Improved FACTS location by optimize searching using hybrid optimization of particle swarm optimization

Aniruddh Sharma Vibhuti
Electrical, Sri Sai College of Engineering & Technology, Bungal, Punjab India

Abstract- For voltage control at the point, shunt controllers are desirable and power flow in the line can be controlled through series controllers. In experiment analysis of two bus system IEEE30 and IEEE41 these two bus system replace fact on effective place in case of congestion. After congestion increase of loss on different loads. In facts placement improve the congestion and reduce loss. In table 5.1 analysis of different three methods like genetic algorithm(GA), particle swarm optimization(PSO), biogreophy optimization (BBO) and hybrid proposed approach particle swarm optimization and genetic algorithm(PSO-GA). analysis the 41 bus system facts placements in different loads like 100,110,125 and comparison of proposed and existing approach. In proposed approach improve the cumulative or average loss. In analysis show when increase the load losses will increase because of congestion in lines will increase and its effect on voltage unstable and its magnitude will reduce and loss will increase. So reduce the loss by reduction of congestion by placement of facts in effective location. Proposed approach optimizes the location by global and local optimization. But comparative 30 bus system reduce the losses than 41 bus system because of possibility of more line congestion and increase losses.

I. INTRODUCTION

The current power program becomes more technically interconnected program because of worrying upsurge in dynamic pattern of the load and the load demand which usually affect the transmitting lines on extreme basis. They may be operating possibly overloaded or perhaps in under loading conditions. The uneven distribution of load distresses the voltage profile and makes the security of the system vulnerable to the fault. It becomes quite difficult to keep up reliability and security of power system [1, 2][3]. Conventional strategy adds transmission lines in the machine and build fresh facilities of power generation which usually bounds with certain elements such as for example specialized and cost-effective bounds. Therefore, the best and necessary solution left is to create optimal usage of existing transmission and generation network. FACTS technology represents the greatest and successful alternative method intended for the improvement of power such as transfer capability, volts security, and decrease in losses etc. rather than making complex novel transmission passage [4, 10] [11]. The unit could be linked in shunt, series, series-series and series-shunt. It is necessary to choose FACTS devices type based on the reason for need. For the control of voltage control at a certain point, shunt controllers are necessary and line-based power flow could be controlled with the help of series controllers. Power flow could be made controllable or flexible using such units of FACTS [9, 16].

1.1 Objectives of FACTS controllers

The main objectives of FACTS controllers are the following:

1. Regulation of power flows in prescribed transmission routes.
2. Secure loading of transmission lines nearer to their thermal limits.
3. Prevention of cascading outages by contributing to emergency control.
4. Damping of oscillations that can threaten security or limit the usable line capacity.

1.2 FACTS Technology

FACTS technology is termed from the idea of combining the power electronics devices with some static elements, which would control the voltage and the power flow in the power system [8]. FACTS refer to multiple power electronics-based devices like the TCSC, STATCOM, UPFC, UPQC, and IPFC etc. The benefits of the FACTS devices are as follows [12, 20]:

1. The dynamic characteristics of the FACTS devices would help in rapid real and reactive power compensation.
2. The congestion in the network could be reduced.
3. The compensation is continuous in nature.
4. Voltage profile and power loss can be controlled inside a limitation.
5. The overloading problem in the lines would get eliminated due to the voltage compensation.
6. Transient stability and the small signal capability improved.

1.2.1 Categories of FACTS

Generally, FACTS devices can be categorized into two generations:

1. First Generation FACTS devices: Fixed capacitance and dynamic devices are first generation of the FACTS technology. These first-generation FACTS devices consist of tap changing and phase changing transformers, series capacitors and synchronous generators.

These are all dynamics devices except the series capacitors which are also called capacitor bank. These devices are generally operated at the generation side of the power system but their cost is very high due to their extremely large size and maintenance. The big disadvantage of these devices is fixed series capacitors, since such devices are made up of several fixed-capacitance capacitors so these devices are very difficult to control to give the exact not-fixed input capacitance to the grid.

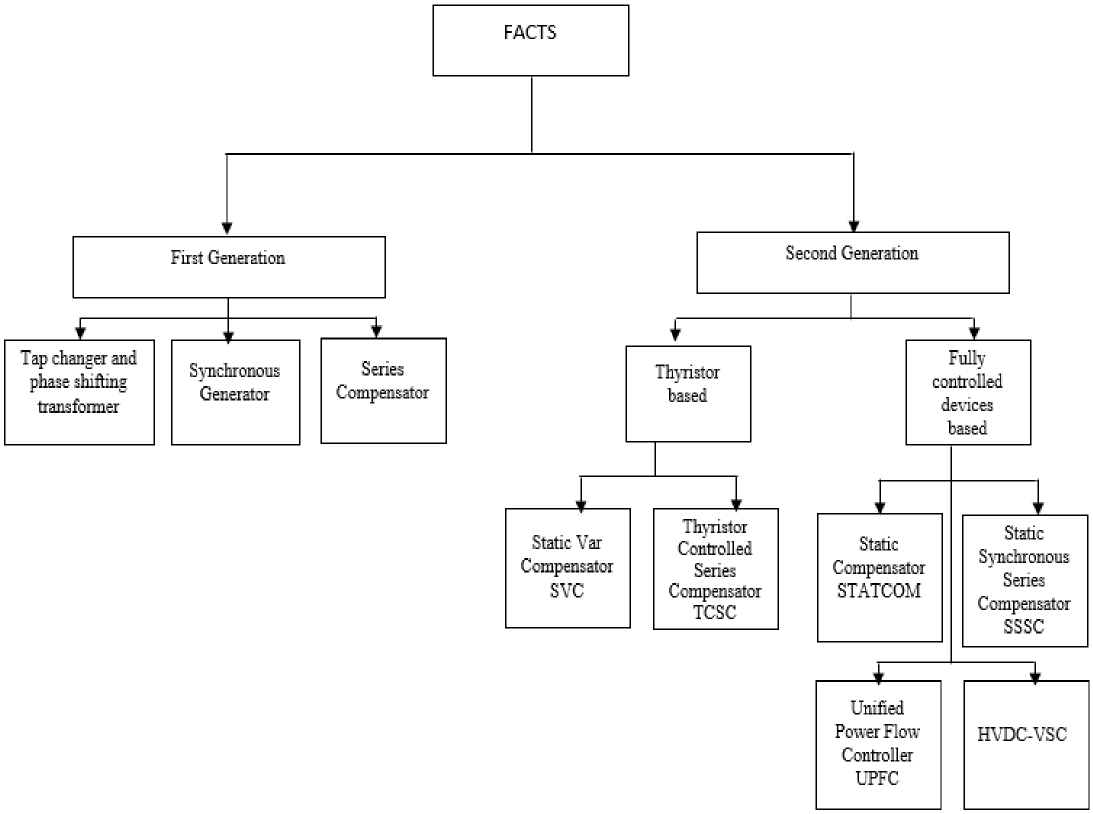

Figure 1: Category of FACTS devices

2. Second Generation FACTS devices: Static state compensator is the second generation of FACTS technology. It can be divided into two categories: thyristor-based technology and fully-controlled compensator based technology [5][6][7]. The thyristor con-trolled device is half controlled device because once the device is on then it cannot be switched off manually until the main power is cut-off. Static Var Compensator (SVC) and Thyristor-Controlled Series Capacitor (TCSC) devices belongs to this category. While the fully controlled devices consist of Gate Turn-Off (GTO) thyristor i.e. these devices can be manually switched on and off when needed. The Static Compensator (STATCOM), Solid Static Series Compensator (SSSC) and Unified Power Flow Controller (UPFC) belongs to fully-controlled devices. Unified Power Flow Controller (UPFC) is technically the most effective and versatile FACT device as it can perform the function of both STATCOM and SSSC at a time and it has transient stability improvement capability by handling the power flow on both sides of transmission line via shunt and series convertors [13].

1.3 Classification of FACTS

In general FACTS controllers can be divided into four categories [12, 13]:

1. Shunt Controllers: A shunt controller may be of variable impedance, variable source or a combination of these. In principle all the shunt controllers inject current into the system at the point of connection. The variable shunt impedance connected to the line voltage causes a variable current flow and hence represents injection of current into the line. Examples are: Static Synchronous Compensator (STATCOM) and Static Var Compensator (SVC)

2. Series Controllers: This controller could be of variable impedance, such as capacitor, reactor etc or power electronics based variable source of main frequency, sub synchronous and harmonic frequencies to serve the desired need 1, 2][5]. Examples are: Static Synchronous Series Compensator (SSSC) and Thyristor Controlled Series Capacitor (TCSC)

3. Combined Series-Series Controllers: This could be a combination of series controllers which are controlled in a separate manner in a multiline transmission system. Further, it can be act as a unified controller in which series controllers provide independent series reactive compensation for transmission line and also transfer real power among lines via the power link. Interline power flow controller (IPFC). Examples are: Thyristor-Controlled Voltage Limiter (TCVL) and Thyristor-Controlled Voltage Regulator (TCVR)

4. Combined Series-Shunt Controllers: This could be a combination of separate shunt and series controllers, which are controlled in a coordinated manner or a unified power flow controller with series and shunt elements. In principle combined series-shunt controllers injects current into the system with the shunt part of the controller and voltage in series in the line with the series part of the controller. However, when the shunt and series controllers are unified there can be real power exchange between the series and shunt controllers via the power link. Examples are: Thyristor Controlled Phase Shifting Transformer (TCPST) and Unified Power Flow Controller (UPFC)

II. RELATED WORK

Arup Das, et.al [1] The utilization of FACTS device is imperative in the present power situation. There is a possibility for congestion event in the current transmission lines because of the addition in the power generation &demand and in the meantime, the confinement in the working of new transmission lines. FACTS Devices can take care of this issue. Numerous researches about are completed for finding the optimal position for the situation of FACTS devices with thinking about various target capacities. This paper abridges the different strategies utilized by the few scientists for position of FACTS device in the system. S.Kundu, et.al [2] presented a great iterative research in Mi-power software intended for IEEE 57 bus check system. The severe nature of the line has been recognized using FVSI i.e. Fast Voltage Stability Index and afterwards SVC was positioned on the recognized critical buses distinctly to save lots of computation as well as the searching space. Using additional aspects based on technical concepts and other aspects i.e. environmental and economic issues were also reflected in this paper while placing SVC at the perfect location. Dipesh Gaur, et.al [3] considered distinct methods of optimization such as Genetic Algorithm (GA), Particle Swarm Optimization (PSO) etc. These methods were debated and compared for optimal placement, rating and type of devices. FACTS devices like Static Synchronous Compensator (STATCOM), Static Var Compensator (SVC), Thyristor Controlled Series Compensator (TCSC) were taken into consideration. It also revealed the effects of FACTS controllers on different parameters of IEEE bus network like the cost of generation, voltage stability, active power loss, etc. have been compared and analysed among the other devices. K. Kavitha, et.al [4] investigated and proposed a novel solution approaches for the optimal FACTS devices placement, for the improvement of system protection under differing system weight (load). The potency of the perfect installing SVC, TCSC, combined TCSC-SVC and UPFC in advancement of the security of power systems, when it comes to minimizing load voltage deviations and the line loading were inspected. The algorithms developed for the perfect placement of numerous FACTS devices was authenticated by performing case research on regular IEEE test systems. The analysis shows that after the placement of optimal FACTS device, both line loadings and load bus voltage deviations were minimized henceforth enhancing the machine security. Even more analysis discloses that Biogeography Optimization (BBO) technique displays best overall performance contrasted with PSO and Weight Increased PSO (WIPSO) approaches.Saurav Raj, et.al [5] studied the minimization of both active power reduction and total system working cost like the cost of FACTS devices were believed while sustaining volts profile inside the permitted limit. Showing the potency of the suggested work, IEEE-57 and IEEE-30 bus check system were analysed. The effect obtained by proposed strategy was weighed against the outcomes obtained simply by Grey wolf optimisation (GWO), Whale optimization algorithm (WOA), Differential Evolution (DE). GWO and Quasi-oppositional based DE were also implemented to progress the solution. The implementation of GWO and quasi-oppositional in DE was primarily completed to expand the searching space which escalates the robustness and exploitability from the algorithm. It was observed the proposed form of WOA provides better and dependable guidance for optimised management of FACTS devices with other sources of reactive power within the energy network.O. Ziaee, et.al [7] formulated the issues related to TCSC location-allocation as a combined integer non-linear program, and proposed a new decomposition process of deciding the perfect area of TCSCs and their own size for the respective network. The strain (load) uncertainty, transmission lines AC characteristics, and of TCSCs non-linear cost explicitly were considered. The full total results of applying the task to the IEEE 118-bus test system were reported, and perceptions related to TCSC location-allocation problem were provided. BasanagoudaPatil, et.al [8] reviewed the paper to deliver knowledge about the different FACTS devices and the improvement in the field of the optimal placement, which is in the stage of growth during the past two decades. The review is limited to the FACTS devices and the optimal placement of the FACTS devices. Different optimization techniques, hybrid meta heuristics techniques and optimization technique with Optimal Power Flow (OPF) were discussed in detail. The optimal placement of different FACTS devices with the different criteria of the objective function was considered for discussion. Sai Ram Inkollu, et.al [9] presented a novel way of optimizing the devices of FACTS technology, in order to keep up with the voltage stability in the energy transmission systems. Right here, the PSO (particle swarm optimization) algorithm and the adaptable form of GSA (gravitational search algorithm) technique was proposed and intended for refining the voltage balance of the energy-based transmission devices. In the suggested approach, the PSO formula can be used to get optimized gravitational constant and enhances the overall GSA searching performance. Using the recommended technique, the optimised settings of the FACTS-based devices were determined. The offered algorithm presents an efficient technique for learning the perfect area and the dimension of the FACTS controllers. The perfect locations and the energy rankings of these devices were actually determined predicated on the voltage-based collapse ranking along with the loss of electrical power system.Arup Das, et.al [1] The utilization of FACTS device is imperative in the present power situation. There is a possibility for congestion event in the current transmission lines because of the addition in the power generation &demand and in the meantime, the confinement in the working of new transmission lines. FACTS Devices can take care of this issue. Numerous researches about are completed for finding the optimal position for the situation of FACTS devices with thinking about various target capacities. This paper abridges the different strategies utilized by the few scientists for position of FACTS device in the system.S.Kundu, et.al [2] presented a great iterative research in Mi-power software intended for IEEE 57 bus check system. The severe nature of the line has been recognized using FVSI i.e. Fast Voltage Stability Index and afterwards SVC was positioned on the recognized critical buses distinctly to save lots of computation as well as the searching space. Using additional aspects based on technical concepts and other aspects i.e. environmental and economic issues were also reflected in this paper while placing SVC at the perfect location.Dipesh Gaur, et.al [3] considered distinct methods of optimization such as Genetic Algorithm (GA), Particle Swarm Optimization (PSO) etc. These methods were debated and compared for optimal placement, rating and type of devices. FACTS devices like Static Synchronous Compensator (STATCOM), Static Var Compensator (SVC), Thyristor Controlled Series Compensator (TCSC) were taken into consideration. It also revealed the effects of FACTS controllers on different parameters of IEEE bus network like the cost of generation, voltage stability, active power loss, etc. have been compared and analysed among the other devices.K. Kavitha, et.al [4] investigated and proposed a novel solution approaches for the optimal FACTS devices placement, for the improvement of system protection under differing system weight (load). The potency of the perfect installing SVC, TCSC, combined TCSC-SVC and UPFC in advancement of the security of power systems, when it comes to minimizing load voltage deviations and the line loading were inspected. The algorithms developed for the perfect placement of numerous FACTS devices was authenticated by performing case research on regular IEEE test systems. The analysis shows that after the placement of optimal FACTS device, both line loadings and load bus voltage deviations were minimized henceforth enhancing the machine security. Even more analysis discloses that Biogeography Optimization (BBO) technique displays best overall performance contrasted with PSO and Weight Increased PSO (WIPSO) approaches.Saurav Raj, et.al [5] studied the minimization of both active power reduction and total system working cost like the cost of FACTS devices were believed while sustaining volts profile inside the permitted limit. Showing the potency of the suggested work, IEEE-57 and IEEE-30 bus check system were analysed. The effect obtained by proposed strategy was weighed against the outcomes obtained simply by Grey wolf optimisation (GWO), Whale optimization algorithm (WOA), Differential Evolution (DE). GWO and Quasi-oppositional based DE were also implemented to progress the solution. The implementation of GWO and quasi-oppositional in DE was primarily completed to expand the searching space which escalates the robustness and exploitability from the algorithm. It was observed the proposed form of WOA provides better and dependable guidance for optimised management of FACTS devices with other sources of reactive power within the energy network.O. Ziaee, et.al [7] formulated the issues related to TCSC location-allocation as a combined integer non-linear program, and proposed a new decomposition process of deciding the perfect area of TCSCs and their own size for the respective network. The strain (load) uncertainty, transmission lines AC characteristics, and of TCSCs non-linear cost explicitly were considered. The full total results of applying the task to the IEEE 118-bus test system were reported, and perceptions related to TCSC location-allocation problem were provided.BasanagoudaPatil, et.al [8] reviewed the paper to deliver knowledge about the different FACTS devices and the improvement in the field of the optimal placement, which is in the stage of growth during the past two decades. The review is limited to the FACTS devices and the optimal placement of the FACTS devices. Different optimization techniques, hybrid meta heuristics techniques and optimization technique with Optimal Power Flow (OPF) were discussed in detail. The optimal placement of different FACTS devices with the different criteria of the objective function was considered for discussion.Sai Ram Inkollu, et.al [9] presented a novel way of optimizing the devices of FACTS technology, in order to keep up with the voltage stability in the energy transmission systems. Right here, the PSO (particle swarm optimization) algorithm and the adaptable form of GSA (gravitational search algorithm) technique was proposed and intended for refining the voltage balance of the energy-based transmission devices. In the suggested approach, the PSO formula can be used to get optimized gravitational constant and enhances the overall GSA searching performance. Using the recommended technique, the optimised settings of the FACTS-based devices were determined. The offered algorithm presents an efficient technique for learning the perfect area and the dimension of the FACTS controllers. The perfect locations and the energy rankings of these devices were actually determined predicated on the voltage-based collapse ranking along with the loss of electrical power system.R.Srinivasa Rao, et.al [10] revealed a general method intended for determining optimal places for placement of FACTS devices in the energy system with a target of reducing actual (real) power reduction and also to decrease the lines-based overloading process. A target (objective) function including above goals was developed and an in-depth mathematical unit for every goal was offered when it comes to program-based parameters. Three of the FACT gaFACTSets, namely, UPFC (Unified Power Flow Controller), IPFC (Interline Power Flow Controller), and OUPFC (Optimal Unified Power Flow Controller) which can handle controlling the two active and reactive powers were believed in the process of analysis and simulation in the networks.Pooja Prasad Kulkarni, et.al [11] provides brief overview of fast and versatile control of transmission line-based power flow. Exceptional highlighting was based upon TCSC, UPFC, and SVC considering their benefits for refining the power system operation. A comparison based on the performance of the known FACTS controllers has been discussed. Additionally, a few of the utility experiences have already been summarized and reviewed. The study based on FACTS applications to power system has already been discussed in the working methodology.Pavlos S. Georgilakis et.al [12] presented various FACTS controllers and analysed their control attributes and benefits. The flexible ac transmission system (FACTS), a new technology based on power electronics, offers an opportunity to enhance controllability, stability, and power transfer capability of ac transmission systems. The application of FACTS controllers throws up new challenges for power engineers, not only in hardware implementation, but also in design of robust control systems, planning and analysis. There has been considerable progress in the application of FACTS controllers. FACTS do not indicate a particular controller but a host of controllers that the system planner can choose, based on cost benefit analysis. Naresh Acharya, et.al [13] presents various facts related to the landmark development: practical installations, benefits and application of FACTS controllers in the electric utilities. The history of development of these devices was presented along with the information regarding the first utility installation/demonstration of FACTS devices. A comprehensive collection of major FACTS installations around the world is then presented. The paper also analysed the benefit that can be achieved and cost associated with these devices. The paper also presented various applications that FACTS devices can have in the deregulated market. Various issues related with the FACTS controllers were also presented

III. THE PROPOSED METHOD

3.1Proposed Methodology

In the below-givensection, we explain the Genetic Algorithm (G.A) and Particle Swarm Optimization (PSO) with the algorithm and their flow chart. The flow chart of explains the step by step working an algorithm represents the technical implementation of the algorithms.

Steps for the proposed methodology are illustrated as follows:

Step 1: Initialize the Load/Power.

Step 2: Initialize the generator Load Power.

Step 3: Allocate the generators and calculate the cost.

Step 4: Apply the PSO for optimization.

Step 5: If the output of PSO is optimized then check the convergence otherwise genetic algorithm starts it working with the following steps.

- *(a)* Initialize the chromosomes.
- *(b)* Crossover between chromosomes.
- *(c)* Apply Roulette Selection.
- *(d)* Check Optimization. If optimize then go to convergence Check otherwise loop is running until the Objective form is not obtained.

Step 6: Check the convergence. If converge then check the cost features otherwise again initialize the particles and Repeat the step 5.

Step 7: If the cost is less than Δ C then stop.

3.2 Proposed methodology: Flowchart

1. *Genetic algorithm:* It is a meta-heuristic algorithm which is used to solve the optimization problems in computing and artificial intelligence. It provides the optimized solution by using the concept of selection and evolution.

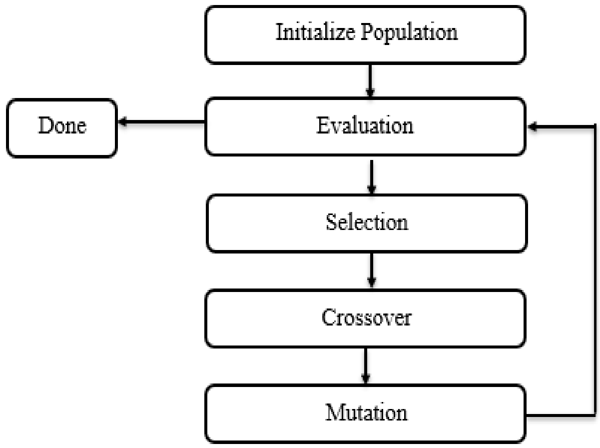

Figure 2: Flow chart of genetic algorithm

Genetic Algorithm

Step 1: Population← initialize Population
Step 2: Evaluate the population.
Step 3: S_{Best}← get best solution from population.
Step 4: while (! Stop condition())
Parents ← select parents(Population, $Population_{Size}$)
Child← ∅
For($Parent_1 Parents_2 \in Parents$)
$Child_1 Child_2 \leftarrow Crossover(Parent_1 Parents_2 \in P_{Crossover})$
$Children \leftarrow Mutate\ (Child_1, P_{mutation})$
$Children \leftarrow Mutate\ (Child_2, P_{mutation})$
End
Evaluate the Population of Children
$S_{Best} \leftarrow get\ best\ solution\ (Children)$
Population← $replace\ the\ least\ fit\ population\ (children) with\ new$
End
Return (S_{Best})

*2. Particle Swarm Optimization: It*is an optimization technique that is based upon bird flocking and fish schooling Every particle moves in the search space to find the point at which objective function is optimized. At any point of time, every particle has some position and velocity in the search space.

PSO

Step 1: In PSO model for each particle i in S do
Step 2: for each dimension d in D do
Step 3: //initialize each particle's position and velocity
Step 4: $x_{i,d}$=$\boldsymbol{Rnd}(\boldsymbol{x_{max}}, \boldsymbol{x}_{min})$
Step 5: $\boldsymbol{v_{i,d}}$=$\boldsymbol{Rnd}(-\boldsymbol{v_{max}}$ /3, $\boldsymbol{v_{max}}$/3)
Step 6: end for
Step 7: //initialize particle's best position and velocity
$\boldsymbol{v_i}(k+1) = \boldsymbol{v_i}(k) + \boldsymbol{\gamma 1_i}(\boldsymbol{p_i} - \boldsymbol{x_i}(k)) + \boldsymbol{\gamma_{2i}}(G - \boldsymbol{x_i}(k))$
New velocity
$\boldsymbol{x_i}(k+1) = \boldsymbol{x}_{\ i}(k) + \boldsymbol{v_i}(k+1)$
Where
i- particle index
k- discrete time index

v_i –velocity of i[th] particle
x_i – position of i[th] particle
p_i- best position found by i[th] particle(personal best)
G- best position found by swarm (global best, best of personal bests)
$G_{(1,2)i}$- random number on the interval[0,1]applied to the i[th] particle
Step 8: $\boldsymbol{pb_i}$=$\boldsymbol{x_i}$
Step 9: // update global best position
Step10: if $\boldsymbol{f}(\boldsymbol{pb_i})$ <$\boldsymbol{f}(\boldsymbol{gb})$
Step 11: $\boldsymbol{gb} = \boldsymbol{pb_i}$
Step12: end if
Step13: end for

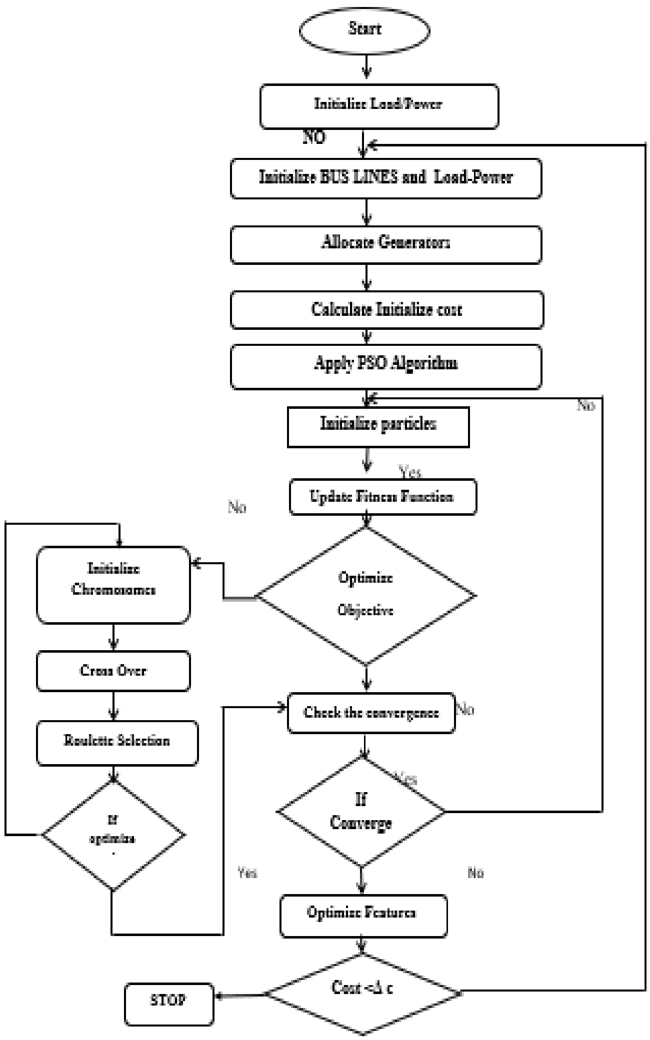

Figure 3: Flow design

IV. RESULT ANALYSIS

4.1 Result Analysis

Table.1 Line wise loss after optimization facts allocation

Line number	From	To	With GA	With PSO	With BBO	With PSO-GA
1	1	2	1.796	1.784	1.647433	1.03521
2	1	3	0.9899	0.97833	1.370633	0.748643333
3	2	4	0.9564	0.9433	1.370467	0.7223
4	3	4	0.9656	0.9243	1.363167	0.699333333
5	2	5	0.9894	0.8993	1.34945	0.6889
6	2	6	0.9345	0.8744	1.31943	0.684233333
7	4	6	0.92445	0.893	1.285997	0.667233333
8	5	7	0.89934	0.8853	1.275613	0.651733333
9	6	7	0.8342	0.8234	1.236933	0.611766667
10	6	8	0.8933	0.8465	1.2037	0.578766667
11	6	9	0.7833	0.7654	1.147367	0.531366667
12	6	10	0.7345	0.7244	1.120733	0.501
13	9	11	0.7243	0.7043	1.1279	0.411533333
14	9	10	0.7034	0.6743	0.894607	0.184566667
15	4	12	0.756	0.456	0.66822	0.033066667
16	12	13	0.02442	0.0234	0.53132	0.0776
17	12	14	0.02424	0.0214	0.567347	0.048366667
18	12	15	0.3453	0.3224	0.743267	0.095933333
19	12	16	0.1325	0.1111	0.636233	0.0074
20	14	15	0.552	0.4543	0.599814	0.037616667
21	16	17	0.0242	0.0124	0.427297	0.180883333
22	15	18	0.023242	0.02045	0.423697	0.18167
23	18	19	0.03445	0.0245	0.437083	0.000353333
24	19	20	0.0134	0.01004	0.446677	0.009313333
25	10	20	0.0634	0.5644	0.469977	0.021513333
26	10	17	0.06323	0.0535	0.46671	0.154753333
27	10	21	0.0833	0.04664	0.4903	0.14142
28	10	22	0.0536	0.0356	0.544033	0.0855
29	21	23	0.134	0.0935	0.534333	0.093233333
30	15	23	0.2445	0.2144	0.507733	0.109566667
31	22	24	0.0245	0.0124	0.4344	0.176366667
32	23	24	0.0542	0.0445	0.4344	0.175683333
33	24	25	0.0245	0.014	0.420467	0.185683333
34	25	26	0.0245	0.01445	0.416003	0.187016667
35	25	27	0.0124	0.0145	0.44067	0.163366667
36	28	27	0.01111	0.01	0.451737	0.1567
37	27	29	0.0985	0.0854	0.469433	0.141866667
38	27	30	0.0456	0.0345	0.44475	0.163183333
39	29	30	0.0642	0.0545	0.433992	0.170636667
40	8	28	0.02445	0.02145	0.418888	0.183205
41	6	28	0.013325	0.01214	0.413325	0.18786

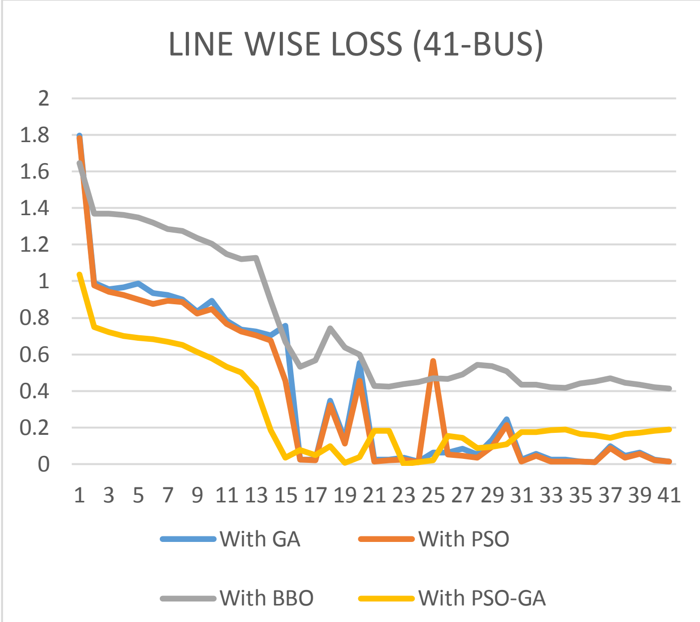

Figure 4: Comparison of Losses by different approaches in 41 Bus

Table.2 Loses in 30 bus in different approaches of Facts placement

LOAD	PSO(loss)	GA(loss)	BBO(loss)	PSO-GA(loss)
LOAD 100	20.123	22.34	21.343	19.23
Load110	22.45	24.566	23.22	20.12
Load 125	24.344	25.445	25	21.23

Table.3: Loses in 41 bus in different approaches of Facts placement

Bus number	GA (125)	BBO (125)	Pso (125)	Pso-GA (125)
1	1.1	1.14416667	1.1	1.4615
2	1.0945	1.13566667	1.1495	1.4665
3	1.088	1.1245	1.115	1.44666667
4	1.0745	1.10666667	1.115	1.435
5	1.061	1.09183333	1.09	1.43666667
6	1.0345	1.05816667	1.08	1.40333333
7	1.03	1.02833333	1.12	1.37166667
8	0.96	0.99666667	0.99	1.31833333
9	0.945	0.98	0.985	1.305
10	0.935	0.96666667	0.96	1.28333333
11	0.91	0.95333333	0.95	1.27333333
12	0.905	0.94333333	0.92	1.25666667
13	0.895	0.92	0.93	1.24833333
14	0.88	0.9	0.9	1.225
15	0.835	0.88	0.895	1.20833333

16	0.835	0.88	0.86	1.20166667
17	0.82	0.87666667	0.85	1.215
18	0.835	0.88333333	0.875	1.22166667
19	0.825	0.89333333	0.9	1.22333333
20	0.84	0.88166667	0.87	1.2
21	0.865	0.86166667	0.88	1.185
22	0.79	0.82666667	0.83	1.16833333
23	0.78	0.82	0.825	1.16833333
24	0.76	0.82666667	0.83	1.17
25	0.77	0.85	0.83	1.18333333
26	0.8	0.86666667	0.83	1.195
27	0.83	0.87	0.87	1.21333333
28	0.82	0.86	0.865	1.21166667
0.82	0.86	0.865	1.211667	0.82
0.81	0.83	0.885	1.322	0.81

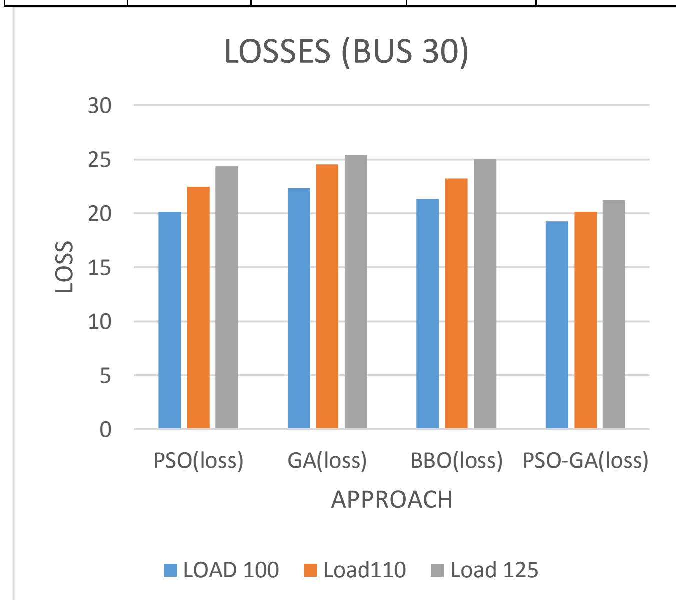

Figure 5: Comparison of losses by different optimization BUS-30

Table.4 Line wise Voltage in Load -125

LOAD	PSO(loss)	GA(loss)	BBO(loss)	PSO-GA(loss)
LOAD 100	23.23	25.34	24.34	20.23
Load110	24.34	26.34	24	21.34
Load 125	25.45	27.34	26	23.2

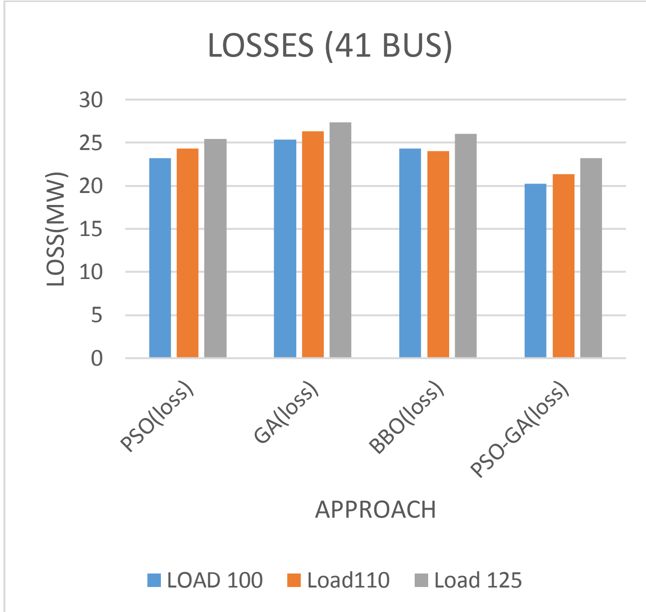

Figure 6: Comparison of losses by different optimization BUS-40

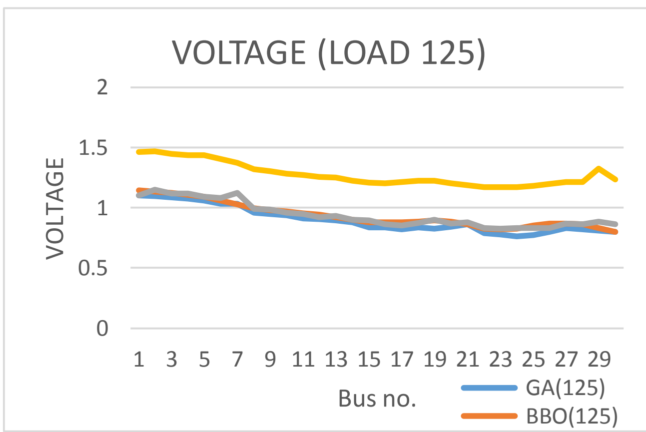

Figure 7: Comparison Line wise Voltage in Load -125

Table.5: Line wise Voltage in Load -100 and load 110

Bus number	GA(100)	BBO(100)	Pso(100)	PSO-GA(100)	GA(110)	BBO(110)	pso(110)	pso-GA(110)
1	1.1	1.09	1.3	1.54	1.1	1.1983333	1.1	1.4096667
2	1.09	1.07666667	1.2	1.47	1.099	1.1946667	1.099	1.423
3	1.08	1.06	1.1	1.43	1.096	1.189	1.13	1.4233333
4	1.06	1.02333333	1.09	1.41333333	1.089	1.19	1.14	1.4166667
5	1.04	0.99	1.08	1.39666667	1.082	1.1936667	1.1	1.4366667
6	0.97	0.95666667	1.05	1.36666667	1.099	1.1596667	1.11	1.4
7	0.96	0.94	1.04	1.34333333	1.1	1.1166667	1.2	1.36
8	0.94	0.92333333	0.99	1.31	0.98	1.07	0.99	1.2866667
9	0.92	0.90333333	0.98	1.28	0.97	1.0566667	0.99	1.29
10	0.91	0.88	0.94	1.24	0.96	1.0533333	0.98	1.2866667
11	0.88	0.85	0.9	1.21666667	0.94	1.0566667	1	1.29
12	0.85	0.81666667	0.86	1.19	0.96	1.07	0.98	1.2833333
13	0.82	0.79	0.87	1.17	0.97	1.05	0.99	1.2866667
14	0.78	0.77	0.82	1.14	0.98	1.03	0.98	1.27
15	0.77	0.76	0.8	1.13333333	0.9	1	0.99	1.2433333
16	0.76	0.76666667	0.78	1.13666667	0.91	0.9933333	0.94	1.2266667
17	0.75	0.78	0.8	1.15	0.89	0.9733333	0.9	1.24
18	0.79	0.80333333	0.81	1.16666667	0.88	0.9633333	0.94	1.2366667
19	0.8	0.82	0.82	1.18333333	0.85	0.9666667	0.98	1.2233333
20	0.82	0.81666667	0.85	1.18333333	0.86	0.9466667	0.89	1.1766667
21	0.84	0.80333333	0.86	1.16666667	0.89	0.92	0.9	1.1633333
22	0.79	0.77666667	0.82	1.14333333	0.79	0.8766667	0.84	1.1533333
23	0.78	0.77	0.8	1.13	0.78	0.87	0.85	1.1666667
24	0.76	0.77666667	0.79	1.14	0.76	0.8766667	0.87	1.16
25	0.77	0.8	0.78	1.16	0.77	0.9	0.88	1.1666667
26	0.8	0.81666667	0.83	1.17666667	0.8	0.9166667	0.83	1.1733333
27	0.83	0.82	0.85	1.18	0.83	0.92	0.89	1.2066667
28	0.82	0.81	0.83	1.17333333	0.82	0.91	0.9	1.21
29	0.81	0.805	0.84	1.175	0.81	0.905	0.93	1.215
30	0.8	0.8	0.83	1.17	0.8	0.9	0.9	1.2

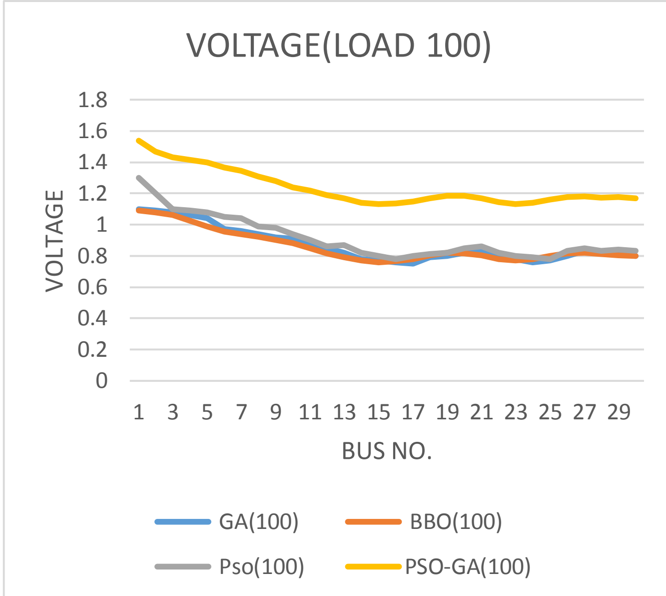

Figure 8: Comparison of Line wise Voltage in load 110

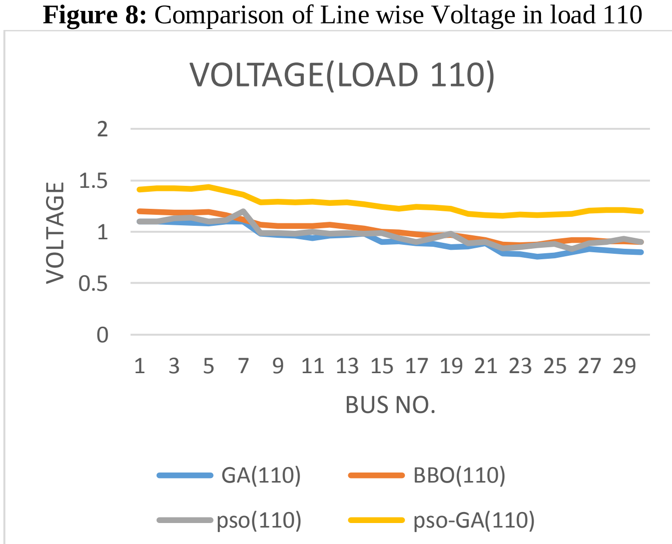

Figure 10: Comparison Line wise Voltage in and load 110

IV. CONCLUSION

Flexible AC Transmission system (FACTS) provides solution to problems like line overloading, voltage stability, losses, power flow etc. FACTS can play important role in improving static and dynamic performance of power system. FACTS devices need high initial investment. Therefore, FACTS location, type and their rating are vital and should be optimized to place in the network for maximum benefit. In this paper, different optimization methods like Particle Swarm Optimization (PSO), Genetic Algorithm (GA) etc. are discussed and compared for optimal location, type and rating of devices. bus system IEEE30 and IEEE41 these two bus system replace fact on effective place in case of congestion. After congestion increase of loss on different loads. In facts placement improve the congestion and reduce loss. In table 5.1 analysis of different three methods like genetic algorithm(GA), particle swarm optimization(PSO), biogreophy optimization (BBO) and hybrid proposed approach particle swarm optimization and genetic algorithm(PSO-GA).

V. REFERENCES

[1] Das, A., Dawn, S., &Gope, S. (2019*). "A Review on Optimal Placement of FACTS Devices".* International Journal of Computational Intelligence &IoT, 2(3).

[2] Kundul, S., Ghosh, T., Maitra, K., Acharjee, P., & Thakur, S. S. (2018, June). "*Optimal Location of SVC Considering Techno-Economic and Environmental Aspect*." In 2018 2nd International Conference on Power, Energy and Environment: Towards Smart Technology (ICEPE) (pp. 1-6). IEEE.

[3] Gaur, D., & Mathew, L. (2018, March). "*Optimal placement of FACTS devices using optimization techniques: A review.*" In IOP Conference Series: Materials Science and Engineering (Vol. 331, No. 1, p. 012023). IOP Publishing.

[4] Kavitha, K., &Neela, R. (2018)."*Optimal allocation of multi-type FACTS devices and its effect in enhancing system security using BBO, WIPSO & PSO*." Journal of Electrical Systems and Information Technology, 5(3), 777-793.

[5] Raj, S., & Bhattacharyya, B. (2018). "*Optimal placement of TCSC and SVC for reactive power planning using Whale optimization algorithm.*" Swarm and Evolutionary Computation, 40, 131-143.

[6] El-Hawary, M. E. (2018). Electrical energy storage systems: A comparative life cycle cost analysis. *Renewable and sustainable energy reviews*, *42*, 569-596. *Electrical energy systems*. Crc Press.

[7] Ziaee, O., &Choobineh, F. F. (2017)." *Optimal location-allocation of TCSC devices on a transmission network*" IEEE Transactions on Power Systems, 32(1), 94-102.

[8] Patil, Basanagouda, and S. B. Karajgi. *"A review on optimal placement of FACTS devices in deregulated environment-a detailed perspective*." In 2017 International Conference on Electrical, Electronics, Communication, Computer, and Optimization *Techniques (ICEECCOT)*, pp. 375-380. IEEE, 2017.

[9] Inkollu, S. R., & Kota, V. R. (2016*)." Optimal setting of FACTS devices for voltage stability improvement using PSO adaptive GSA hybrid algorithm*". Engineering science and technology, an international journal, 19(3), 1166-1176.

[10] Rao, R. S., & Rao, V. S. (2015). ". *International Journal of Electrical Power & Energy System A generalized approach for determination of optimal location and performance analysis of FACTs devices"s*, *73*, 711-724.

[11] Kulkarni, P. P., &Ghawghawe, N. D. (2013*)." A Review Paper on Optimal Location and Parameter Setting of Facts To Improve The Performance Of Power System*" Int. J. Electr. Electron. Data Commun, 1, 1-5.

[12] Georgilakis, Pavlos S., and Peter G. Vernados. "*Flexible AC transmission system controllers: An evaluation*." In *Materials Science Forum*, vol. 670, pp. 399-406. Trans Tech Publications, 2011.

[13] Acharya, N., Sode-Yome, A., &Mithulananthan, N. (2005, September). "*Facts about flexible AC transmission systems (FACTS) controllers: practical installations and benefits". Australia* (pp. 533-538).
In Australasian universities power engineering conference (AUPEC*)*,