There are two fundamental strategies for the GA to create itself, specifically generational or unfaltering state. On account of generational, a whole populace is supplanted after cycle (era), though in enduring state, just a couple of individuals from the populace are disposed of at each era and the populace size stays steady.

Fitness calculation:-

In this work, the fitness function is bus overloading consider. $Fitness = Bus\ loading * 100000000$; Where, $Bus\ loading = (k) + pcost\_f + pcost\_v + pcost\_qg + pcost\_s$;

$(k) = \exp(lamda * (1 - a(spq(k))')/ spqmax(k)))$;

pcost_f=calculating penalty for violation of line flow limits;

pcost_v= calculating penalty for violation of load bus voltage limits;

pcost_qg= calculating penalty for violation of generator reactive power limits;

pcost_s= calculating penalty for violation of slack bus active power limits;

Selection Operator:--

Key thought: offer inclination to better people, permitting them to go on their qualities to the following generation. The integrity of every individual depends on its wellness. Wellness might be controlled by a target capacity or by a subjective judgment.

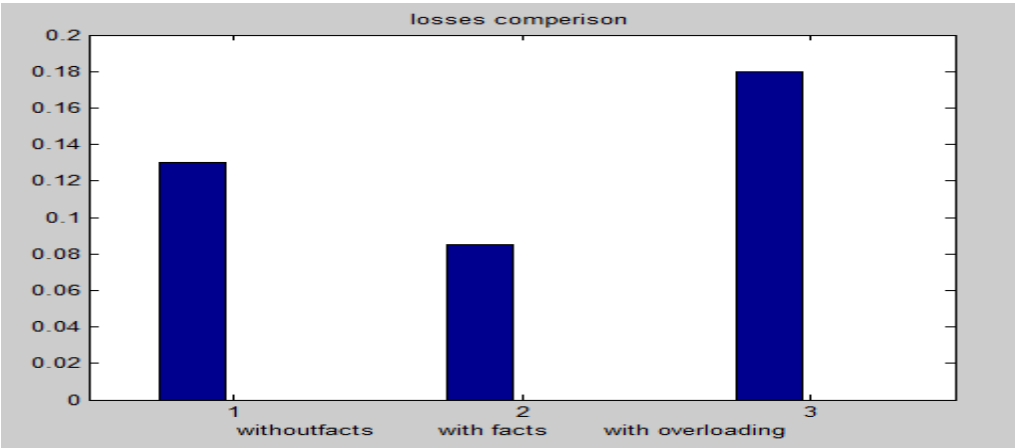
Crossover Operator:-

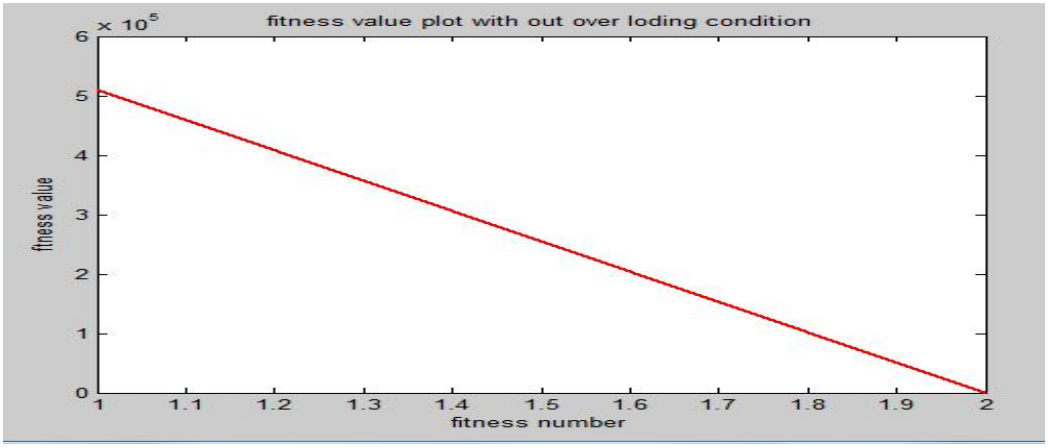
Prime recognized component of GA from other advancement strategies. Two people are picked from the populace utilizing the choice administrator .A hybrid site along the bit strings is haphazardly picked. The estimations of the two strings are traded up to this point. In the event that S1=000000 and S2=111111 and the hybrid point is 2 then S1'=110000 and S2'=001111. The two new posterity made from this mating are put into the up and coming era of the populace .By recombining parts of good people, this procedure is prone to make far and away superior people.

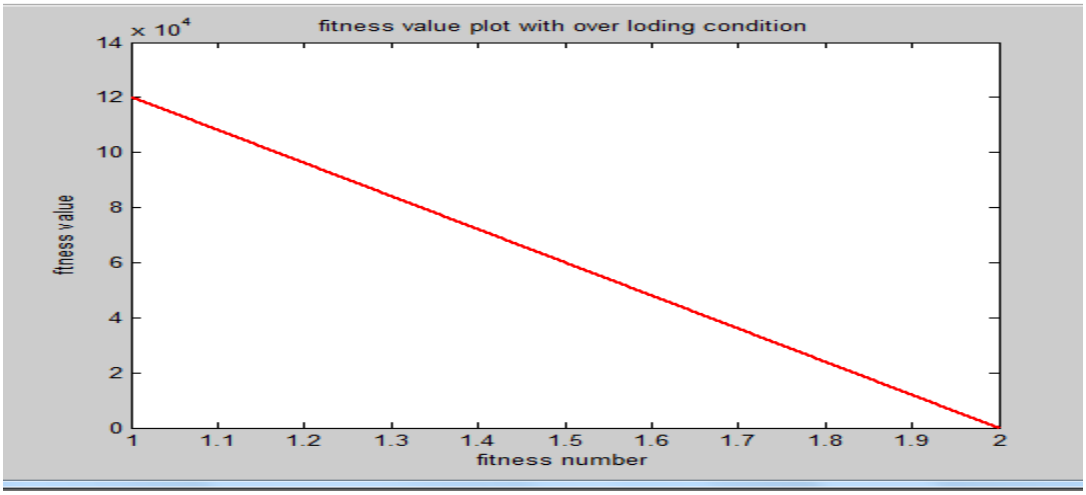
Mutation Operator:-

With some low likelihood, a segment of the new people will have some of their bits flipped. Its object is to keep up differing qualities inside the populace furthermore, restrain untimely joining.

Proposed results



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x 10^4
fitness value
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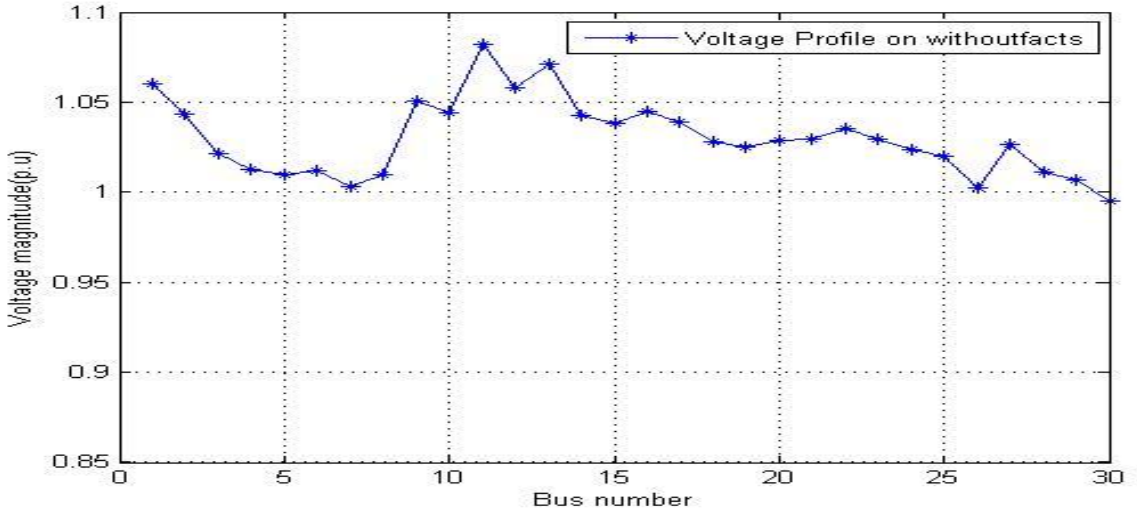
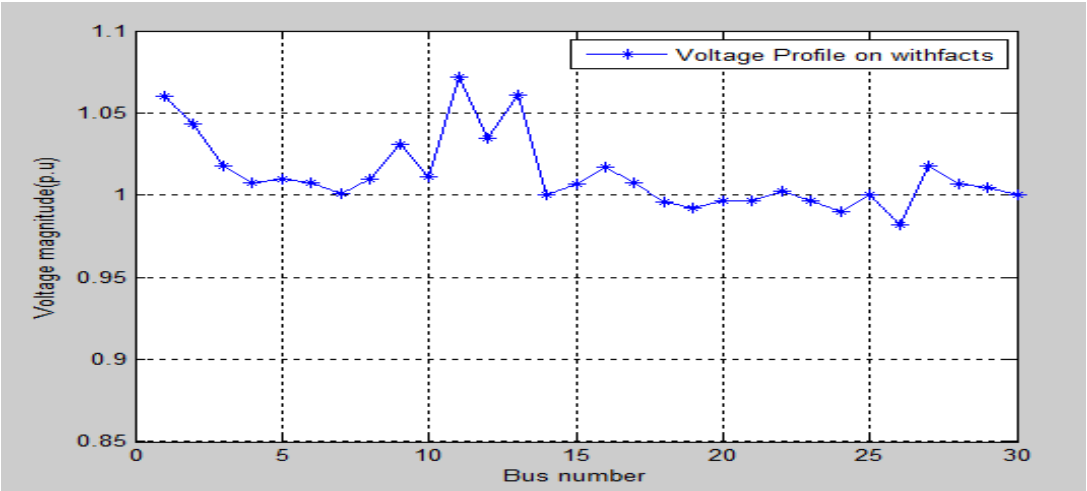

Voltage Profile on withoutfacts
Voltage magnitude(p.u)
Bus number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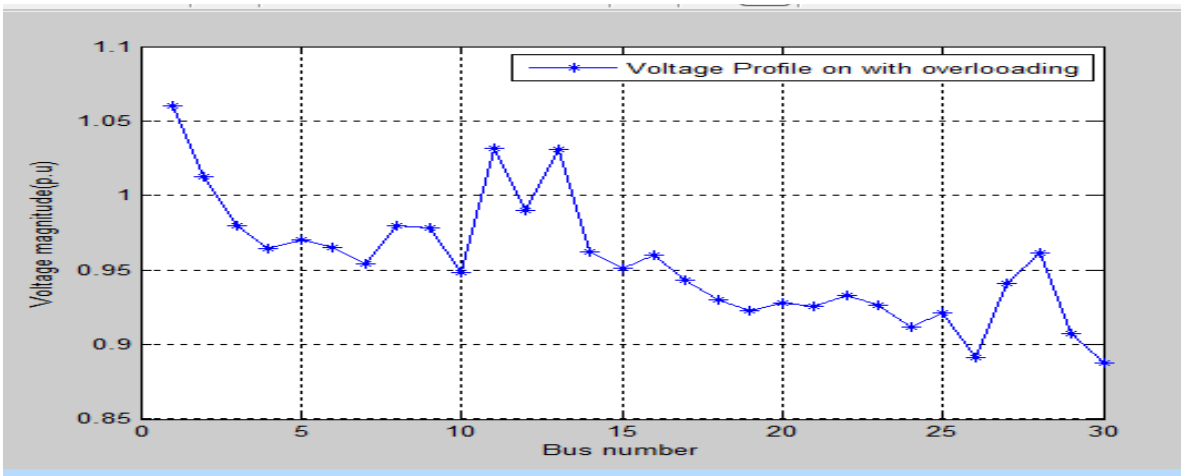


case	**Location of FACTS devices**	**Device name**	**Fitness value of bus loading**	**Line losses (p.u.)**
Normal loading	LINE-14	UPFC	809.0529	1.5634
	LINE-25	SVC		
	LINE-30	TCSC		

Extension topic

Particle Swarm Optimization

PSO is a quick, straightforward and productive populace based streamlining strategy which was proposed by Eberhart and Kennedy. Every molecule upgrades its position based upon its own particular best position, worldwide best position among particles and its past speed vector as indicated by the accompanying conditions:

$$v_i^{k+1} = w \times v_i^k + c_1 \times r_1 \times (p_{best_i} - x_i^k) + c_2 \times r_2 \times (g_{best} - x_i^k) \qquad (3)$$

$$x_i^{k+1} = x_i^k + \chi \times v_i^{k+1} \qquad (4)$$

Where,

v_i^{k+1}: The velocity of i^{th} particle at $(k+1)^{th}$ iteration

w : Inertia weight of the particle

v_i^k : The velocity of i^{th} particle at k^{th} iteration

c_1, c_2 : Positive constants having values.

r_1, r_2 : Randomly generated numbers.

p_{best_i} : The best position of the i^{th} particle obtained based upon its own experience

g_{best} : Global best position of the particle in the population

x_i^{k+1} : The position of i^{th} particle at $(k+1)^{th}$ iteration

x_i^k : The position of i^{th} particle at k^{th} iteration

χ : Constriction factor. It may help insure convergence.

Suitable selection of inertia weight w provides good balance between global and local explorations.

$$w = w_{\max} - \frac{w_{\max} - w_{\min}}{iter_{\max}} \times iter$$

Where, $w_{\max}$ is the value of inertia weight at the beginning of iterations, $w_{\min}$ is the value of inertia weight at the end of iterations, $iter$ is the current iteration number and $iter_{\max}$ is the maximum number of iterations.

Step by step procedure for ORPD using PSO for IEEE 30 bus test system

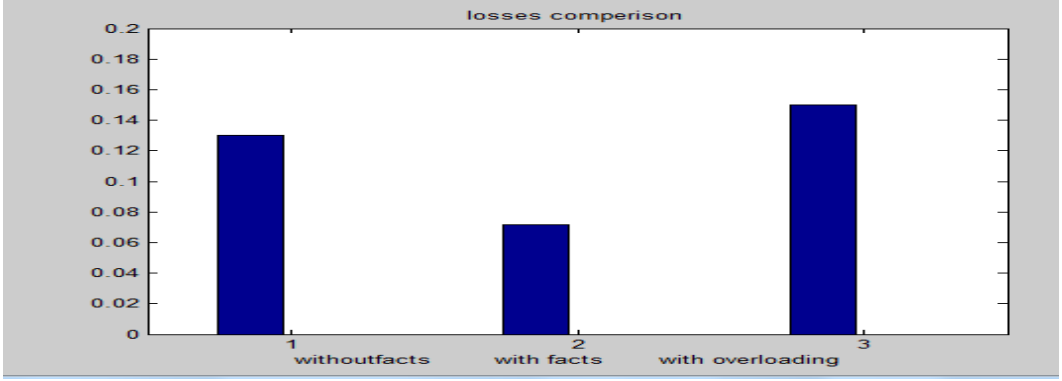
(1)Define control variables (vg1, vg2, vg5, vg8, vg11, vg13, T1, T2, T3, T4, QC3, QC10 and QC24) within their permissible range, define population size, no of iteration (=200), assume suitable values of PSO parameters, input the data of 30 bus test system
(2)Take iter=0
(3)Randomly generate the population of particles and their velocities
(4)For each particle run NR load flow to find out losses.
(5)Calculate the fitness function of each particle using equ. (2)
(6)Find out "personal best (Pbest)" of all particles and "global best(Gbest)" particle from their fitnesses
(7)Iter=iter+1
(8)Calculate the velocity of each particle using equ. (3) And adjust it if its limit gets violated
(9)Calculate the new position of each particle using equ. (4)
(10)For each particle run NR load flow to find out losses.
(11)Calculate the fitness function of each particle using equ. (2)

(12)For each particle if current fitness(P) is better than Pbest then Pbest=P

(13)Set best of Pbest as Gbest

(14)Go to step no. 7, until max. no of iterations is completed.

(15)Coordinate of Gbest particle gives optimized values of control variables and its fitness gives minimized value of losses.


losses comperison
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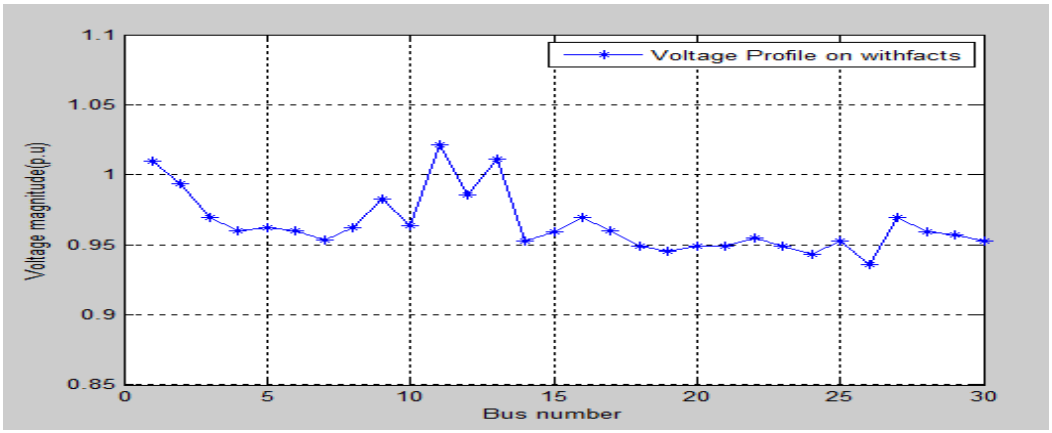
Voltage Profile on withfacts
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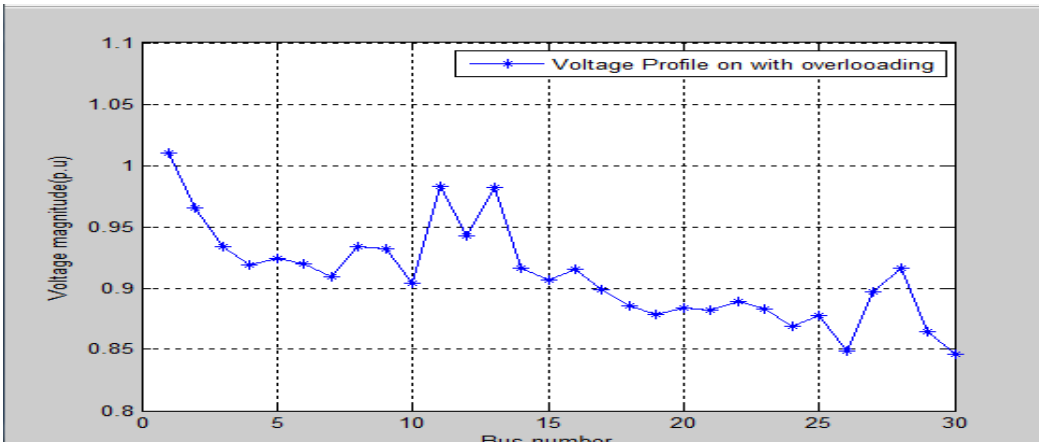
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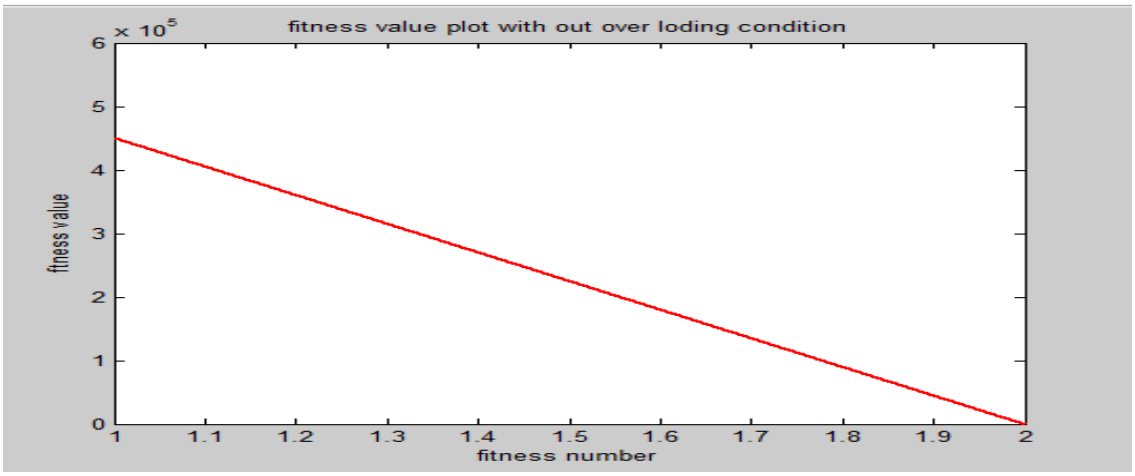

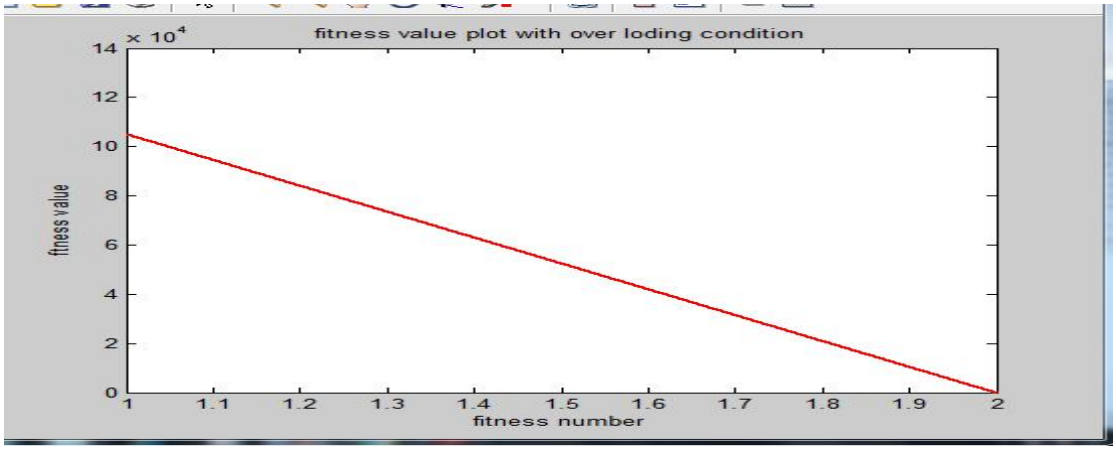

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Normal loading	LINE-14	UPFC	792.0393	0.8152
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	LINE-30	TCSC		

IV.CONCLUSION

In this project a genetic algorithm based approach is proposed to determine the suitable type of FACTS controllers, its optimal location and rating of the parameter of the devices at different loading condition in power system and also minimizes the total losses of the system. The proposed algorithm is an effective and a practical method for the allocation of FACTS controllers.

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